# Abstracts

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# TABLE OF CONTENTS


| SECTION | ABSTRACT | PAGE |
|---|---|---|
| **ANIMAL BEHAVIOR, HOUSING, AND WELL-BEING SYMPOSIUM:** | | |
| Finding Effective Ways to Manage Pain in Livestock | 001-005 | 1 |
| Animal Behavior, Housing, and Well-Being | 006-019 | 3 |
| **BILLY DAY SYMPOSIUM:** | | |
| Batch Farrowing: Reasons, Limitations and Reproductive Management | 020-024 | 9 |
| **BREEDING AND GENETICS SYMPOSIUM:** | | |
| Genomics of Reproduction | 025-028 | 11 |
| Breeding and Genetics | 029-045 | 13 |
| **DAVID BAKER SYMPOSIUM:** | | |
| Current Issues in Amino Acids in Pigs | 046-049 | 22 |
| **DAVID SCHINGOETHE SYMPOSIUM:** | | |
| Key Challenges to Dairy Cattle Production in the Midwest | 050-053 | 23 |
| Equine Science | 054 | 25 |
| Extension – Beef/Small Ruminant | 055-056 | 26 |
| **EXTENSION – DAIRY SYMPOSIUM:** | | |
| The Optimization of the Nutrition of Transition Cows | 057-061 | 27 |
| Extension – Dairy | 062 | 29 |
| Extension – Swine | 063-077 | 30 |
| **GARY ALLEE SYMPOSIUM:** | | |
| Swine Industry Expansion: Needs and Opportunities Within | 078-081 | 37 |
| Graduate Student Oral Competition: M.S. | 082-096 | 38 |
| Graduate Student Oral Competition: Ph.D. | 097-106 | 45 |
| Graduate Student Poster Competition: M.S. | 107-116 | 50 |
| Graduate Student Poster Competition: Ph.D. | 117-121 | 55 |
| **GROWTH, DEVELOPMENT, MUSCLE BIOLOGY, AND MEAT SCIENCE SYMPOSIUM:** | | |
| Is Bigger Better? A Discussion about the Benefits and Implications of Pigs Becoming Heavier | 122 | 57 |
| Growth, Development, Muscle Biology, and Meat Science | 123-138 | 58 |
| **HARLAN RITCHIE SYMPOSIUM** | 139-142 | 66 |
| **NONRUMINANT NUTRITION SYMPOSIUM:** | | |
| Programming of the Immune System | 143-149 | 68 |

Nonruminant Nutrition ... 150-306 ... 71

**PHYSIOLOGY SYMPOSIUM:**
Molecular Events Impacting Production of Fertile Gametes ... 307-311 ... 149

Physiology ... 312-330 ... 152

**RUMINANT NUTRITION SYMPOSIUM:**
Genetic, Dietary and Microbial Contribution to Feed Efficiency in Cattle ... 331-334 ... 161

Ruminant Nutrition ... 335-378 ... 163

Undergraduate Student Oral Competition ... 379-396 ... 183

Undergraduate Student Poster Competition ... 397-407 ... 192

Bentley Abstract: Pain management in livestock: understanding the views of producers and veterinarians ... 408 ... 198

DPP Abstract: Nutrient sensing and appetite in pigs ... 409 ... 198

Author Index ... 201

Keyword Index ... 208

Young Scholar Presentation Index ... 213

## ANIMAL BEHAVIOR, HOUSING, AND WELL-BEING SYMPOSIUM:

## FINDING EFFECTIVE WAYS TO MANAGE PAIN IN LIVESTOCK

**001 Why does pain in livestock matter? A philosophical view of pain management.** A. Shriver*, *University of Pennsylvania, Philadelphia.*

Most people agree that unnecessarily causing severe pain in livestock can be morally problematic. But how much moral weight should we put on different intensity levels of pain? And how do we decide which pains are truly unnecessary? In this presentation, I describe how philosophers approach the problem of assessing the moral significance of pain in livestock. I will consider different views on how to weigh the moral significance of pain and how these views lead to different policy recommendations. I will examine the concept of "necessary" used in arguments suggesting that causing unnecessary pain is morally problematic, including a discussion of how pain has been evolutionarily adaptive and how it can be behaviorally beneficial. Finally, I will discuss the ethical dimensions of various proposals for how pain in livestock can be minimized.

**Key Words:** ethics, pain, philosophy
doi: 10.2527/asasmw.2017.001

**002 Pharmacological approaches to pain management in cattle.** H. Coetzee*, *Kansas State University, Manhattan.*

Societal concern about the moral and ethical treatment of animals is increasing. In particular, the negative public perception of pain associated with routine animal management practices such as dehorning and castration is mounting, with increasing call for the development of practices to relieve pain and suffering in livestock. Preemptive analgesia can be applied in advance of the painful stimulus, thereby reducing sensitization of the nervous system to subsequent stimuli that could amplify pain. Agents that could be used to provide preemptive analgesia include local anesthetics, nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, α2-agonists, and *N*-methyl *D*-aspartate receptor antagonists. However, less than 20% of U.S. veterinarians currently report using analgesia routinely at the time of dehorning and castration. There are several challenges associated with providing effective analgesia in food animals in the United States. Most notably, that there are currently no analgesic drugs specifically approved by the Food and Drug Administration (FDA) for the alleviation of pain in livestock. Therefore, use of any drug for pain relief constitutes extra-label drug use (ELDU) and is regulated by the Animal Medicinal Drug Use Clarification Act of 1994 (AMDUCA, 1994). A list of compounds available for potential ELDU for pain relief in cattle in the United States can be found in Table 002.

The capacity to experience pain is considered to have a protective role by eliciting behavioral responses aimed at reducing further tissue damage and enhance wound healing. However, persistent pain syndromes offer no biological advantage and are associated with suffering and distress. Pathological pain states in cattle occur as a result of tissue damage,

**Table 002.**

| Drug | Approved species | Indications | Dose (cattle) | T ½ in cattle | Withhold period |
|---|---|---|---|---|---|
| Flunixin meglumine (Merck®) | Cattle, horses, and pigs | Antipyretic, anti-inflammatory. BRD and mastitis | 2.2 mg/kg IV ONLY! Oral F = 60% | 3–8 h | Meat: 4 days Milk: 36 h |
| Phenylbutazone | Horses and dogs | Anti-inflammatory | 4 mg/kg IV ONLY! | 40–55 h | Not approved in cattle in the USA |
| Ketoprofen (Merial®) | Horses and dogs | Anti-inflammatory | 1.5 mg/kg IV, IM | 0.42 h | Not approved in cattle in the USA |
| Aspirin | No FDA approval Horses and Cattle | Reduction of fever Relief of minor muscle aches and joint pain | 50–100 mg/kg PO Oral F < 20% | 0.5 h (IV salicylate) | No formal FDA approval. Not for use in lactating cattle |
| Carprofen (Zoeitis®) | EU approval in cattle Dogs | Adjunctive therapy of acute restiratory disease and mastitis | 1.4 mg/kg bodyweight IV or SC Oral tablets | Age dependent <10 weeks: 49.7 h | Not approved in cattle in the USA EU: 21 days (meat), 0 days (milk) |
| Meloxicam (Boehringer Ingelheim®) | EU and Canadian approval in cattle Dogs and cats | Adjunctive of BRD; diarrhea and acute mastitis (EU). Analgesia after disbudding (Can) | 0.5 IV, SC 0.5–1 mg/kg PO Oral F = 100% | 27 h (Range: 19.97–43.29 h) | Not approved in cattle in the USA. 15 days EU and 20 days Canada. F ARAD 21 days (meat) |
| Firocoxib (Merial®) | Dogs and horses | Anti-inflammatory | 0.5 mg/kg (PO) Oral F = 98.4% | 18.8 h (Range: 14.2–25.5 h) | Not approved in cattle in the USA or EU. |

nerve damage, and inflammation and are frequently associated with pain hypersensitivity. Pain hypersensitivity manifests as hyperalgesia (exaggerated responses to painful stimuli) and allodynia (pain resulting from normally innocuous stimuli). Hyperalgesia has been reported to persist in dairy cattle and lame sheep for at least 28 d after the causal lesion has resolved. Consequently, chronic pain associated with lameness is considered one of the most significant welfare concerns in dairy cows. Inflammatory pain associated with lameness responds modestly to treatment with non-steroidal anti-inflammatory drugs (NSAIDs) but neuropathic pain (due to nerve damage or neuronal dysfunction) is considered refractory to the effects of NSAIDs and many opioid analgesics. Therefore, there is an urgent need to identify novel drugs and drug targets for alleviating chronic pain of neuropathic origin in animals. A multimodal approach using both local anesthesia and an anti-inflammatory drug optimizes pain relief in livestock procedures known to cause distress and pain. The use of meloxicam, ketoprofen, and flunixin in the development of analgesic protocols is supported by randomized controlled trials.

**Key Words:** pain, cattle, ethics
doi: 10.2527/asasmw.2017.002

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**003 Pigs in pain—causes, mechanisms, and possibilities for future development.** M. S. Herskin[1,*], P. Di Giminiani[2], [1]*Aarhus University, Tjele, Denmark,* [2]*Newcastle University, Newcastle, United Kingdom.*

Despite a long history of debate about negative affective states in animals, it was only in the last decades of the 20th century that the state of pain was mentioned in definitions of animal welfare, included in veterinary education, and became a target of scientific interest. Pain is a perceptional phenomenon built from information gathered by specialized sensory receptors for tissue damage and integrated into a discrete experience with a negative emotional valence in the brain. Based on knowledge about porcine neuroanatomy, physiology, and studies focusing on pig behavior and pathology, we review evidence for causes of pain in pigs, underlying biological mechanisms, as well as the possibility to quantify different types of indicators of pain states relevant to the welfare of the animals under production conditions. The presentation will primarily focus on pigs because of the dual purpose of this species as a meat producing as well as research animal species (the latter driven by the anatomical and physiological homologies with humans), making pigs unique among livestock. We will present methodologies and results from current research projects across Europe and North America targeting typical industry-related injuries (e.g., tail docking, lameness, and shoulder lesions) and aiming to understand the welfare consequences for the pigs. Throughout the talk, the emphasis will be put on future opportunities to link research outcomes with industry initiatives toward the improvement of animal welfare and production. In addition, possible future research efforts to help face current methodological limitations and favor a more comprehensive evaluation of animal pain as an overall experience will be discussed. This seeks to facilitate common future targeted research and enable us to overcome the paradoxical low level of knowledge about porcine pain and its alleviation under production conditions.

**Key Words:** pain, pig, welfare
doi: 10.2527/asasmw.2017.003

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**004 Lessons learned from pain management research in dairy cattle.** T. F. Duffield*, *University of Guelph, Guelph, ON, Canada.*

One area of increasing focus of health management research has been pain management in food animals. My position at the Ontario Veterinary College allows me to teach undergraduate DVM students in all years of the program, interact with producers on farm, and conduct research both at our dairy research facility and on commercial dairy farms. Through these interactions and research experiences, I have learned many lessons over the twelve years that I have been involved in this area of research. These lessons are: 1. I teach students but students teach me. 2. Producers care about their animals and will do the right thing. 3. Not all treatments are good. 4. Dystocia hurts both the calf and the cow. 5. Sickness behavior is a key concept—particularly for producers and veterinarians. 6. Change is difficult. Through the work that our research group has conducted in pain management of disbudding, mastitis, diarrhea, calving, and surgery and surveys of changes in Ontario of both producer and veterinary approaches to disbudding in the past 10 yr, these lessons will be illustrated and explored.

**Key Words:** pain, education, veterinary medicine
doi: 10.2527/asasmw.2017.004

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**005 Withdrawn**

## ANIMAL BEHAVIOR, HOUSING, AND WELL-BEING

**006 Characterization of the lying down sequence in lame and non-lame sows.** J. M. Mumm[1,*], J. D. Stock[1], S. Azarpajouh[1], K. J. Stalder[1], A. K. Johnson[1], J. A. Calderon Diaz[2,3], *[1]Department of Animal Science, Iowa State University, Ames, [2]Pig Development, Teagasc Moorepark Grassland Research and Innovation Centre, Fermoy, Co. Cork, Ireland, [3]Department of Animal Behavior and Welfare, Institute of Genetics and Animal Breeding, Polish Academy of Sciences, Jastrzębiec, Magdalenka, Poland.*

The objectives of this study were to characterize the different postures and movements for the lying down sequence in multiparous sows and to identify differences between lame and sound sows. Eighty-five multiparous sows (parity range 1 to 4) were used for this study. Sows were moved from their gestation stall to a stall in an empty area of the barn. A digital video camera was positioned on the adjacent stall so the sows' profiles were visible. Sows were video recorded for one lying down event on Days 30, 60, and 90 of gestation. Observations ceased when the sow successfully lay down or if 2.5 h elapsed since recording began. Prior to recording, sows were scored for lameness on a 3-point scale, (1 = normal to 3 = severely lame). From the video, postures and movements that occurred during the lying sequence were identified. Time from kneeling to shoulder rotation (KSR; seconds), time from shoulder rotation to lying (SRHQ; seconds), total time to lie down (TLIE; seconds), latency to lie down (LATENCY; minutes), and number of attempts (ATTEMPTS) to successfully lie down were recorded. Sows were re-classified as sound or lame. Parities were reclassified as 1, 2, and ≥ 3 due to small numbers of older sows. Time variables were analyzed using mixed-model methods. ATTEMPTS were classified as 1, 2, and ≥ 3 and analyzed using multinomial logistic regression. Models included gestation day, lameness status, and parity. On average, sows took 13.9 s for KSR, 7.7 s for SRHQ, 20.5 s for TLIE, and 66.1 min for LATENCY. Lameness was not a significant source of variation for any trait evaluated. However, lame sows tended to take longer during KSR (15.5 vs. 11.9 ± 1.59 s for lame and sound sows, respectively; $P = 0.08$) and to spend less time standing (54.1 vs. 69.8 ± 6.20 min for lame and sound sows, respectively; $P = 0.06$) compared with sound sows. Gestation day and parity were not associated with the time taken for the different movements in the lying down sequence ($P > 0.05$). Additionally, there were no significant associations between gestation day, lameness status, or parity and ATTEMPTS. Results suggest that lameness scores do not greatly affect the lying down sequence. However, this could be due to the fact that lameness recorded in this study was not severe enough to affect the lying down sequence.

**Key Words:** lameness, lying down sequence, sows
doi: 10.2527/asasmw.2017.006

**007 Do lame sows need more time to stand up?** J. M. Mumm[1,*], S. Azarpajouh[1], J. D. Stock[1], K. J. Stalder[1], A. K. Johnson[1], J. A. Calderon Diaz[2,3], *[1]Department of Animal Science, Iowa State University, Ames, [2]Department of Animal Behavior and Welfare, Institute of Genetics and Animal Breeding, Polish Academy of Sciences, Jastrzębiec, Magdalenka, Poland, [3]Pig Development, Teagasc Moorepark Grassland Research and Innovation Centre, Fermoy, Co. Cork, Ireland.*

Lameness is a prominent disease in swine production, and it might affect the way sows interact with their environment. The objectives of this study were to determine the time required and the behavioral sequence to move from lying to standing for lame and non-lame sows. Eighty-five multiparous sows (parity range 1 to 4) were enrolled. Prior to recording, sows were scored for lameness while walking on a 3-point scale (1 = normal to 3 = severely lame). Sows were moved into a gestation stall where they were digitally video recorded continuously (30 frames/s) for one standing up event on Days 30, 60, and 90 of gestation. Time (sec) to stand up was defined as the first leg fold to sit (TLS), time from sit to rise (TSR), and total time to rise (TRISE). The frequency of TLS, TSR, and TRISE were also collected. Sows were re-classified as sound or lame, and parities were re-classified as 1, 2, and ≥ 3 for statistical analysis. The likelihood of performing the different movements for the standing sequence was analyzed using logistic regression. Time variables were analyzed using mixed model equation methods. Models included gestation day, lameness status, and parity. There were no significant associations between gestation day, parity, lameness, and the likelihood of performing different movements during the standing up behavioral sequence. However, lame sows tended to be more likely to sit while transitioning from lying to standing compared with sound sows ($P = 0.07$). On average, sows took 8.0 sec for TLS, 6.9 sec for TSR, and 9.8 sec for TRISE. Lameness did not affect the time taken for TLS, TSR, and TRISE ($P > 0.05$). Parity 2 sows had greater TLS compared with parity 1 sows (20.9 vs. 4.7 ± 3.01 sec; $P < 0.05$) and parity ≥ 3 (20.9 vs. 5.5 ± 3.62 sec; $P < 0.05$). Additionally, parity 2 sows tended ($P = 0.09$) to take 8.1 and 6.7 sec more for TRISE when compared to parity 1 and ≥ 3 sows; respectively (16.0 vs. 7.9 ± 1.9 and 9.3 ± 3.3 sec; $P < 0.10$). Under the conditions of this study, lameness did not influence the timings or order of the standing up sequence. However, lameness recorded was mild, and thus, it might not have been severe enough to affect the sequence. Other factors such as parity seem to be related

with timing of the standing sequence.

**Key Words:** lameness, sows, standing up sequence
doi: 10.2527/asasmw.2017.007

**008 The effect of blunt trimming verses functional trimming on sows.** A. Tinkle[1,*], M. E. Wilson[2], M. A. Parsley[3], M. J. Azain[1], C. R. Dove[1], *[1]University of Georgia, Athens, [2]Zinpro Corporation, Eden Prairie, MN, [3]Zinpro Corporation, Sheridan, IN.*

The object of this study was to ascertain if blunt verses functional claw trimming provided similar benefits. Twenty-one PIC (Cambrough 29) sows were used with an average claw length of 6.5 cm and dewclaw length of 6.2 cm pre trimming. Sows were trained for 3 d before recording. Sows were individually walked through a dog bone track (7.5 m long) and recorded on a pressure mat (Gaitrite) for five useable repetitions on d 0, d 4, d 8, and d 12 of the study. After d 0, sow locomotion was recorded, dewclaws were trimmed even with coronary band. Sows were recorded on d 4, and then claws were straight cut across the toe using a lopper (Blunt cut). Sows were recorded on d 8 and then were functionally trimmed. The final recording was on d 12. Recordings were analyzed using Gaitfour (Gaitrite) software to assess swing, stance, stride length, gait cycle, percent stance of gait cycle, and overall velocity. Data were analyzed using the PROC MIXED procedure of SAS as a repeated measures design with each sow serving as her own control. There was an increase from d 0 to d 12 for velocity ($P < 0.003$; d 0 94.8, d 8 97.62) and d 8 to d 12 ($P < 0.009$; d 0 94.8, d 12 105.5 cm/s), stride length (front d 0 to d 12, $P < 0.003$; d 8 to d 12, $P < 0.035$; 97.80, 99.74, 101.77 cm; rear 98.09, 99.04, 101.67 cm on d 0, d 8, and d 12, respectively) and percent stance of gait cycle (front d 0 to d 12, $P < 0.0001$; d 8 to d 12, $P < 0.001$; 69.06, 69.95, 65.68%; rear d 0 to d 12, $P < 0.001$; d 8 to d 12, $P < 0.002$; 67.49, 66.04, 64.12% on d 0, d 8, and d 12, respectively). There was a decrease from d 0 to d 12 and d 8 to d 12 for stance (front d 0 to d 12, $P < 0.0001$; d 8 to d 12, $P < 0.0041$; 0.75, 0.7, 0.66 s; rear d 0 to d 12, $P < 0.0001$; d 8 to d 12, $P < 0.005$; 0.75, 0.71, 0.6 s on d 0, d 8, and d 12 respectively) and gait cycle (front d 0 to d 12, $P < 0.003$; d 8 to d 12, $P < 0.03$; 1.08, 1.04, 0.99 s; rear d 0 to d 12, $P < 0.0012$; d 8 to d 12, $P < 0.02$; 1.11, 99.04, 1.01 s on d 0, d 8, and d 12, respectively). This illustrates that blunt cut trimming the claw is not enough to improve gait quality in the sows and functional trimming will provide better results in sow locomotion.

**Key Words:** blunt trimming, functional trimming, sows
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**009 Effects of genetics on thermal regulatory responses to repeated heat stress exposure in pigs.** W. M. Rauw[1,2], E. J. Mayorga[2,*], S. Lei[2], J. C. M. Dekkers[2], J. F. Patience[2], N. K. Gabler[2], S. M. Lonergan[2], L. H. Baumgard[2], *[1]Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Madrid, Spain, [2]Department of Animal Science, Iowa State University, Ames.*

Heat stress (HS) accounts for over $900 million loss in the US swine industry annually. In addition, HS negatively impacts animal welfare. Evidence suggests that efficient, fast-growing pigs may be more susceptible to HS. Study objectives were to investigate the effects of genetics on respiration rate (RR) and skin (ST) and rectal temperatures (RT) in response to repeated exposure to HS. A total of 97 animals from a commercial line and a divergent line selected for high and low residual feed intake (RFI) were subjected three times to a 4-d HS load that was preceded by a 9-d thermal neutral (TN) adaptation period and alternated by 7-d TN conditions: 1-TN adaptation, 2-HS, 3-TN, 4-HS, 5-TN, 6-HS, and 7-TN. RR, ST, and RT were measured daily in each period. Mixed models with a repeated statement were fitted to describe the individual data. RR, ST, and RT were higher during HS compared with TN conditions ($P < 0.0001$; Table 009). RR was positively correlated with ST during TN ($r = 0.27$; $P < 0.0001$) but not during HS ($r = 0.03$). Commercial pigs had higher RR than low and high RFI pigs during TN ($P < 0.05$); high RFI pigs had higher RR than commercial and low RFI pigs during HS ($P < 0.05$). During TN, ST and RT were higher in commercial pigs than in low and high RFI pigs and higher in high RFI than in low RFI pigs ($P < 0.001$). During HS, ST and RT were higher in commercial pigs than in low and high RFI pigs ($P < 0.01$). Results indicate that fast growing commercial pigs had higher body temperatures that reached fever temperatures during HS. This suggests that fast growing animals may be more affected by HS, which may negatively impact their welfare. Selection for increased feed efficiency may eventually result in pigs that are less affected by heat stress.

**Key Words:** heat stress, pigs, welfare
doi: 10.2527/asasmw.2017.009

**Table 009.** Least square means ± s.e. for RR, ST, and RT for pigs from a commercial, low RFI and high RFI line during HS and TN conditions.

| | RR (bpm) | | ST (°C) | | RT ST (°C) | |
|---|---|---|---|---|---|---|
| | TN | HS | TN | HS | TN | HS |
| Commercial | 42 ± 1 | 93 ± 2 | 33.8 ± 0.1 | 37.8 ± 0.1 | 39.4 ± 0.02 | 40.0 ± 0.03 |
| Low RFI | 34 ± 1 | 92 ± 1 | 32.2 ± 0.1 | 37.3 ± 0.1 | 39.1 ± 0.02 | 39.4 ± 0.03 |
| High RFI | 39 ± 1 | 100 ± 2 | 32.5 ± 0.1 | 37.4 ± 0.1 | 39.2 ± 0.02 | 39.5 ± 0.03 |

**010 Effects of increasing space allowance by removing a pig or gate adjustment on finishing pig growth performance.** C. B. Carpenter, C. J. Holder, M. D. Tokach, J. M. DeRouchey, J. C. Woodworth, R. D. Goodband, and S. S. Dritz, *Kansas State University, Manhattan*

A total of 256 pigs (PIC 327 × 1050; initially 55.9 kg) were used in a 71-d study to determine the effects of space allowance and pig removal on finishing pig performance. The 4 treatments included: 0.91m$^2$/pig or 0.63m$^2$/pig for the entire study and initially 0.63m$^2$/pig with a gate adjusted or the heaviest pig removed to keep pigs above their predicted minimum space requirement (m$^2$ = 0.0336*BW$^{0.66}$). Initially, there were 8 pigs/pen and 8 pens/treatment. From d 0 to 28, prior to any space adjustments, ADG was marginally greater ($P$ = 0.076) for pigs provided 0.91m$^2$ compared with those provided 0.63m$^2$. From d 28 to 71, ADG and ADFI decreased ($P$ = 0.001) when pigs were provided 0.63m$^2$ compared with pigs provided 0.91m$^2$. Pigs provided increased space by removing pigs had similar performance to those where gates were adjusted; however, pig removal resulted in lower ADFI than pigs allowed 0.91m$^2$ throughout the experiment. Overall, pigs allowed 0.91m$^2$ had increased ($P$ = 0.001) ADG compared with pigs allowed 0.63m$^2$ or either adjusted space treatment. Removing pigs or adjusting gating increased ($P$ = 0.001) ADG compared to those kept at 0.63m$^2$; however, neither treatment had ADG similar to pigs allowed 0.91m$^2$. Pigs allowed 0.91m$^2$ had greater ($P$ = 0.001) ADFI compared with pigs allowed 0.63m$^2$ with adjusted space allowance pigs being intermediate. Feed efficiency was not affected in the cumulative growth periods. In summary, either removing a pig or adjusting the gating as pigs reached the critical $k$-value influenced growth similarly. Results indicate the performance benefit from removing the heaviest pigs from the pen is primarily from increased space allowance. Pigs provided more space as they reached the space requirement had lower growth than unrestricted pigs indicating the minimum space prediction equation (m$^2$ = *0.0336*BW$^{0.66}$) doesn't fully explain pen space effects on pig performance.

**Key Words:** finishing pig, growth, space
doi:10.2527/asasmw.2017.010

**011 Withdrawn**

**012 Design and feasibility of a novel sprinkler control algorithm for swine heat stress alleviation.** B. C. Ramirez*, S. J. Hoff, J. D. Harmon, *Agricultural and Biosystems Engineering, Iowa State University, Ames.*

Pigs have a relatively low capacity to dissipate excess body heat and depend more on reducing metabolic heat production through a reduction in voluntary feed intake in hot conditions, resulting in a growth performance decrease. Effectiveness of current cooling devices (e.g., evaporative coolers or sprinklers) in facilities is governed by the Water Vapor Pressure (WVP) concentration gradient between the air (a function of dry-bulb temperature, $t_{db}$; relative humidity, RH; and atmospheric pressure) and saturated WVP at a wet surface. Traditional sprinkler control systems (TSCS) often operate solely on $t_{db}$ feedback and at fixed "off" intervals to allow dispersed water to evaporate. This control strategy does not account for the WVP concentration gradient; hence, water is wasted and only a limited amount of latent heat can be removed from the animal. Therefore, the objectives were to develop and simulate a novel variable interval sprinkler control system (VISCoS) that dynamically changes the "off" interval based on $t_{db}$, RH, and airspeed feedback. A theoretical convective mass transfer model (i.e., evaporation) was developed to estimate water evaporation rate as a function of the thermal environment, surface area, skin temperature, and volume of water applied. A pig's geometry was assumed a cylinder approximately 30% wet with a 1-mm film of water. The feasibility of implementing VISCoS was evaluated at six locations (AZ, IA, MN, MO, IN, and NC) by simulating water usage for a 1000 hd, mechanically ventilated,

**Table 010.**

| Item[1] | 0.91m$^2$ | 0.63m$^2$ | Gate adjustment | Pig removal | SEM | Probability, $P$ < |
|---|---|---|---|---|---|---|
| BW, kg | | | | | | |
| d 0 | 55.9 | 56.0 | 55.9 | 55.6 | 0.15 | 0.361 |
| d 28 | 84.0$^{x}$ | 82.3$^{y}$ | 82.6$^{y}$ | 82.8$^{y}$ | 0.47 | 0.081 |
| d 71 | 127.3$^{a}$ | 121.7$^{c}$ | 124.9$^{b}$ | 122.5$^{c}$ | 0.73 | 0.001 |
| d 0 to 28 | | | | | | |
| ADG, kg | 1.00$^{x}$ | 0.94$^{y}$ | 0.95$^{y}$ | 0.97$^{xy}$ | 0.015 | 0.076 |
| ADFI, kg | 2.39 | 2.28 | 2.35 | 2.37 | 0.036 | 0.200 |
| d 28 to 71 | | | | | | |
| ADG, kg | 1.01$^{a}$ | 0.92$^{b}$ | 0.98$^{a}$ | 0.98$^{a}$ | 0.013 | 0.001 |
| ADFI, kg | 3.01$^{a}$ | 2.77$^{c}$ | 2.97$^{ab}$ | 2.89$^{b}$ | 0.035 | 0.001 |
| d 0 to 71 | | | | | | |
| ADG, kg | 1.00$^{a}$ | 0.93$^{c}$ | 0.97$^{b}$ | 0.98$^{b}$ | 0.009 | 0.001 |
| ADFI, kg | 2.76$^{a}$ | 2.58$^{c}$ | 2.73$^{ab}$ | 2.66$^{b}$ | 0.029 | 0.001 |

[1]Means within a row differ: $^{abc}P < 0.05$, $^{xyz}P < 0.10$.

grow-finish building with an assumed water delivery (75.71 L/min), sprinkler "on" time (30 s), and constant BW (100 kg). Typical meteorological year 3 weather data (365 d) was used to determine outdoor $t_{db}$ and RH at each location, where indoor $t_{db}$ was assumed 2°C greater than outdoor $t_{db}$ with a 2 m/s air velocity across the animal's back. The VISCoS performance was compared with two TSCSs with fixed "off" intervals (15 and 30 min; "on" $t_{db} \geq 29.44$°C). Simulation results for each region showed water usage for 15 min (154, 72, 60, 50, 80, 164 $m^3$) and 30 min (79, 37, 31, 26, 41, 83 $m^3$) "off" interval TSCS to be greater than VISCoS (49, 15, 8, 10, 17, 44 $m^3$). Duration (±SD) for complete water evaporation estimated by VISCoS (19.6 ± 1.4, 28.0 ± 3.6, 27.8 ± 2.5, 31.8 ± 6.5, 32.2 ± 3.3, 26.9 ± 3.3 min) varied by region and provides insight on incorporating more thermal environment measurements to reduce water usage in swine facilities.

**Key Words:** housing, humidity, temperature
doi: 10.2527/asasmw.2017.012

### 013 Evaluating the health and productivity of weaned piglets after simulated transport and heat stress when antibiotics are eliminated from the diet.

J. S. Johnson*, D. C. Lay Jr., *USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN.*

The study objective was to evaluate the effects of post-weaning transport during heat stress (HS) on post-transport piglet health and productivity when dietary antibiotics were removed or replaced with a nutraceutical. Sixty mixed sex piglets from 10 sows ($n$ = 6 piglets/sow) were weaned (18.8 ± 0.8 d of age) and then herded up ramps into one of two simulated transport trailers in thermoneutral (TN; 28.8 ± 0.2°C; $n$ = 30 piglets) or HS (cyclical 32 to 37°C; $n$ = 30 piglets) conditions for 12 h. This procedure is referred to as simulated transport, as in piglets are weaned from the sow, herded down an alley and up a ramp into a trailer, fans simulated air movement, and feed and water were withheld; however, trailer movement was not simulated, only the regrouping, isolation, and duration component. Following the 12-h simulated transport, piglets were unloaded from the trailer, weighed, and then housed individually in TN conditions (28.5 ± 0.1°C; 29.1 ± 0.1% RH) and assigned to one of three dietary treatments balanced by weaning weight, sex, sow, and transport environment. Treatments were dietary antibiotics [A; $n$ = 20 piglets; 5.5 ± 0.2 kg BW; chlortetracycline (400 g/ton) + tiamulin (35 g/ton)], no dietary antibiotics (NA; $n$ = 20 piglets; 5.6 ± 0.2 kg BW), or 0.20% L-glutamine (GLU; $n$ = 20 piglets; 5.6 ± 0.2 kg BW) fed for 14 d. Feed intake (FI), BW, and behaviors were monitored daily. On d 15, all piglets were euthanized and intestinal samples were collected for histology. Data were analyzed using PROC MIXED in SAS 9.4 and pig was the experimental unit. Throughout the 14-d dietary treatment phase, FI was greater overall ($P$ < 0.01; 60.3%) in GLU compared to A and NA pigs and tended to be greater ($P$ = 0.08; 37.7%) in A compared to NA pigs. BW was greater overall ($P$ < 0.01; 8.7%) in GLU and A compared to NA pigs, but no differences were detected between A and GLU pigs. Lying behavior was greater ($P$ = 0.05; 11.7%) in NA compared to A and GLU piglets in the first 2 d following simulated transport, indicating greater illness behavior in NA pigs. The villus height to crypt depth ratio was greater ($P$ < 0.05) in the duodenum (12.1%) and jejunum (12.8%) for A and GLU compared to NA pigs and greater in the ileum (15.6%) for GLU compared to A and NA pigs. No temperature by diet treatment differences were observed with any comparison. In summary, withholding dietary antibiotics after weaning and transport can increase illness behaviors, reduce productivity, and negatively alter intestinal morphology compared to dietary antibiotic or L-glutamine provision.

**Key Words:** antibiotics, heat stress, transport
doi: 10.2527/asasmw.2017.013

### 014 Dynamic space requirements of lame and non-lame sows determined by the lying-standing sequence.

J. M. Mumm[1,*], J. D. Stock[1], K. J. Stalder[1], A. K. Johnson[1], A. Ramirez[2], S. Azarpajouh[1], J. A. Calderon Diaz[3,4], *[1]Department of Animal Science, Iowa State University, Ames, [2]Iowa State University, Ames, [3]Pig Development, Teagasc Moorepark Grassland Research and Innovation Centre, Fermoy, Co. Cork, Ireland, [4]Department of Animal Behavior and Welfare, Institute of Genetics and Animal Breeding, Polish Academy of Sciences, Jastrzębiec, Magdalenka, Poland.*

Increasing consumer awareness of animal production systems has influenced housing specifications through legislation in several countries. Understanding how sows utilize their dynamic space could assist in gestation housing design specifications. The aim of this study was to calculate the dynamic space requirements for lame and non-lame sows during a lying-standing postural sequence. A total of 85 multiparous sows (parity range 0 to 4) were used in this study. Lameness was evaluated when each sow was moved from its gestation stall to a pen using a 3-point scale while walking (1 = normal to 3 = severely lame). Individual sows were moved to a pen on gestation Days 30, 60, and 90, and a ceiling camera above the pen recorded one lying down-standing up event. Observations ceased when the sow laid-down and stood-up or if 2.5 h elapsed from recording commencement. Two space measurement methods were conducted after still frames of lying-down and standing-up sequences were combined into a single image and measured in Adobe Photoshop Elements by (1) counting the number of pixels by contouring the sows' body or (2) overlaying a grid on the sow image. Lameness was reclassified as non-lame (score 1) and lame (scores ≥ 2), and parity was reclassified as 1, 2, and 3+. Data were analyzed using mixed model equations methods. Models included lameness status,

gestation day, parity, and space measurement method. There were no observed differences in the space required to perform the lying-down or standing-up sequence between lame and non-lame sows ($P > 0.05$). There was no difference in the space required between the two measuring methods used ($P > 0.05$). On average, sows used 1.16 ± 0.4 $m^2$ to lie down and stand up. Space required to lie down and stand up increased as gestation progressed ($P < 0.05$). Parity 3+ required 0.20 $m^2$ more space to lie down compared with parities 1 and 2 and required 0.26 $m^2$ more space to stand up compared with parity 1 sows ($P < 0.05$). Under the conditions of this study, lameness did not affect the dynamic space needed to lie down and stand up, but parity and stage of gestation did. Results from this study could be important in the decision making process for new regulations regarding space needs for gestation sow housing in the USA.

**Key Words:** dynamic space, lie-down stand-up sequence, sow lameness
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**015 Do pigs form social structures: an application of social network analysis?** Y. Li[1,*], H. Zhang[1], L. J. Johnston[1], W. Martin[2], *[1]West Central Research and Outreach Center, University of Minnesota, Morris, [2]University of Minnesota Extension, St Paul.*

As social animals, pigs in a group may form certain social structures which could be important to their welfare. The objective of this study was to use social network analysis to assess social structure and social position of pigs when grouped with littermates or non-littermates. Pigs ($n = 96$; initial wt = 6.93 ± 1.56 kg) weaned at 4 wk of age were housed in 12 pens (8 pigs/pen) for 5 wk, which consisted of 6 pens of littermates and 6 pens of non-littermates. Pigs were weighed at birth, 4 wk, and 9 wk of age. The behavior of pigs was video recorded for 6 h between 0900 and 1500 h at 7 wk and 8 wk of age. Videos were scanned at 20-min intervals to register individual pigs that were lying together (1) or not (0) in binary matrices. Pigs that were lying together were considered to be socially connected. Social network analysis was performed using the UNICET software. Degree centrality (DC) and closeness centrality (CC) measure direct and indirect connections, respectively, that a pig has with its pen mates. Network density describes how frequently pigs in a pen were lying together. Larger values for DC, CC, and network density indicate a greater degree of social connection. No differences in average DC (0.79 ± 0.23 for littermates vs. 0.83 ± 0.25 for non-littermates), CC (0.63 ± 0.34 vs. 0.73 ± 0.30), or network density (4.12 ± 0.96 vs. 4.34 ± 0.54) were found between litter origin treatments, indicating that pigs in pens of littermates connected with each other in a similar way to pigs in pens of non-littermates. Standard deviation of CC tended to be higher ($P = 0.06$) for littermates than non-littermates. This suggests that some littermates may form more indirect connections than other littermates, while non-littermates form similar indirect connections among themselves. Furthermore, CC was correlated with bodyweight at 4 wk ($r = 0.242$; $P < 0.05$) and 9 wk ($r = 0.233$; $P < 0.05$) of age. Network density was correlated with bodyweight at 9 wk ($r = 0.629$; $P < 0.05$) and 4 wk ($r = 0.559$; $P < 0.10$) of age, and ADG ($r = 0.568$; $P < 0.10$). These data suggest that heavy pigs had more indirect connections and connected with their pen mates more frequently than lightweight pigs. These preliminary results suggest that social network analysis may be a useful tool to measure social structure among pigs.

**Key Words:** behavior, pigs, social network analysis
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**016 Changes in scratches and skin elasticity in cull sows after transport to the abattoir.** K. Thodberg*, K. K. Fogsgaard, C. Gaillard, M. S. Herskin, *Aarhus University, Tjele, Denmark.*

Each year, over 400,000 Danish sows are transported by road to abattoirs. Only very limited knowledge about these animals is available. In this study, the clinical condition of 522 sows was examined before and after transport to an abattoir. The effects of journey duration (max 8 h), temperature in the vehicles, as well as the effect of sows' pre-transport condition on their clinical condition at arrival were investigated. The study included sows from 12 private farms sampled randomly and stratified according to distance to a larger slaughterhouse. Selection of animals to slaughter was done by the farmers taking into account the EU Council Regulation (EC 1/2005) that excludes animals unable to move independently without pain; present open wounds or prolapse; pregnant females in late gestation or having given birth within a week. Transport duration ranged from 46 to 469 min (mean = 236 ± 114 min) and average temperatures from 3.4 to 26.1°C (mean = 14.3 ± 5.3°C). Clinical registrations were made on-farm before transport and immediately on arrival at the abattoir, and we here present data on the number of scratches and skin elasticity (a measure of the degree of dehydration). Overall differences in these two variables were analyzed with the signed-rank test (PROC NPAR1WAY), and the effects of journey and sow characteristics were analyzed with PROC GLIMMIX, both analyses in SAS. Table 016 shows the median and IQR (25% and 75%) of number of scratches and skin elasticity before and after transport. The risk of having more scratches was affected by an interaction between transport duration and average temperature ($F_{3, 405} = 8.44$; $P < 0.001$). The risk was generally high with temperatures above 18°C but also increased

**Table 016.**

| Variable | Before transport | After transport | Signed Rank Test |
|---|---|---|---|
| Number of scratches | 0 [0; 1] | 6 [2; 12] | N = 509; S = 38134.5; $P < 0.001$ |
| Skin elasticity (sec) | 3 [2; 3] | 3 [3; 4] | N = 492; S = 5001.5; $P < 0.001$ |

with transport time with more moderate temperatures. At temperatures below 6.5°C, the risk was highest on short transports. Among other findings, the risk of more scratches was higher in dry sows compared to lactating sows ($F_{1, 405} = 7.96$; $P < 0.01$). Odds of getting more dehydrated were 2 to 6 times higher at temperatures above 18°C compared to lower temperatures ($F_{3,423} = 8.12$; $P < 0.001$). These results show that the clinical condition of cull sows are worsened by the transport. Among the most important risk factors were transport duration and temperature. Future studies should examine whether and to what extent cull sows can be transported without the welfare impact of the worsened clinical parameters.

**Key Words:** clinical condition, cull sows, transport
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**017 Bio-pesticide management of pasture flies in the great plains via a push-pull strategy.** D. J. Boxler[1,*], G. J. Brewer[2], J. Zhu[2], R. N. Funston[3], *[1]University of Nebraska-Lincoln, West Central Research & Extension Center, North Platte, [2]University of Nebraska-Lincoln, Lincoln, [3]University of Nebraska, North Platte.*

Pasture flies threaten the profitability of beef cattle production in the Great Plains. While horn flies have traditionally been the major fly pest of range cattle, in recent years stable fly populations have greatly increased. Fly control is confounded by having few conventional insecticides available for use and by documented or suspected resistance to current insecticides. These factors make fly management and protection difficult, creating a need for alternative insecticides such as plant-derived biopesticides, also known as repellents. Sprayable and encapsulated biopesticide formulations were tested on yearling crossbred (Simmental × Red Angus) cattle in a push-pull system against native stable fly populations. The push-pull strategy in this study used a repellent to 'push' flies from some animals and 'pull' them to animals treated with an insecticide, which would reduce fly numbers. Cattle were randomized into 4 treatments, and stable fly populations were recorded by visually counting flies on all four legs and belly region of each animal. The 4 treatments included push-pull (half of the animals in the group were treated with a repellent, Geraniol, and half treated with an insecticide, permethrin), push only (treated with repellent, Geraniol), pull only (treated with an insecticide, permethrin), and Control (no treatment). Testing was done in adjacent drylot pens (44 m by 7.6 m) in 2013 and 2014 and in adjoining upland range pastures in 2015 (6.8 ha). All animals were treated weekly in a holding chute and then released back into their treatment group. A repeated measures design was used. Although the stable fly population differed each year, results were similar across years and locations (drylot or pasture). Both treatments including repellent (push only and push-pull) as well as the insecticide (pull) treatment had similar numbers of flies per animal (10.01, 9.97, 9.75, ± 0.67 respectively; $P > 0.05$). Overall, repellent only, insecticide only, and the combination of insecticide and repellent reduced stable fly numbers per animal ($P < 0.05$) compared with the untreated Controls (14.98 flies per animal). The biopesticide geraniol offers promise for incorporation into stable fly management programs for pasture cattle. However, besides reducing stable fly numbers on cattle, an implementation strategy compatible with ranching systems will be required.

**Key Words:** beef cattle, bio-pesticide, stable fly
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**018 Salivary cortisol concentrations of group-housed gestating sows: individual vs. group samples.** Y. Li[1,*], S. Cui[1], X. Yang[2], B. A. Crooker[3], S. K. Baidoo[2], L. J. Johnston[1], *[1]West Central Research and Outreach Center, University of Minnesota, Morris, [2]Southern Research and Outreach Center, University of Minnesota, Waseca, [3]Department of Animal Science, University of Minnesota, St Paul.*

The objectives of this study were to determine salivary cortisol concentrations and evaluate differences between individual and group samples collected from gestating sows. Mixed parity sows ($n = 928$, Parity 1 to 9) from 20 breeding groups were used. Sows of each breeding group were moved from stalls and housed in pens (42 to 51 sows/pen) with an electronic sow feeder after pregnancy confirmation at 5 wk postmating. Sows remained in pens until d 109 of gestation when they were moved to farrowing rooms. Within each breeding group, 8 focal sows balanced for parity were identified for saliva sampling. Saliva samples were collected from focal sows using absorbent cotton swabs in stalls before mixing, 2 d after mixing, and about 109 d of gestation in pens. Once sows were moved to pens, group samples of saliva were collected on the same day that individual samples were collected using a cotton rope hung on the front partition of the pen for 30 min until the rope was fully saturated with saliva. Saliva was removed by centrifugation and frozen for subsequent analysis of cortisol concentration by ELISA assay. Sensitivity of the assay was 0.04 ng/mL. The intra-assay CV was less than 10%. For individual focal sows, salivary cortisol concentrations were lower before mixing when sows were housed individually compared with 2 d after mixing and d 109 of gestation when sows were housed in groups (0.65 vs. 3.03 and 3.44 ng/mL, SE = 0.258; $P < 0.001$), suggesting that stress was induced by mixing and by physiological changes with the progress of pregnancy. Group cortisol concentrations were similar (group, 3.04 vs. individual, 3.44 ng/mL, SE = 0.536; $P = 0.88$) to individual concentrations on d 109 of gestation but tended to be lower (1.78 vs. 3.03 ng/mL, SE = 0.529; $P < 0.10$) 2 d after mixing than individual concentrations. No interactions of group and gestation period were detected ($P = 0.29$). Pearson correlation was moderate for d 109 ($r = 0.732$, $P < 0.001$) but not significant at d 2 after mixing between group and individual cortisol concentration. These results suggest that salivary

cortisol concentrations in group samples tend to be lower than in samples collected from individual sows, which may be due to lower stress to animals during sample collection for groups of sows. Cortisol concentrations in group saliva samples may be a good indicator of animal welfare at the group level.

**Key Words:** gestating sows, saliva cortisol, welfare
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**019 The use of prepartal standing behavior as a parameter for early detection of subclinical ketosis in postpartal dairy cows.** S. Rodriguez-Jimenez[1,*], K. J. Haerr[2], J. J. Loor[2], J. S. Osorio[3], F. C. Cardoso[2], *[1]South Dakota State University, Brookings, [2]University of Illinois, Urbana, [3]Dairy and Food Science Department, South Dakota State University, Brookings.*

Subclinical ketosis is a common disease that typically occurs during early lactation in dairy cows and consequently has a great economic impact on the dairy industry. Twenty-four multiparous Holstein cows were enrolled at 30 d prior to calving and received a common prepartal (1.5 Mcal/kg DM, 15% CP) and postpartal (1.76 Mcal/kg DM, 18% CP) diet. From −30 d until 15 d postpartum, Hobo Pedant G data loggers (Pocasset, MA) were used to record 3-dimensional acceleration at 60-s intervals. The acceleration data were used to analyze cow behavior, such as standing and lying time, bouts (n/24 h), and bout duration. Blood samples were taken from the coccygeal vein or artery at 1, 3, 5, 7, 9, 11, 13, and 15 d postpartum and used to measure the blood concentration of ketones (BHB) with the handheld Precision Xtra. A retrospective analysis of BHB data allowed the classification of cows as subclinically ketotic (KET; $n = 13$; ketones > 1.4 mmol/L) or non-ketotic (NONKET; $n = 11$; ketones < 1.4 mmol/L) during early postpartum. The behavior and BHB data were analyzed using the MIXED procedure of SAS. The CORR procedure of SAS was used to analyze correlations between behavior data and BHB. The REG procedure of SAS was used to build a model to predict postpartal BHB using prepartal data. Prepartal standing time was greater ($P = 0.02$) in NONKET cows than KET cows, whereas lying time was greater ($P = 0.02$) in KET cows. As expected, BHB were greater ($P < 0.01$) in KET cows than NONKET cows. Overall, BHB reached 1.2 mmol/L by 3 d postpartum and continued to increase over time. Therefore, correlation analysis was performed between behavior data from −30 d to 3 d relative to parturition and BHB at 3 d postpartum. The greatest significant correlation between BHB and behavior data was observed with standing time at 6 d prepartum ($P < 0.01$; $r = -0.84$). The latter meant that cows that were the least susceptible to postpartal subclinical ketosis remained standing for a longer time in the prepartum period. A model containing standing time, BW, BCS, and DMI at 6 d prepartum accounted for most of the variation ($P < 0.01$; $R^2 = 0.90$) in the BHB data at 3 d postpartum. These preliminary data suggest that behavioral data such as standing and lying time can be a powerful tool to build prediction models for early detection of postpartal subclinical ketosis.

**Key Words:** behavior, ketosis, transition cow
doi: 10.2527/asasmw.2017.019

## BILLY DAY SYMPOSIUM:

## BATCH FARROWING: REASONS, LIMITATIONS, AND REPRODUCTIVE MANAGEMENT

**020 Batch farrowing as a health strategy in modern pork production systems.** D. A. Baumert*, *JBS Live Pork Production, Marshall, MO.*

Batch farrowing, the strategy of breeding, farrowing, and subsequently weaning large groups of sows (generally 28 d of production) rather than weekly or continuous farrowing systems is a re-emerging technology in modern pork production systems. Rather than being driven by climatic/environmental conditions as were the batch farrowing programs of the 1960s, modern batch farrowing programs are being driven by the need for large batches of uniform-aged weaned pigs to efficiently fill large nursery and/or wean-to-finish sites. A significant ancillary driver of batch farrowing in modern pork production systems is the opportunity to utilize batch farrowing's pig flow schedule as a strategy to positively impact the overall health of the sow herd and the wean pig flow. A typical, modern batch farrowing schedule will be presented and briefly discussed. After which, the positive effects of batch farrowing on the health of the primary sow herd, the health of suckling piglet population, and finally, the subsequent effects on the health of the weaned pig flow will be described.

**Key Words:** batch farrowing, pig flow, swine health
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**021 Gilt management using Matrix.** K. F. Greiner*, *Merck Animal Health, Carthage, IL.*

Matrix has been used to help manage groups of gilts on farm. Some of the advantages of synchronizing gilts include hitting gilt mating targets within a defined period and increasing lactation length in first parity sows. In the past few years, there has been renewed interest, even in large farms, in delivering larger batches of pigs to nursery or wean to finish facilities. With the continued evolution of swine diseases in breed to wean facilities, there seem to be some health advantages to switching from weekly batches to biweekly or monthly batches. In this presentation, I will talk about the use of Matrix in gilt programs and how to improve the synchronization of gilts to help hit batch mating targets. We will discuss different batch groups and the advantages and disadvantages of each in

a production system.

**Key Words:** batch farrowing, estrus synchronization, Matrix
doi: 10.2527/asasmw.2017.021

**022 Using controlled ovulation to keep sow groups together.** S. L. Terlouw[1,*], M. E. Johnston[2], *[1]JBS United Animal Health, Sheridan, IN, [2]JBS United, Inc., Sheridan, IN.*

Synchronization of ovulation to accomplish single fixed-time insemination (SFTAI) has leveraged management and superior genetics for more efficient food production from cattle and pigs. Recently, triptorelin acetate, a GnRH-agonist in a gel formulation (OvuGel®) for intravaginal delivery, has been implemented in the swine industry for the purpose of SFTAI in weaned sows. In an OvuGel® Breeding Program, OvuGel® is given to all sows at 96 h after weaning regardless of estrus status, and all OvuGel® sows are inseminated 22 ± 2 h later. OvuGel® triggers ovulation and thus synchronizes the wean-to-ovulation interval (WOI) in a group of sows responding normally to weaning. Synchronization of the WOI provides a known and precise window of ovulation relative to weaning for insemination at an optimal fixed time. Together, control of the WOI and synchronization of ovulation in a group of weaned sows facilitate successful SFTAI in sows. Results show normal fertility for sows in estrus on Day 5 post-weaning. Additionally, sows not in estrus on Day 5 post-weaning have a 30% farrowing rate on average; these sows are difficult to get into a batch breed group but stay with the wean group of origin in an OvuGel® Breeding Program, resulting in more sows farrowing the next litter in 120 d. Control and synchronization of ovulation provide more precise knowledge of the time of ovulation and a more accurate knowledge of gestation length. Since OvuGel® controls and synchronizes the WOI, lactation length is longer than contemporary sows, allowing for an older and potentially heavier pig at weaning. Experimentally, triptorelin gel has been successfully used to control and synchronize ovulation in gilts following withdrawal of Matrix®. Therefore, the opportunity exists to provide full control of mating and farrowing of an entire batch group for more uniform and heavier pigs at weaning. Implementation of an OvuGel® breeding program in a daily, weekly, or monthly wean program will control and synchronize ovulation to facilitate SFTAI that results in decreased labor requirement, increased genetic leverage, and increased lactation length. Furthermore, an OvuGel® breeding program pulls into the desired breeding group sows that respond normally to weaning but have a silent estrus or are missed at estrus detection, which is a significant benefit to a batch program.

**Key Words:** batch farrowing, fixed-time insemination, OvuGel
doi: 10.2527/asasmw.2017.022

**023 Batch farrowing: labor, pig flow, and other things to consider.** R. Schmitt*, *Seaboard Foods, Guymon, OK.*

Batch farrowing can be an effective method of improving the health and increasing the growth and performance of commercial pigs by filling and emptying an entire nursery site at one time. The size of farms and scale of production in a large vertically integrated system provides constraints that make a batch farrowing system difficult to implement. Among the constraints are variations in breeding/farrowing performance, effective use of labor, and effective use of facilities. The health advantages of a batch farrowing system can be quickly overwhelmed by a decrease in breeding numbers, an increase in return sows, or a decrease in farrowing numbers. Any combination of these situations would entail a longer fill time in the nursery with pigs of a greater age range. In a batch farrowing system, the needs for labor are concentrated on the weeks where the sow farm crew is breeding, farrowing, or weaning. On a large sow farm, it would be a challenge to meet all the labor demands in the hours available during the "busy" weeks and then effectively employ a full farm crew during the "non -busy" weeks. There are a few situations where batch farrowing could be used in a vertically integrated system. One would be in a farrow to finish system, where variation in production and labor can be shifted from one phase to another, within the same site, without comprising pig flow or labor needs. Another situation would be in a system were four sow farms of similar size, location, and production would each farrow/wean 1 wk out the month to fill a nursery site. Any variation in production or allocation of labor needs can be shifted between the sow farms depending on pig flow needs, available space, and needed labor. While batch farrowing may be a viable means of improving pig performance, care must be taken to ensure that facilities and labor can be effectively utilized to implement the system.

**Key Words:** batch farrowing, constraints, large farms
doi: 10.2527/asasmw.2017.023

**024 The impact of batch farrowing systems on managing boar stud operations**. A. M. Minton*, R. L. Bowman, K. L. Van Dyke, *The Maschhoffs, Carlyle, IL.*

The primary value contribution of boar studs to the entire production system is the ability to deliver genetically superior, cost-effective doses of semen in a biosecure manner. To drive genetic progress, boar studs must operate inventories tightly and efficiently. The impact of how boar studs are managed in light of batch farrowing is largely related to the proportion of the mated inventory utilizing this production strategy. With batch farrowing systems, boar studs are forced to maintain a subset of the population that does not produce semen on a routine basis. Maintenance of these boars increases operating cost of production by $200 per boar when not in use. Operating

costs include items such as animal health, feed, labor, and royalties. During periods of seasonal infertility, boar studs tend to increase inventory because of amplified ejaculate discard rates. Couple this with additional inventory needed for batch farrowing and efficiencies decline further. Semen quality, including handling and temperature management, become even more crucial in batch farrowing systems. The ability of the stud to produce doses within an acceptable range of sperm per dose and identifying abnormalities during processing has an impact on sow fertility. How semen is handled and the fluctuation in temperature that the semen is subjected to during transport and at the sow farm influence shelf life and viability. The importance of semen quality is magnified given the increased proportion of sows in a batch wean group. On the other hand, fewer semen deliveries help mitigate disease risk at the sow farm. Also, depending on the batch strategy, if farms of equal size can develop a plan to rotate the batch, then no efficiency is lost at the boar stud. Prior to transitioning to batch farrowing, a commercial production system should evaluate whether the advantages to the sow farm (i.e., health, transport costs) offset the increased cost of production at the boar stud.

**Key Words:** batch farrowing, boar stud, semen production
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## BREEDING AND GENETICS SYMPOSIUM:

## GENOMICS OF REPRODUCTION

**025 Identification of variants causing early embryonic loss in beef cattle.**

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Reproductive efficiency is among the most important of the productive traits of cattle and yet has a relatively low heritability, likely because it is a complex trait with many physiological processes required to correctly function to deliver a normal healthy calf. Among the earliest expressed of the fertility component traits is embryonic loss for which a genetic basis has now been established in cattle with the discovery of chromosomal segments containing haplotypes that never occur in homozygous form. Invariably, these haplotypes are found to harbor mutations that disrupt genes that are essential for life. Since about 33% of mammalian genes are essential for life, there is considerable opportunity for deleterious mutations in these genes to be driven to moderate frequency in highly selected populations employing artificial insemination. To identify mutations likely to impact fertility via early embryonic loss, we analyzed the genome sequences of 262 taurines and multiple tissue transcriptomes from 153 taurines to identify variants. Among the identified variants, we focused on those that occurred within the open reading frames of genes and designed a new genotyping assay called the GGP-F250 that queried genotype at 227,233 genomic locations. A total of 18,271 animals from 22 breeds were genotyped with the assay, and a cluster file was developed to successfully call genotypes for 206,652 of the variants. Among these, 173,609 variants were variable and genotyped with a call rate of at least 90% in all 18,271 individuals. Among these were 82,979 variants predicted to change the amino acid structure of encoded proteins. To identify variants as candidates for early embryonic lethals, we first determined those for which no homozygotes were found for one of the homozygote classes. This identified 28,193 loci in Angus cattle; however, 92% of these had allele frequencies of $\leq 1\%$ indicating that the sample size was insufficient to detect homozygotes should they be viable. Of the 2,224 loci for which homozygotes were expected to have been observed, many clustered into regions of the genome harboring gene families, including olfactory receptors, the major histocompatibility complex, and the pregnancy associated glycoproteins, suggesting that the assay may be detecting segregating copy number variants rather than genic SNP. The next phase of the project is to identify loci within single copy genes that are predicted to be essential for life to identify candidates for early embryonic lethals in beef cattle.

**Key Words:** embryonic loss, heifer fertility, lethal variants
doi: 10.2527/asasmw.2017.025

**026 Genetic improvement of sow lifetime productivity.**

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Sow lifetime productivity is a complex trait that would benefit commercial populations if improved. Sows need to produce 3 litters to cover the cost of replacement; yet, nearly half of gilts retained for breeding are removed prior to producing 3 litters, resulting in an economic loss. Longevity and lifetime productivity are complex phenotypes with numerous contributing factors, resulting in low estimates of heritability. To facilitate selection for lifetime productivity, scientists have searched for genetic markers associated with improved performance as well as indicator traits that can be measured at an early age. Research has led to numerous marker associations of genetic variation in candidate genes with litter size as well as a discovery that gilts reaching puberty at an earlier age had a greater likelihood of producing 3 or more litters in a National Pork Board supported study. Commercial breeding companies

have greatly increased litter size with traditional BLUP selection and have adopted genomic selection methodology. To unlock the genetic factors contributing to lifetime productivity, a principal component analysis was conducted, which included a number of key phenotypes associated with productivity. Phenotypes on 1633 sows included lifetime number born, born alive and weaned, days in production, final parity, average litter birth weight, average litter weaning weight, age at puberty, Day 140 weight, and Day 140 backfat measurements. Analysis indicated strong correlations among lifetime number of piglets born (total, alive, and weaned) with final parity and days in the herd, moderate correlations among lifetime performance traits (pigs born and weaned) with average litter weights (birth and weaning), and virtually no correlation among lifetime performance and Day 140 measurements or age at puberty in these data. Lack of association between age at puberty and lifetime performance is likely due to population management, as all retained gilts reached puberty early. Genome-wide association analyses were performed using GENSEL for five principal components (PC1 to PC5) that describe the most variation. PC1 was the primary component affiliated with lifetime performance traits and accounted for 54% of the phenotypic variation. PC1 had a genomic heritability of 0.19 with marker associations residing on chromosomes 5, 12, 14, 15, and X. These results identified considerable genetic variation for sow lifetime performance, indicating selection should be very effective at improving this trait. Genomic selection would enable ranking potential replacement animals early in life and increase the accuracy of selection. USDA is an equal opportunity provider and employer.

**Key Words:** genetics, lifetime performance, pig
doi: 10.2527/asasmw.2017.026

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**027 The roles of age at puberty and energy restriction |in sow reproductive longevity: a genomic perspective.**

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Approximately 50% of sows are culled annually with more than one-third due to poor fertility. Our research demonstrated that age at puberty is an early pre-breeding indicator of reproductive longevity. Age at puberty can be measured early in life, has a moderate heritability, and is negatively correlated with lifetime number of parities. Detection of age at puberty is tedious and time consuming and is therefore not collected by the industry, which limits genetic progress. Genomic prediction is a viable approach to preselect gilts that will express puberty early and have superior reproductive longevity. The hypothesis that genetic variants explaining differences in age at puberty also explain differences in sow reproductive longevity was tested. Phenotypes, genotypes, and tissues from the UNL resource population ($n > 1700$) were used in genome-wide association analyses, genome, and RNA sequencing to uncover functional polymorphisms that could explain variation in puberty and reproductive longevity. A BeadArray including 56,424 SNP explained 25.2% of the phenotypic variation in age at puberty in a training set ($n = 820$). Evaluation of major windows and SNPs of subsequent batches of similar genetics ($n = 412$) showed that if all SNPs located in the major 1-Mb windows were tested, they explained a substantial amount of phenotypic variation (12.3 to 36.8%). Due to differences in linkage disequilibrium status, the most informative SNP from these windows explained a lower proportion of the variation (6.5 to 23.7%). To improve genomic predictive ability, the limited capability of BeadArray was enhanced by potential functional variants uncovered by genome sequencing of selected sires ($n = 20$; >20X). There were 11.2 mil. SNPs and 2.9 mil. indels discovered across sires and reference genomes. The role of gene expression differences in explaining phenotypic variation in age at puberty was investigated by RNA sequencing of the hypothalamic arcuate nucleus (ARC) in gilts ($n = 37$) with different pubertal statuses. Seventy genes, including genes involved in reproductive processes, were differentially expressed between gilts with early and late puberty status ($P_{adj} < 0.1$). Dietary restriction of energy 3 mo before breeding delayed puberty by 7 d but improved the potential of a sow producing up to three parities ($P < 0.05$). Energy restriction was associated with differential expression in 42 genes in the ARC, including genes involved in energy metabolism. This integrated genomic information will be evaluated in commercial populations to improve the reproductive potential of sows through genomic selection. This project is supported by AFRI Competitive grant no. 2013-68004-20370 from the USDA-NIFA. USDA is an equal opportunity provider and employer.

**Key Words:** genomic selection, age at puberty, sow reproductive longevity
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**028 Identification of gene and gene sets enriched for heifer conception rate in US Holstein heifers.**

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Heifer conception rates remain low in the dairy industry. The objective of this study was to identify genes and the biological pathways associated with heifer conception in Holstein dairy heifers. Breeding and health records were analyzed from a

commercial dairy heifer raising facility in Southern Idaho. All heifers were bred by artificial insemination (AI) at observed estrus, and pregnancy was determined at Day 35 after AI via palpation. A total of 497 heifers were classified as highly fertile (HF; conceived on their first AI service), and 429 heifers did not conceive until after their fourth AI service or were culled due to failure to conceive and were classified subfertile (SF). Genotyping of heifers was conducted using the Illumina BovineHD BeadChip. Quality control consisted of removing animals with <90% of genotypes and removing markers with less than a 90% call rate, a minor allele frequency of <1%, or if they failed Hardy-Weinberg Equilibrium testing. Based on those criteria, 466 HF and 368 SF heifers and 590,904 SNPs remained for the analysis. A genome-wide associated analysis (GWAA) was conducted using an additive model of the efficient mixed-model association expedited (EMMAX) statistical test with a genomic relationship matrix. The GWAA identified 147 QTLs ($P < 5.5 \times 10^{-5}$) that were moderately associated and 26 QTLs ($P < 5.5 \times 10^{-7}$) that were strongly associated with heifer fertility. The most significant SNP within 8 kb of each of 19,723 genes was used in a gene-set enrichment SNP analysis (GSEA-SNP) with the GenGen software package and gene sets from Gene Ontology ($n = 3147$), Kyoto Encyclopedia of Genes and Genomes ($n = 186$), Reactome ($n = 674$), Biocarta ($n = 217$), and Panther ($n = 165$). The significance for each gene set was calculated using the null distribution generated from 10,000 phenotype-based permutations using GenABEL. The GSEA-SNP identified seven gene sets associated (normalized enrichment score > 3.0) with heifer conception rate and 195 leading edge genes. These results provide insight into the interaction and mechanism of genes important in heifer conception rate. This project was supported by Agriculture and Food Research Initiative Competitive Grant no. 2013-68004-20365 from the USDA National Institute of Food and Agriculture.

**Key Words:** genomic selection, age at puberty, sow reproductive longevity
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## BREEDING AND GENETICS

### 029 Effects of genetics on growth and feed intake in response to repeated exposure to heat stress.

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Heat stress (HS) accounts for over $900 million loss in the U.S. swine industry annually due to poor reproduction, slow growth, and reduced feed efficiency. Selection for improved lean tissue growth may increase susceptibility to HS. Study objectives were to investigate the effects of genetics on growth and feed intake in response to repeated exposure to HS. A total of 97 animals from three genetic lines (commercial, low residual feed intake (RFI), high RFI) where subjected three separate times to a 4-d HS load, preceded by a 9-d thermal neutral (TN) adaptation period and alternated by 7-d TN conditions: 1-TN adaptation, 2-HS, 3-TN, 4-HS, 5-TN, 6-HS, and 7-TN. Body weight was recorded at the start and end of each period, and ad libitum feed intake was recorded daily. Average daily body weight gain (BWG) and daily feed intake (FI) were calculated for each period. Feed efficiency was estimated as BWG/FI. HS negatively affected BWG, FI, and BWG/FI in all three lines (Table 029; $P < 0.05$). Commercial pigs grew faster than both low and high RFI pigs ($P < 0.0001$) but only in TN periods 1, 3, 5, and 7 ($P < 0.0001$). Pigs of the commercial line ate more than pigs of both the low and the high RFI lines ($P < 0.0001$); pigs of the high RFI line ate more than pigs of the low RFI line ($P < 0.05$). BWG/FI decreased from 0.32 to 0.03 in the commercial line, from 0.21 to 0.06 in the low RFI line, and from 0.19 to 0.07 in the high RFI line between periods 5-TN and 6-HS ($P < 0.0001$). Commercial pigs ate more and grew faster than the low and high RFI lines but also appeared to be more susceptible to HS.

**Key Words:** heat stress, pigs, production traits
doi: 10.2527/asasmw.2017.029

**Table 029.** Least square means ± s.e. for FI, BWG, and BWG/FI for pigs from a commercial, low RFI, and high RFI line during heat stress (HS) and thermoneutral (TN) conditions.

| | FI (kg/d) | | BWG (kg/d) | | BWG/FI | |
|---|---|---|---|---|---|---|
| | TN | HS | TN | HS | TN | HS |
| Commercial | 3.15 ±0.04 | 2.61 ±0.04 | 1.09 ±0.04 | 0.51 ±0.05 | 0.35 ±0.02 | 0.20 ±0.02 |
| Low RFI | 2.5 ±0.04 | 2.04 ±0.04 | 0.73 ±0.03 | 0.43 ±0.04 | 0.28 ±0.02 | 0.23 ±0.02 |
| High RFI | 2.71 ±0.04 | 2.22 ±0.04 | 0.69 ±0.04 | 0.51 ±0.05 | 0.25 ±0.02 | 0.25 ±0.02 |

**030 Effect of swine sire line and selection index category on wean-to-finish growth performance and carcass characteristics.** N. M. Stas[1,*], M. Ellis[1], N. S. Grohmann[1], C. R. Schwab[2], C. M. Shull[2], K. Ewing[2], *[1]University of Illinois, Urbana-Champaign, [2]The Maschhoffs, LLC, Carlyle, IL.*

The objective of this study was to compare 3 sire lines and the effect of selection index category within line on growth (6.1 ± 0.29 to 129.8 ± 2.16 kg BW) and carcass characteristics of commercial pigs. A randomized complete block design (blocking factor being day of start on test) was used with a 3 × 2 factorial arrangement of treatments: 1) sire line [L; Green (GL) vs. Blue (BL) vs. Yellow (YL)] and 2) selection index category [IC; High (HIC) vs. Low (LIC)]. The lines were representative of ones widely used in the industry. The HIC and LIC sires were from the top 25% and at the mean line-specific index value, respectively. Ten sires from each IC from each line were mated to 15 crossbred dams; dam lines were equally represented across sires. Progeny ($n$ = 2880) were housed in mixed-sex groups (barrows and gilts) of 32 pigs (15 replicates) at a floor space of 0.66 $m^2$ per pig. Pigs had ad libitum access to feed and water throughout the study. Pen was the experimental unit, and data were analyzed using PROC MIXED of SAS; the model accounted for L, IC, 2-way interaction, block, and replicate. There were L × IC ($P < 0.05$) for most measurements. For ADG, there was no difference ($P > 0.05$) between HIC and LIC for the GL (0.76 vs. 0.77 kg, respectively) or the YL (0.76 vs. 0.76 kg, respectively); however, ADG was greater ($P < 0.05$) for HIC than LIC for BL (0.83 vs. 0.80 kg, respectively). For G:F, there was no difference ($P > 0.05$) between HIC and LIC for the GL (0.402 vs. 0.410 kg:kg, respectively) or for the BL (0.425 vs. 0.429 kg:kg, respectively); however, G:F was greater ($P < 0.05$) for HIC than LIC for YL (0.432 vs. 0.419 kg:kg, respectively). For carcass lean, there was no difference ($P > 0.05$) for HIC and LIC for the GL (53.34 vs. 53.51%, respectively) or for the BL (53.44 vs. 53.30%, respectively); however, carcass lean was greater ($P < 0.05$) for HIC than LIC for YL (54.71 vs. 54.18%, respectively). These results show important differences in growth performance and carcass measurements between commercial sire lines and that the relative differences between sires with high and low selection index differs between sire lines, which probably reflects differences in the weighting given to traits in each line-specific index.

**Key Words:** pigs, selection index category, sire line
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**031 Selection for age at puberty in swine: correlated response in sow productivity.** G. M. See*, M. T. Knauer, *North Carolina State University, Raleigh.*

The objective was to examine correlated sow productivity characteristics from genetic lines (GL) divergently selected for age at puberty (AGEPUB). Selection on composite Landrace × Large White females resulted in two genetic selection lines, young AGEPUB (AP) and old AGEPUB (OLD). Data consisted of sows ($n$ = 332) from four generations (GEN) raised at the North Carolina Department of Agriculture Tidewater Research Station. Females were reared in a curtain-sided building with fully slatted floors and natural ventilation. Gilts were placed in pens of 15 (0.84 $m^2$ per pig). At 130 d of age, gilts were exposed to mature boars for 7 min/d for 90 d. Puberty was defined as the first observed standing reflex in the presence of a boar. Traits included total number born (TNB), litter birth weight (LBW), average piglet birth weight (BWT), BWT CV, litter weaning weight (LWW), average piglet weaning weight (WWT), WWT CV, and litter size at weaning (LSW). Statistical analysis was performed in SAS using PROC GLM. Fixed effects included GL, GEN, and GL × GEN. Covariates of TNB and LSW were included for BWT and BWT CV and WWT and WWT CV, respectively. In GEN 4, AP and OLD gilts obtained puberty at 162 and 177 d of age, respectively, and 85 and 50%, respectively, exhibited puberty. Total number born tended ($P = 0.07$) to be greater for OLD when compared to AP (11.73 vs. 11.03), and LSW tended ($P = 0.06$) to be greater for OLD when compared to AP (9.68 vs. 8.96). Both AP and OLD had similar ($P > 0.05$) LBW (12.20 vs. 12.27 kg, respectively) and LWW (50.7 vs. 52.6 kg, respectively). Overall, AP had greater ($P < 0.05$) BWT than OLD (1.12 vs. 1.07 kg). Yet in GEN 1, BWT did not differ ($P > 0.05$) between AP and OLD (1.17 vs. 1.16 kg, respectively), but in GEN 4 AP had greater ($P < 0.01$) BWT than OLD (1.09 vs. 1.00 kg). Similar to BWT, AP had greater ($P < 0.05$) overall WWT than OLD (5.72 vs. 5.47 kg). Yet in GEN 1, WWT did not differ ($P > 0.05$) between AP and OLD (5.75 vs. 5.66 kg, respectively), but in GEN 4 AP had greater ($P < 0.05$) WWT than OLD (5.53 vs. 5.19 kg). Birth weight CV was greater ($P < 0.01$) for AP when compared to OLD (17.7 vs. 15.8%), yet WWT CV was lower ($P = 0.05$) for AP when compared to OLD (14.0 vs. 15.5%). Results suggest selection for AP may enhance piglet quality yet impair litter size.

**Key Words:** genetic, puberty, swine
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**032 Genomic prediction accuracies using regularized quantile regression (RQR) methodology.** L. M. Barroso[1,2], F. Morgante[3], T. F. Mackay[3], A. C. C. Nascimento[1,2], M. Nascimento[1,2], N. V. Serão[1,*], *[1]North Carolina State University, Raleigh, [2]Universidade Federal de Viçosa, Viçosa, Brazil, [3]Department of Biological Sciences, North Carolina State University, Raleigh.*

The objective of this work was to evaluate the use of regularized quantile regression (RQR) for genomic prediction analyses in traits with or without skewness and with different proportions of epistatic variance. Data were simulated for 2500

**Table 032.** Accuracies of genomic prediction.

| Trait distribution | Methodology | Percentage of epistatic / additive genetic variance | | |
|---|---|---|---|---|
| | | 100% / 0% | 50% / 50% | 0% / 100% |
| Symmetric normal | Blasso | 0.15 | 0.17 | 0.19 |
| | $RQR_{0.15}$ | 0.10 | 0.16 | 0.13 |
| | $RQR_{0.50}$ | 0.14 | 0.13 | 0.20 |
| | $RQR_{0.85}$ | 0.11 | 0.16 | 0.16 |
| Positive skewness | BLASSO | 0.09 | 0.17 | 0.18 |
| | $RQR_{0.15}$ | 0.16 | 0.26 | 0.27 |
| | $RQR_{0.50}$ | 0.12 | 0.18 | 0.21 |
| | $RQR_{0.85}$ | 0.05 | 0.12 | 0.12 |

individuals. The genome included 5K markers and 50 QTL for a lowly heritable trait (heritability = 0.1) simulated for six scenarios: combinations of trait distributions (symmetric normal or positive skewed) and percentage of epistatic and additive genetic variances (100% epistatic, 50% epistatic and 50% additive, 100% additive). Only additive-by-additive effects were simulated for epistasis. Three replicates were generated per scenario. Estimation of marker effects was performed using 2000 individuals (training). The remaining 500 individuals were used for validation. Accuracy was calculated as the correlation between genomic estimated breeding values and true breeding values. Analyses were performed using Bayesian LASSO (BLASSO) and RQR considering three quantiles (0.15 [$RQR_{0.15}$], 0.50[$RQR_{0.50}$], 0.85[$RQR_{0.85}$]) in R. Results are shown in Table 032. Overall, accuracies of genomic prediction for the normal symmetric trait were variable. There was no relationship between RQR quantiles and accuracies of genomic prediction. In general, accuracies of genomic prediction decreased as the proportion of epistatic variance increased. The highest accuracies of genomic prediction were 0.15 (BLASSO), 0.17 (BLASSO), and 0.20 ($RQR_{0.15}$) for the proportions of epistatic variance of 100%, 50%, and 0%, respectively. For the positively skewed trait, the greatest accuracies were obtained for $RQR_{0.15}$, with 0.16, 0.26, and 0.27, followed by $RQR_{0.50}$, with 0.12, 0.18, and 0.21 for the proportions of epistatic variance of 100%, 50%, and 0%, respectively. Accuracies for $RQR_{0.15}$ were 77%, 53%, and 50% greater than those obtained using BLASSO. For RQR, accuracies decreased as quantiles increased. Within each method, accuracies were similar for proportions of epistatic variances of 50% and 0%. In conclusion, for the symmetric normal trait, BLASSO had, overall, slightly greater accuracies than for RQR. In contrast, RQR presented greater accuracies of genomic prediction compared to BLASSO when quantiles 0.15 and 0.50 were used for the trait with positive skewness. These results suggest that improved accuracy of genomic prediction for skewed traits can be obtained using RQR.

**Key Words:** accuracy, epistasis, skewness
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## 033 Estimation of genetic parameters, genetic trends, and growth curve parameters of pigs selected for residual feed intake using quantile regression.

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The objective of this study was to estimate genetic parameters and genetic trends in pigs selected for low residual feed intake (RFI) and classified into different growth curve groups based on quantile regression (QR) methodology. We used data on 750 Yorkshire pigs selected for low RFI for 5 generations, including data on average daily gain (ADG), average daily feed intake (ADFI), and Gompertz growth curve parameters (asymptotic weight [a], inflection point [b], and decay parameter [c]). We estimated QR growth curves for the whole population for three quantiles (0.1, 0.5, and 0.9) of the body weight (BW) data. Each animal was classified into one of the quantile regression groups (QRG) based on their Euclidian distance between each observed and estimated BW from the quantile growth curves. Genetic parameters were estimated for these traits and QRG. In addition, genetic trends for each QRG were observed. Three distinct growth curves were observed for animals classified into $QRG_{0.1}$, $QRG_{0.5}$, or $QRG_{0.9}$. Animals in $QRG_{0.1}$ had a greater ($P < 0.05$) estimate for parameter a (266.5 ± 11.5 kg) than animals in $QRG_{0.5}$ (250.8 ± 9.9 kg) and $QRG_{0.9}$ (243.6 ± 11.0 kg). In addition, $QRG_{0.1}$ animals had greater ($P < 0.05$) estimates for b (187.9 ± 4.5 d) and c (144.7 ± 4.3 d) than animals in $QRG_{0.5}$, which had greater ($P < 0.05$) estimates for b (163.2 ± 3.6 d) and c (111.0 ± 3.3 d) than animals in $QRG_{0.9}$ (144.7 ± 4.3 d and 98.3 ± 3.8 d, respectively). For all other traits, animals classified into $QRG_{0.1}$ had the lowest ($P < 0.05$) ADFI (1.86 ± 0.03 kg) and ADG (0.66 ± 0.01 kg), whereas those classified into $QRG_{0.9}$ had the highest ADFI (2.23 ± 0.03 kg) and ADG (0.85 ± 0.01 kg). Estimates of heritability for growth curve parameters were low, with 0.13 ± 0.07, 0.07 ± 0.06, and 0.09 ± 0.06 for parameters a, b, and c, respectively. For all other traits, estimates were moderate to high, with 0.50 ± 0.09, 0.41 ± 0.08, and 0.33 ± 0.09 for ADFI, ADG, and RFI, respectively. QRG analyzed as a trait had moderate-high heritability (0.41), and it was genetically similar to ADG, with a genetic correlation of 0.8 ± 0.08. The genetic correlation between QRG and RFI was moderate (0.46 ± 0.11). Downward genetic trends of each QRG were observed for all traits as a function of selection for reduced RFI, with the exception of ADG. For ADG, $QRG_{0.1}$ was the only group that had a positive genetic trend. Altogether, these results indicate that quantile regression methodology was able to identify animals with different genetic potential for feed efficiency, bringing a new

opportunity to improve selection for reduced RFI.

**Key Words:** genetic parameters, nonlinear models, quantile regression

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**034 Biological evidence for genomic regions associated with host response to co-infection with PRRS virus and PCV2b in commercial nursery pigs.**

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Previously, a major quantitative trait locus (QTL) for host response to porcine reproductive and respiratory syndrome (PRRS) was identified on chromosome (SSC) 4. The WUR10000125 (WUR) single nucleotide polymorphism (SNP) is used as a tag SNP for this QTL. The objectives of this study were to identify genomic regions (other than WUR) associated with average daily gain (ADG) and viral load (VL) following co-infection with PRRS virus (PRRSV) and porcine circovirus type 2b (PCV2b) and to assess the biological relevance of these regions. Data originated from two trials of 200 pigs each. Pigs from the same genetic source were pre-selected (half AA/half AB) for WUR SNP genotype since the "B" allele is completely dominant. At weaning, pigs were sorted into one of two rooms, and pigs in one room received a modified live PRRSV vaccine 28 d prior (Pre Co-X) to co-infecting all pigs with PRRSV and PCV2b (Post Co-X). PRRS and PCV2b VL were quantified using serum viremia data from 0 to 21 and 0 to 42 d post-infection, respectively. Bivariate SNP genome-wide association studies (GWAS) were conducted fitting animal models in ASReml4, where ADG, PRRS VL, and PCV2b VL of vaccinated (Vx) and non-vaccinated (Non-Vx) pigs were analyzed as separate traits. For each GWAS, SNPs with $\log_{10}$ *P*-values greater than 2, 2.5, or 3 were used to assess statistical overrepresentation of neighboring genes associated with protein pathways using PANTHER software and overrepresentation of health (production) QTL for VL (ADG) using a binomial test. Regions near the major histocompatibility complex were associated with PCV2b VL and ADG Post Co-X of Vx and Non-Vx pigs ($P < 0.0001$). For Vx pigs, additional regions on SSC11 and 12 and SSC1 and 7 were associated with ADG Pre and Post Co-X, respectively ($P < 0.00001$). Regions on SSC15 were associated with ADG of Non-Vx pigs Pre and Post Co-X ($P < 0.00001$). Genes near SNPs associated with ADG of Vx pigs Pre Co-X were overrepresented for cell signaling and for chromatin organization/assembly for PCV2b VL of Vx pigs and ADG of Non-Vx pigs Pre and Post Co-X. For ADG of Vx pigs Post Co-X, production QTL and genes near neighboring SNPs were overrepresented for metabolic processes and macrophage activation. Taken together, these results provide biological evidence that support statistical associations identified from GWAS, which present opportunities to select for improved host response to PRRSV and PCV2b co-infection. Research was supported by USDA-NIFA grants 2012-38420-19286 and 2013-68004-20362.

**Key Words:** disease, GWAS, swine

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**035 Reaction norm for reproductive performance during porcine reproductive and respiratory syndrome (PRRS) and porcine epidemic diarrhea (PED) outbreaks.**

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PRRS and PED are two diseases with the largest economic impact in the swine industry. However, information regarding the relationship between host genetics and levels of disease impact has not been studied. The purpose of this study was to estimate reaction norms to evaluate the host genetic response in reproductive sows naturally infected with PRRS or PED. Performance data and a five-generation pedigree were available from 10 commercial farms in North Carolina. A total of 21,060 farrow events from 5448 crossbred (Large White x Landrace) multiparous sows were used for analyses. Traits included number of piglets born alive (NBA), stillborn piglets (SB), mummified piglets (MUM), born dead (NBD), and weaned (NW). Originally, PED and PRRS outbreaks were identified based on observations at the farms and confirmed by serological results. However, the dates of the PED and PRRS outbreak phases on each farm were determined based on data using herd-year-week (HYW) estimates of the reproductive performance. A total of 8 and 15 outbreaks were identified for PRRS and PED, respectively. First-order reaction norm analyses included the fixed effects of HYW (covariate), season, disease phase, parity, year, and farm with the random additive effect of intercept and slope (HYW). Separate analyses were performed for each disease: clean and PRRS phases and clean and PED phases. The clean phase was defined as a time when reproductive performance returned to normal levels of production based on the HYW estimates. Traits with a large number of zeros (SB, MUM, and NBD) were analyzed as the natural log of the phenotype + 1. Analyses were done in ASReml4. For PRRS, heritability estimates for plasticity (slope) were 0.24 ± 0.04 (NBA), 0.20 ± 0.03 (SB), 0.40 ± 0.02 (MUM), 0.10 ± 0.02 (NBD), and 0.83 ± 0.01 (NW). For PED, these were 0.25 ± 0.04, 0.19 ± 0.02, 0.27 ± 0.02, 0.21 ± 0.03, and 0.81 ± 0.01, respectively. The heritability of the intercept ranged from 0.05 ± 0.01 (NW) to 0.16 ± 0.01 (NBA) for PRRS. For PED, heritability of the intercept ranged from 0.03

± 0.01 (NW) to 0.15 ± 0.01 (NBA). For PRRS, genetic correlations between the intercept and slope were −0.45 ± 0.07 (NBA), 0.59 ± 0.07 (SB), 0.80 ± 0.05 (MUM), 0.96 ± 0.09 (NBD), and −0.84 ± 0.02 (NW). For PED, these were −0.48 ± 0.08, 0.63 ± 0.07, 0.85 ± 0.05, 0.52 ± 0.08, and −0.82 ± 0.03, respectively. These results show a clear genotype-by-environmental interaction for both diseases. The only trait with considerable re-ranking of animals was NBA for both diseases. In addition, the response to PRRS and PED was similar, which is advantageous for selection for improved performance in both disease environments simultaneously.

**Key Words:** disease genetics, genotype-by-environment, random regression
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**036 A natural challenge model for disease resilience in wean-to-finish pigs.** A. M. Putz[1,*], J. C. S. Harding[2], F. Fortin[3], G. Plastow[4], J. C. M. Dekkers[5], *[1]Iowa State University, Ames, [2]University of Saskatchewan, Saskatoon, SK, Canada, [3]Centre de développement du porc du Québec, Québec, QC, Canada, [4]University of Alberta, Edmonton, AB, Canada, [5]Department of Animal Science, Iowa State University, Ames.*

Selecting for tolerance or resistance to specific diseases may be detrimental for the ability of the animal to respond to other major pathogens. In commercial herds, disease often reflects the outcome of infection with multiple pathogens at different stages of development. Thus, the objective is to determine the genetic basis of resilience to multiple common diseases, which is defined as the ability to respond to infection to minimize the impact of disease. To investigate the genetic basis and develop early predictors of resilience, a natural challenge model has been established at the wean-to-finish research facilities at the Centre de Développement du Porc du Québec. In this project, batches of 60 to 76 $F_1$ (Yorkshire x Landrace) barrows from healthy multiplier herds representing 7 PigGen Canada (www.piggencanada.org) members are entered into a clean nursery for 3 wk (at 17 to 29 d of age), where samples and phenotypes under healthy conditions are collected and then moved into a continuous flow grow-finish facility at ~60 d of age (52 to 72 d) that was seeded using pigs from commercial farms with targeted diseases to simulate a commercial health environment. Alternating medicated and non-medicated feed is used to moderate the disease challenge within set limits. These results include the first 441 of ~3,300 pigs that will be evaluated over 3 yr. Each pig was weighed every 3 wk, and mortality and treatment records were recorded throughout. In the finisher, individual feed and water intake were recorded. In total, 35% of pigs died or were humanely euthanized. Basic mixed models were fit with litter as a random effect as an indicator of the heritability due to the lack of pedigree and genotypes currently. Models for average daily gain (ADG) in the nursery and in the finishing unit included fixed effects of batch, entry age (nursery only), days on test (finishing only), batch*pen, and mortality (1/0) with litter as a random effect. Litter explained 25.9% of the phenotypic variation for nursery ADG and 20.5% for finishing ADG. ADG in the nursery and finishing unit showed a phenotype correlation of 0.19. Future analyses will focus on developing early predictors of resilience and include dense SNP genotype data for genome-wide association studies and genomic prediction to dissect and utilize the genetic basis of disease resilience. Funding from Genome Alberta (ALGP2), Genome Canada, and PigGen Canada.

**Key Words:** commercial health, disease resilience, swine diseases
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**037 A survey of single nucleotide polymorphisms identified from whole-genome sequencing and their functional effect in the porcine genome.** B. N. Keel*, D. J. Nonneman, G. A. Rohrer, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

One of the key aims of livestock genetics and genomics research is to discover the genetic variants underlying economically important traits, such as reproductive performance, feed efficiency, disease susceptibility, and product quality. Next-generation sequencing has recently emerged as an economically feasible tool for assessing genomic variation among populations. Sequence variants, in contrast to currently used commercial SNP panels, are expected to allow direct estimation of the effects of causal mutations on a given trait, which could significantly boost the reliability of genomic predictions. Utilization of genome annotations may help in identifying SNPs that are more likely to affect the phenotype. Loss-of-function variants and others that disrupt or alter proteins coded by a gene, as well as variants that regulate protein production, likely have a greater effect on phenotype than other types of variation. Hence, narrowing our focus to these high-impact variants may allow us to explain a significant amount of phenotypic variation, while reducing the number of SNPs that need to be analyzed. The objectives of this study were to identify SNPs from DNA sequence of 72 founders (12 Landrace boars, 12 Duroc boars, and 48 Yorkshire-Landrace composite sows) of a heavily phenotyped experimental swine herd at the U.S. Meat Animal Research Center and to predict the effects of these variants on gene function. Approximately 14 billion reads were generated by short-read sequencing on the Illumina HiSeq and NextSeq platforms. Sequence reads covered each pig's genome at a mean of 6.1-fold (x) coverage. Individual coverage per animal ranged from 1.15x to 21.11x. We identified a total of 22,342,915 SNPs from the 72 sequenced genomes, of which 38% were listed in the National Center for Biotechnology Information genetic variation database (dbSNP), and a total of 49,105 overlapped with the 62,163 SNPs assayed by the PorcineSNP60 BeadChip. Variation was detected in coding sequence or untranslated regions

(UTRs) of 18,753 of the 25,322 protein-coding genes annotated in the swine genome. A total of 162,000 SNPs were classified as high impact, which suggests that over 99% of the variation detected in our pigs could potentially be ignored, allowing us to focus on a much smaller number of SNPs during future analyses. Future work, including additional sequencing to impute sequence variants through our population and developing assays to directly genotype sequence variants, will aim to discover the extent to which these high-impact variants affect economically important traits.

**Key Words:** loss-of-function, single nucleotide polymorphism, whole-genome sequence
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**038 Assessment of methods for accurate reproductive tract scoring by vulva width as a tool for gilt selection.** M. R. Romoser[1,*], B. J. Hale[1], J. T. Seibert[1], K. L. Bidne[1], M. J. Dickson[1], T. J. Gall[2], L. H. Baumgard[1], A. F. Keating[1], J. W. Ross[1], *[1]Iowa State University, Ames, [2]TriOak Foods, Oakville, IA.*

Improving sow lifetime productivity (SLP) is essential for maximizing sow farm profitability; however, SLP is a complex trait heavily influenced by a variety of postpubertal and prepubertal environmental factors. One of the best predictors of SLP for replacement gilts is age at puberty. Our group has shown a higher percentage of gilts who possess an average or above vulva size at 95 to 115 d of age achieve puberty by 180 d of age compared to counterparts with a below average vulva size. The objective of this study was to determine the accuracy of different vulva scoring methods on a commercial farm. To accomplish this, prepubertal replacement gilts ($n$ = 1198) in a commercial system were selected at 15 wk of age. Body weight for each gilt was recorded, and four different vulva scoring methods were used to classify gilts based on vulva width (VW). Methods included a digital caliper measurement of VW, evaluation and scoring by trained farm personnel (small, medium, and large), and two methods using scoring tools (A and B) specifically calibrated based on the distribution of gilt VW in previous studies. Tool A was designed to assign gilts one of three VW scores (small, medium, and large). Tool B was designed to discriminate gilts into five groups corresponding with a numerical score (1 to 5, with 1 being the smallest and 5 being largest). At 15 wk of age, a low proportion of variability in vulva size (27.58 + 0.12 mm) could be explained by body weight (61.6 + 0.02 kg) ($R^2$ = 0.06). Importantly, correlation between the measurement with digital calipers was strong for the farm personnel score ($R^2$ = 0.50), tool A score ($R^2$ = 0.64), and tool B score ($R^2$ = 0.82), demonstrating each method's effectiveness in accurately discerning gilts into groups based on vulva size. The trained farm personnel score assigned 21.8, 71.2, and 7.0% of the gilts as small, medium, and large, respectively. Scoring tool A assigned 23.5, 70.3, and 6.2% of the gilts to the small, medium, and large categories, while scoring tool B assigned 22.7, 25.5, 34.3, 12.3, and 5.2% of the gilts to numerical categories 1 to 5, respectively. Assessment of gilt reproductive performance in the sow herd is underway and will enable the retrospective analysis of the utility of each scoring method as a predictor of SLP. This project was supported in part by the Iowa Pork Producers Association and Tri-Oak Foods.

**Key Words:** gilt selection, reproductive tract score, sow lifetime productivity
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**039 Young scholar presentation: follicle dynamics and hormonal environment in a novel high fecundity genotype in cattle.** A. Garcia-Guerra[1,2,*], B. W. Kirkpatrick[1], M. C. Wiltbank[1], *[1]Univeristy of Wisconsin-Madison, Madison, [2]The Ohio State University, Columbus.*

A high fecundity bovine genotype has been recently discovered. Carriers of this allele have multiple ovulations (MO), while half-sibling non-carriers have single ovulations (SO). In sheep, high fecundity genotypes have mutations in pathways involving oocyte-derived TGF-β members, BMP-15/GDF-9. Consistent with this mechanism, MO cattle exhibit 6.6-fold greater expression of SMAD6 compared to SO ($P < 5 \times 10^{-5}$). SMAD6 is an inhibitor of BMP-15 transduction pathways that regulate granulosa cell proliferation and differentiation. Thus, we hypothesized that MO carriers would have reduced follicle growth rate and earlier differentiation than SO. In experiment 1, a synchronized follicular wave was induced with follicle growth in a controlled progesterone (P4) environment (intravaginal P4 implant for 5d). In experiment 2, a complete interovulatory interval was evaluated. Circulating FSH, P4, and estradiol (E2) were evaluated, and size of follicles and CL were determined by ultrasound. In experiment 1, number of ovulations was greater for MO than SO (Table 039). Mean ovulatory follicle size was greater for SO than MO; however, total ovulatory follicle volume was not different. Interestingly, follicle growth rate (volume basis) was 3.2-fold greater for SO than MO cattle. Peak FSH was similar ($P$ = 0.65) for MO and SO with declining but similar FSH during the next 2 d.

**Table 039.**

| Study | Endpoint | MO (n = 9) | SO (n = 5) |
|---|---|---|---|
| Experiment 1 | Ovulations | $4.1 \pm 0.4^{A}$ | $1.6 \pm 0.2^{B}$ |
| | Mean ovulatory follicle (mm) | $9.43 \pm 0.7^{A}$ | $15.5 \pm 0.9^{B}$ |
| | Mean ovulatory follicle ($mm^3$) | $508 \pm 127^{A}$ | $2033 \pm 321^{B}$ |
| | Total ovulatory follicle ($mm^3$) | $2100 \pm 312$ | $3153 \pm 487$ |
| | Follicle growth rate ($mm^3$) | $69.9 \pm 18^{A}$ | $225 \pm 25^{B}$ |
| Experiment 2 | Ovulations | $4.0 \pm 0.5^{A}$ | $1.2 \pm 0.2^{B}$ |
| | Maximal P4 (ng/ml) | $8.1 \pm 0.7$ | $8.7 \pm 1.2$ |
| | Mean CL ($mm^3$) | $1300 \pm 353^{A}$ | $4742 \pm 668^{B}$ |
| | Total luteal volume ($mm^3$) | $4337 \pm 605$ | $4742 \pm 668$ |

AB Indicates differences within row ($P < 0.05$).

However, nadir FSH (ng/ml) concentrations were greater for MO (0.25 ± 0.02) than SO (0.17 ± 0.02; $P = 0.02$) cattle. In experiment 2, individual CL volume on d 7 was greater for SO than MO (Table 039); however, total luteal tissue volume and circulating progesterone was not different. In experiment 3, size for attaining ovulatory capacity was evaluated by means of a challenge with 200μg of GnRH at different intervals after wave emergence. In MO cattle, 100% (34/34) of follicles ≥ 6 mm ovulated, while in SO cattle, follicles < 7.5 mm did not ovulate (0/44) but 100% (16/16) of follicles ≥ 9 mm ovulated to the GnRH challenge. Thus, MO cows have a reduced rate of follicle growth in spite of greater nadir FSH concentrations, with smaller individual follicle volume but similar total follicle volume. In addition, follicles in MO cattle attain dominance and ovulatory capacity at smaller follicle size.

**Key Words:** cattle, fecundity, follicle
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**040 Impact of blood collection on scoring temperament in angus-based weaned calves is negligible.**

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The objective was to determine if temperament scores were affected by blood sampling of calves. At weaning, Angus-based calves ($n = 420$) were scored over 2 d in a single year by evaluators for docility score (DS; 1 to 6, 1 is calm), temperament score (TS; 1 to 5, 1 is calm, 3 is excluded), and qualitative behavior assessment (QBA; 12 behavioral attributes assessed for expression using a 136-mm line). Each evaluator was randomly assigned 2 of 3 subjective methods ($n = 6$, 4 per method). An index value, temperament index (TI), was created using the first principal component of the 12 QBA attributes as an additional score. Novel measurements of activity were quantified using a four platform standing scale measuring weight over time (SD over set number of records; SSD) and adjusting that value for the calf's total weight (CVSSD). Calves were brought into the working facilities in random groups, where they were assigned in sets of 5 as they entered the chute to a treatment group (blood drawn before vs. after temperament evaluation). In this case, DS was always scored before blood draw and not included in analyses. Subjective traits were analyzed by evaluator ($n = 56$) or combined datasets ($n = 14$) to include evaluator as a main effect. As SSD and CVSSD had one observation per calf, they followed models on an evaluator basis ($n = 2$; 72 total models). An animal model fitting pedigree was used with main effects of collection date, sex, and blood draw within collection date (BLDDRW); fixed covariate of sequence within collection date (SEQ); and random effect of calf. Repeated measures were fitted with an unstructured residual covariance matrix for each calf. When including evaluator effect, BLDDRW tended to be significant for QBA Agitated ($P = 0.062$) but was not significant for the remaining 13 traits ($0.178 \leq P \leq 0.904$). Tendencies were found for SSD, CVSSD ($P = 0.053$ each), and evaluator 3's TS ($P = 0.054$). Evaluator 1's QBA Active and 6's QBA Happy ($P = 0.022$ and 0.034, respectively) were significant. The remaining 58 models by evaluator were not significant ($0.109 \leq P \leq 0.983$). As significance was often evaluator specific and only a few treatment differences detected in analyses of any trait, it can be concluded that the impact of blood draw on temperament scoring is negligible for calves of similar age and type.

**Key Words:** blood draw, cattle, temperament
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**041 Evaluation of functional variation in candidate genes for pork quality.**

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Considerable variation exists in pork quality traits, and consumer perception of pork eating satisfaction is largely driven by tenderness and sensory juiciness scores, which are related to shear force, cooking loss, and ultimate pH. Water loss from meat during postmortem storage reduces profitability and consumer appeal. Other measures of pork quality, such as color and intramuscular fat, also affect consumer satisfaction ratings and may influence purchase decisions. Because pork quality is measured only after slaughter, development of predictive markers would improve selection and management of product quality. Several genome-wide associations (GWAS) have been performed for a multitude of pork attributes and quality traits, but the causative variation for these traits has only been identified and validated for a few candidate genes. The objective of this study was to use a commercial population to evaluate potential functional variation in candidate genes identified in a GWAS for pork quality in the USMARC Swine herd. Traits measured at 14 d postmortem included slice shear force (SSF), pH, purge loss % (PURGE), cooking loss (Ck_Loss), color (L*, a*, and b*), and desmin degradation (DES). Potential functional variation was identified from the whole genome sequence of the USMARC founders and from public databases (http://genome.ucsc.edu/). One hundred twelve markers in 37 candidate genes were genotyped in 1536 commercial swine collected from six different slaughter plants. Data were analyzed in Golden Helix using a single-locus mixed linear model (EMMAX) with sex and plant (contemporary group) as fixed effects. A genomic relationship matrix constructed from markers shared on the Illumina PorcineSNP60v2 and GeneSeek GGP BeadChips was used to correct for population stratification. Markers that we previously identified in calpastatin (CAST) on the GeneSeek GGP BeadChip were associated with SSF, Ck_Loss, and DES and

were the most significant markers for SSF. PRKAG3 markers were associated with PURGE, Ck_Loss, pH, and L*. Most of the associations were with SNPs in genes with large known effects. Novel associations included associations of markers in CAPN1 and PEPD with SSF and CAPN1 with DES. GWAS have identified associations of the region near or containing CAPN1 with pork tenderness; however, this is the first report of potentially functional SNP in CAPN1 to be associated with tenderness and related traits.

**Key Words:** pork quality, SNP association, swine
doi: 10.2527/asasmw.2017.041

**042 Genome-wide association of myoglobin concentrations in pork loins.** A. J. Cross[1,*], D. A. King[2], S. D. Shackelford[2], T. L. Wheeler[2], J. P. Cassady[1], D. J. Nonneman[2], G. A. Rohrer[2], *[1]South Dakota State University, Brookings, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Pork is a widely consumed protein source. To remain competitive, pork quality must improve. Pork quality is a focus not only for producers and packers but also for consumers. Consumer purchasing decisions are largely based on lean meat color, indicating freshness. Myoglobin content in pork is the main factor that determines color. To increase myoglobin content and change lean pork color, it is important to understand genetic variation and parameters affecting myoglobin concentration. The objective of this study was to identify genetic markers associated with myoglobin concentration and lean meat color. Data were collected on pigs ($n$ = 559) from two different commercial swine facilities. Each farm sent an equal number of pigs to three different processing facilities. All pigs were from the same genetic line. After processing, ultimate pH was measured in the longissimus muscle, a sample was then frozen, and myoglobin concentration was measured from the frozen tissue using an AMSA suggested protocol. DNA was extracted and genotyping conducted using the NeoGen GGP porcine chip. After quality checks, a total of 7755 single nucleotide polymorphisms (SNP) were used for the analysis. A Bayes-C model implemented in GenSel software was applied with pi = 0.9996. The model included a fixed effect of slaughter group, which consisted of farm and plant, and ultimate pH as a covariate. Greater than 60% of the genetic variance was explained by regions within five chromosomes, where each position accounted for >1% of genetic variance. Chromosome 7 accounted for 36.0% of the genetic variance. Chromosome 14 had three significant regions, accounting for 23.2% of the genetic variance in myoglobin concentration. Candidate genes were identified on chromosome 7 that affect iron homeostasis and muscle development. Myoglobin concentration was then analyzed using a general linear model. Slaughter group was included as a fixed effect. Ultimate pH and the most significant SNP from the detected regions were included as covariates. Top three SNP from the general linear model exceeded a Bonferroni correction factor ($6.4 \times 10^{-6}$), and three other SNP had nominal significance levels of $P < 0.0001$. An increase in ultimate pH resulted in an increase in myoglobin concentration. Genes associated with myoglobin concentrations were identified, enabling selection for higher myoglobin concentrations in pork. Increasing myoglobin concentrations will improve lean meat color, therefore increasing consumer acceptance and consumption of pork. USDA is an equal opportunity provider and employer.

**Key Words:** genetics, myoglobin, pigs
doi: 10.2527/asasmw.2017.042

**043 Genetic parameters for age at puberty and associated traits in swine.** G. M. See*, N. V. Serão, M. T. Knauer, *North Carolina State University, Raleigh.*

The objective of this study was to estimate variance components for age at puberty and associated traits in swine. Multigenerational records were compiled from composite Landrace × Large White animals ($n$ = 4994) reared at the North Carolina Department of Agriculture Tidewater Research Station. Animals were part of a four-generation selection experiment for age at puberty. Females ($n$ = 2428) were reared in a curtain-sided building with fully slatted floors and natural ventilation. Sprinklers activated when temperatures reached 27°C. Gilts were placed in pens of 15 (0.84 $m^2$ per pig). At 130 d of age, gilts were exposed to mature boars for 7 min daily and estrous behavior recorded. Estrous detection continued for 90 d. Puberty was defined as first observed standing reflex in the presence of a boar. Female reproductive traits included: age at puberty (AP), length of estrus at puberty (LEN1), estrous length at second estrus (LEN2), puberty weight (PUBWT), vulva width at puberty (VW1), and vulva width at second estrus (VW2). Production traits included: piglet birth weight (BWT), piglet weaning weight (WWT), loin eye area (LEA), backfat depth (BF), and weight at 178 d of age (WT). Variance components were averaged over all animal models where the trait appeared in ASReml. Models included generation and sex as fixed effects and random effects of maternal environment and animal. Covariates were fit for reproductive traits (age at boar exposure), LEA and BF (WT), and WT (age). Heritability estimates for AP, LEN1, LEN2, PUBWT, VW1, VW2, BWT, WWT, LEA, BF, and WT were 0.31, 0.18, 0.15, 0.29, 0.28, 0.41, 0.21, 0.12, 0.42, 0.43, and 0.39, respectively. Common litter effects for AP, PUBWT, VW1, BWT, WWT, LEA, BF, and WT were 0.08, 0.04, 0.05, 0.03, 0.29, 0.02, 0.10, and 0.11, respectively. Genetic and phenotypic correlations between AP with LEN1, LEN2, PUBWT, VW1, VW2, BWT, WWT, LEA, BF, and WT were −0.15, −0.38, 0.84, 0.12, 0.13, −0.11, −0.16, 0.26, −0.30, and −0.46 and −0.03, −0.11, 0.81, 0.30, 0.18, 0.01, 0.02, 0.14, −0.20, and −0.18, respectively. Results indicate maternal effects exist for weaning weight, age at puberty, backfat, and growth rate. Selection for reduced age at puberty in swine

would generate gilts that have a longer length of estrus and are lighter at puberty yet faster growing.

**Key Words:** genetic, puberty, swine
doi: 10.2527/asasmw.2017.043

**044 Non-random distribution of runs of homozygosity across the genome of Landrace x Large White crossbreds.** L. Gomez-Raya[1,2], J. R. Dunkelberger[1,*], J. K. Lunney[3], R. R. R. Rowland[4], W. M. Rauw[1,2], J. C. M. Dekkers[1], *[1]Department of Animal Science, Iowa State University, Ames, [2]Departamento de Mejora Genética Animal, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Madrid, Spain, [3]USDA ARS BARC APDL, Beltsville, MD, [4]Department of Diagnostic Medicine/Pathobiology, Kansas State University, Manhattan.*

Runs of homozygosity (ROH) are continuous and uninterrupted stretches of DNA sequences without heterozygosity in the diploid state. ROH can be simply detected by searching for DNA stretches of homozygous loci with genotyped information from SNP arrays. A total of 202 Landrace x Large White barrows were genotyped for the Illumina 80K array. Monomorphic SNPs or SNPs with an average GC call rate of less than 0.80 were removed, such that 33,194 SNPs were retained for further analyses. A genome-wide search for ROH was performed for each animal. A likelihood function using the binomial distribution (animals with or without autozygous SNPs in that position) was developed. A likelihood ratio test was used for each SNP to test if its position had the same chance of being autozygous than any other SNP on the same chromosome. Under the null hypothesis, the probability of being autozygous is the ratio of the length of the genome covered by ROH over the total chromosome length. An overall genome-wide test constructed by summing up LRT values for each SNP (with the degrees of freedom equal to the number of SNPs) was highly significant, supporting that the distribution of regions of autozygosity is not random across the genome among these crossbred animals. A Bonferroni test with a significance level of 0.001 was used to identify SNPs and regions of high and low autozygosity. The chromosomal regions with the highest autozygosity were on SSC10 (position 2,388,937 to 2,915,401 bp) and SSC11 (position 34,824,047 to 37,398,762 bp). The chromosomal regions with the lowest autozygosity were on SSC2 and SSC15. Landrace and Large White have been bred separately over a long period of time. The existence of a high autozygosity may correspond to either regions harboring genes selected in both breeds or regions that are highly conserved because of their biological function. Generation of these data was supported by the USDA ARS and NIFA award 2012-38420-19286.

**Key Words:** autozygosity, runs of homozygosity, swine
doi: 10.2527/asasmw.2017.044

**045 Selection for age at puberty in swine: correlated boar response.** G. M. See*, W. L. Flowers, M. T. Knauer, *North Carolina State University, Raleigh.*

The objective of the study was to examine correlated boar characteristics from genetic lines (GL) selected for female age at puberty. Composite Landrace × Large White females were divergently selected for age at puberty, defined as first observed standing reflex in the presence of a boar. Selection resulted in two GL, young age at puberty (AP) and old age at puberty (OLD). Data consisted of boars from generations 3 ($n$ = 35) and 4 ($n$ = 113) reared at the North Carolina Department of Agriculture Tidewater Research Station. In generation 4, AP and OLD gilts obtained puberty at 162 and 177 d of age, respectively, and 85 and 50%, respectively, exhibited puberty. Boars were group housed on partial slatted floors in environmentally controlled buildings. Sprinklers were manually activated when the temperature reached 27°C. Production traits included birth weight (BWT), weaning weight (WWT), ADG, backfat depth (BF), and loin eye area (LEA). Reproductive traits included testis width (TW), testis length (TL), testis volume (VOL), testosterone (TEST), progressive sperm motility (MOTILITY), total sperm cells per ejaculate (TOT_CELL), projected semen doses per boar (DOSE), and libido score (LIBIDO). In generation 3 and 4, reproductive traits were measured when animals were on average 293 and 214 d old, respectively. Semen collection was performed on cull sows. Statistical analysis was performed in SAS using PROC GLM. Fixed effects of generation, boar age (used as a covariate), and generation nested within boar age were added in models when $P < 0.05$. Genetic line did not influence ($P > 0.05$) WWT, ADG, BF, or LEA. Yet AP boars had greater ($P < 0.05$) BWT when compared to OLD (1.24 vs. 1.15 kg). Least squares means for reproductive traits are shown in Table 045. Boars from the AP line had increased ($P < 0.05$) TW, TL, VOL, TEST, and LIBIDO when compared to OLD. Yet AP and OLD lines did not differ ($P > 0.05$) for MOTILITY, CELL, or DOSE. Results suggest divergent selection for early puberty in females impacted piglet birth weight, testicular development, and testosterone in boars.

**Key Words:** boar, puberty, reproduction
doi: 10.2527/asasmw.2017.045

**Table 045.** Least squares means for boar reproductive traits by genetic line.

| Trait | No. | AP | OLD | SE |
|---|---|---|---|---|
| Testis width, cm* | 147 | 4.35 | 4.02 | 0.13 |
| Testis length, cm* | 147 | 11.77 | 11.11 | 0.23 |
| Testis volume, $cm^2$* | 147 | 392 | 324 | 19.6 |
| Testosterone, log(np/ml)* | 30 | 3.89 | 2.56 | 0.36 |
| MOTILITY, % | 29 | 72.6 | 82.1 | 5.7 |
| TOT_CELL, billions | 29 | 21.2 | 19.6 | 3.3 |
| DOSE | 29 | 7.6 | 8.7 | 2.0 |
| LIBIDO* | 35 | 5.9 | 4.6 | 0.5 |

*Genetic line differed ($P < 0.05$)

## DAVID BAKER SYMPOSIUM:

## CURRENT ISSUES IN AMINO ACIDS IN PIGS

**046 Basic concepts and potential impact of precision feeding technologies in the production of growing-finishing pigs.** C. Pomar*, *Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada.*

Nutrient requirements can be defined as the amount of nutrients that allows a given animal at a given time to perform its natural functions in a normal manner, that is, to express its production potential. However, farm animals are raised in groups within which animals can greatly differ in body weight, growth potential, etc., and consequently, in the required amount of nutrients. In the context of rearing animals in groups with a unique feed, the requirement for a given nutrient is rather defined as the level of supply which results in a given (desired) level of production (e.g., maximal growth). For most nutrients, however, underfed animals exhibit reduced performance while the overfed ones exhibit near optimal performance. The desired level of production is therefore obtained with levels of nutrients that satisfy the requirements of the most demanding pigs, with the result that most of the pigs receive more nutrients than needed. Providing growing animals with excess nutrients to avoid reducing herd performance has become a common practice in commercial swine operations, hence contributing to increasing feed costs and nutrient inefficiency. Precision feeding is proposed to alleviate the limitations of actual group-feeding systems. Precision feeding allows feeding individual pigs with diets tailored daily to their estimated nutrient requirements by using daily feed intake and body weight measurements. It has been demonstrated that feeding pigs with diets tailored daily to each pig's lysine requirements allows obtaining similar intake and growth performance than conventional feeding systems. Precision feeding reduces lysine intake by more than 25% and feeding costs by more than 8%. It is an effective approach to improve nutrient utilization efficiency and to reduce nutrient excretion and feed costs. The real-time individual pig nutrient requirement estimated using each pig pattern of feed intake and growth represents a fundamental paradigm shift in pigs nutrition because pig nutrient requirements are no longer a fixed population attribute but a dynamic process that evolves independently for each animal while regulated by its own intrinsic (e.g., genetics) and extrinsic (e.g., environmental and social stressors) modulating factors.

**Key Words:** nutrient requirements, precision feeding, swine
doi: 10.2527/asasmw.2017.046

**047 Use of low protein diets for weanling pigs.** M. Nyachoti*, *University of Manitoba, Winnipeg, MB, Canada.*

The practice of using antimicrobial growth promoters (AGP) to manage incidences of post-weaning diarrhea in piglets is becoming increasingly untenable in many parts of the world, including North America. Thus, there is a concerted effort to develop alternative nutritional strategies to profitably raise pigs without AGP. To this end, utilization of a low-crude protein (LCP) diet fortified with crystalline amino acids (AA) has been suggested as an important piece in the overall strategy of raising weanling pigs without in-feed AGP. This is because dietary protein is an important risk factor for post-weaning diarrhea in piglets. Undigested dietary protein is subjected to bacterial fermentation in the large intestine, which produces metabolites with toxic effects and favors the proliferation of pathogenic bacteria. Thus, feeding a LCP diet to weanling pigs limits the amount of substrate entering the lower gut, which restricts the proliferation of pathogenic bacteria and the associated toxic metabolites that predispose the weanling pig to diarrhea. Indeed, many studies have shown that feeding a LCP diet reduces the proliferation of pathogenic bacteria in the gut and favors those with potential gut health benefits. Also, feeding a LCP diet minimizes the attachment of enterotoxigenic *E. coli* to the intestinal mucosa, which is an important step in its ability to cause disease. Existing evidence suggests that a LCP diet may be used in combination with other dietary interventions, such as probiotics and fermentable fiber, to further enhance gut health outcomes in piglets. A practical consideration for using a LCP diet for weanling pigs is that reduction in dietary protein content invariably leads to deficiencies of essential AA beyond those that are typically limiting (i.e., Lys, Met, Thr, and Trp) in high-protein nursery pig diets, including Val and Ile. An alternative view is to accept the short-term loss in performance as a result of feeding a LCP diet as pigs might be able to "catch up" later on in life through compensatory growth. A minimum reduction of dietary protein by 4% units coupled with supplementation of those AA that might become limiting is necessary to effectively utilize a LCP diet as part of the overall strategy to control piglet diarrhea.

**Key Words:** diarrhea, pigs, protein concentration
doi: 10.2527/asasmw.2017.047

**048 New directions and technologies in AA research for livestock.** P. J. Moughan*, *Riddet Institute, Massey University, Palmerston North, New Zealand.*

The world currently faces one of its greatest challenges, that of feeding in a sustainable manner, nine billion people by the year 2050. It is estimated by the FAO that meat consumption alone will double by 2050. There will be an important role for the pig and poultry industries in meeting this challenge. Considerable progress has been made over the last several decades in

the improvement of the average daily gain and feed conversion efficiency in pigs and poultry, and much of this improvement can be ascribed to gains from genetic selection and to advances in dietary formulation practice. Although genetic selection has led to animals with higher potential rates of whole-body protein deposition, lower body lipid to protein ratios, and altered rates of food intake, the underlying efficiency of dietary protein utilization has remained consistently low. There is thus considerable scope for the further improvement of productive efficiency. Simulated values for the efficiency of utilization of dietary lysine for six commercial pig grower diets given at two levels of intake to a 50-kg female pig ranged from 35% to 59%. Generally, over 50% of dietary lysine was not used for body protein deposition. Such inefficiencies highlight the importance of understanding the physiological processes leading to losses of amino acids (AA) from the body. The absorption and metabolism of AA is complex and highly integrated, with continuous flux within and between cells. It is useful, however, to visualize AA metabolism as a framework of discrete physiological processes. The integumental AA losses are quantitatively minor, as are losses from the use of AA to synthesize "other" compounds, irreversible AA modifications, and urinary AA losses. Supplying balanced dietary protein in excess of the requirement for maximal rates of body protein deposition (set by the genotype, breed, and strain) can, under some dietary conditions, lead to considerable inefficiency of utilization. Losses due to preferential AA catabolism, inevitable AA catabolism, gut endogenous AA excretion, and structurally altered (damaged) AA and fecal AA excretion are less easily avoided and are critical causes of inefficiency in the utilization of the first-limiting AA. These losses and novel "omic" approaches to studying them will be addressed.

**Key Words:** amino acids, efficiencies, metabolism
doi: 10.2527/asasmw.2017.048

**049 Amino acid requirements of sows nursing 13 to 14 piglets.** P. K. Theil*, *Aarhus University, Tjele, Denmark.*

Selection for high prolific sows has increased the requirements for dietary protein, AA, and energy. However, optimal daily supply to sows in farrowing units is challenging because most farms use the same diet during the last 5 to 7 d before parturition and until weaning around 4 wk of age. Factorial calculations indicate that protein, lysine, and energy may be the limiting factor for sow productivity depending on the physiological stage. We have used different approaches to quantify how nutrients are utilized by late-gestating and lactating sows with the final aim of improving sow yield of colostrum and milk or minimizing body mobilization. For that purpose, two multicatheterized sow models have been established; the first model to allow quantification of net portal uptake and net hepatic clearance of metabolites including AA and the second model to compare mammary uptake of AA with AA secreted into milk. Both studies indicated that the intermediary metabolism of sows changed greatly from 3 d prior to parturition to 3 d after parturition. Furthermore, the studies suggested that sows lacked energy in early lactation more than dietary AA or dietary protein, whereas lysine limited the milk production at peak lactation. To match the rapid changes in daily requirements for lysine, protein, and energy in early lactation, two other experiments have been conducted using 2-component feeding strategies. The 2 components were formulated to contain low and high standardized ileal digestible (SID) lysine per unit of ME to better match the requirements for maintenance and milk production, respectively, and the sows responded by producing more milk and/or by reducing the body mobilization of energy. Optimal daily protein requirement is less easy to evaluate, as the loss of nitrogen via urine depends on the protein intake, the energy intake, the AA profile of the diet, and the live weight of the sow. In conclusion, major changes in the nutrient requirements of sows occurred when housed in farrowing units and using a 2-component feeding strategy seems to be a promising approach to increase milk yield and/or reduce mobilization of body nutrients from lactating sows because the daily supplies of lysine and energy may be partly separated.

**Key Words:** amino acids, energy, lactating sows
doi: 10.2527/asasmw.2017.049

## DAVID SCHINGOETHE SYMPOSIUM:

## KEY CHALLENGES TO DAIRY CATTLE PRODUCTION IN THE MIDWEST

**050 Inflammation and immune activation during periods of stress in dairy cattle.** M. Garcia*, B. J. Bradford, *Kansas State University, Manhattan.*

Throughout the year, the sustainability of the dairy industry is jeopardized because of the challenges cows face during the transition to lactation, and this is further worsened during the summer months. Daily milk production losses ranging from 1.4 to 6.3 kg have been documented for cows undergoing heat stress during late gestation. Furthermore, heat stress also impairs immune response, health, and short-term and lifelong productivity. At least 50% of the farm morbidity occurs during the first 20 d after parturition, increasing the risk of cow removal from the herd. Inflammation can be triggered in response to infectious (e.g., bacteria) or noninfectious agents (e.g., endogenous danger signals). The process of parturition requires the initiation of a noninfectious inflammation, which is coupled with an intense oxidative stress and several other pathological and/or adaptive responses. Other drastic events around parturition, e.g., galactopoiesis, marked reduction of feed intake, and endotoxin overload, may exacerbate the parturition-initiated inflammatory process leading to a systemic inflammation. Dairy cows orchestrate an adaptive homeorhetic process, inducing insulin

resistance in peripheral tissues to spare glucose for the mammary gland, potentially sacrificing nutrient supply to immune cells to some degree. Hence, as insulin resistance is associated with inflammation, it is possible that endogenous inflammation is an adaptive mechanism of dairy cows to regulate partitioning of nutrients and energy balance. Although the process of parturition is initiated by a "sterile inflammation," cows with a higher degree of inflammation during the first days after parturition have greater incidence of diseases, lower milk yields, and poorer reproductive efficiency. These associations of inflammation imply a subsequent or parallel inflammation with infectious origin, where immune cells fail to resolve infection due to an apparent hypo-responsiveness during the peripartum period. An activated immune system significantly increases the demand for nutrients. Consequently, so-called peripartum immunosuppression may be due to a limited availability of nutrients coupled with an exhausted immune system due to an aberrant sterile inflammation occurring not only in the uterus but also in the adipose tissue, muscle, and liver. Therefore, the development of assertive nutritional strategies to optimize the extent and resolution of postpartum inflammation may improve the health and productivity of cows transitioning to lactation. However, such strategies require greater knowledge of mechanisms underlying postpartum inflammation as well as identifying the most limiting nutrients of microbial- and tissue damage-stimulated immune cells.

**Key Words:** immunity, inflammation, transition cow
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**051 Potential impact of Midwest dairy facility design on cow time budgets.** J. P. Harner*, *Department of Biological and Agricultural Engineering, Kansas State University, Manhattan.*

Many management decisions impact a facility's ability to allow normal animal behavior. Decisions such as stocking density, feed space available, resting space, and stall dimensions or milking routine impact the dairy facilities. Prudent facility design makes every effort to enable cows to live a normal life based on current research and best design practices. Facilities have a 20- to 40-yr life span and best design practices change. However, animal welfare may be compromised by management and financial decisions in spite of utilizing best design guidelines. The facility occupancy rate index helps identify potential areas of concern prior to making a change in management or investment in facilities. The impact of 2-row vs. 3-row, stocking density, milking frequency, and time away from a pen are examples of management decisions that can be evaluated prior to making an actual change. The facility occupancy rate is the summation of the free stall occupancy rate and the feedline occupancy rate indexes. Current recommendations for cow time budget can be utilized to determine the potential impact of a facility and management decisions. Dairy facility design will adapt to utilize best design practices merging the overall demands of efficiency, environment, and animal welfare. The impact of automated milking systems on potential facility design will explored using the facility occupancy rate index. New and expanded knowledge through sound research will be necessary to form the basics of future "best design practices."

**Key Words:** cow time budget, facilities, freestalls
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**052 Key challenges to dairy cattle production in the Midwest environment: forage quality.** D. K. Combs*, *University of Wisconsin, Madison.*

The objective of this presentation is to discuss challenges to optimizing forage utilization by dairy cattle in the Midwest. Corn silage, alfalfa, grasses, co-product feeds, and crop residues are widely used in Midwest dairy cattle diets. These materials provide fiber (NDF) and energy to dairy cattle diets. In diets for high producing dairy cows, about 20 to 25% of the energy for milk production comes from digested fiber. The digestibility of NDF is more variable than the digestibility of any other feed component and can profoundly affect intake and milk production. Variation in total tract fiber digestion can account for enough digestible energy to support as much as 4 to 5 L of potential milk yield. Fiber digestion is affected both by characteristics of the forage and by the animal consuming the fiber. To accurately predict how fiber will be utilized, laboratory measures that predict the rate of fiber digestion and the proportion of total fiber that is potentially digestible are needed. The rate and potential extent of NDF digestion are heavily influenced by the genetics and growing environment of the forage. Fiber digestion is also affected by the rate of passage of the potentially digestible fiber through the animal's rumen and hindgut. University of Wisconsin researchers have developed an in vitro assay and model for predicting the total tract digestibility coefficient for NDF (TTNDFD). The TTNDFD value is benchmarked to fiber digestibility values that have been obtained from feeding studies where NDF digestion has been directly measured. Total tract fiber digestibility is reported because this value can be used not only to predict in vivo fiber utilization but also to predict forage DE, NE, or TDN values. The in vitro method has been calibrated to near infrared spectroscopy (NIR) so that kd and iNDF fractions can be predicted quickly and with little additional cost. Several feeding studies have been conducted with various forages to test the model and to validate that the in vitro estimates of digestion and passage are consistent with what is measured in cattle fed diets containing the test forages. Optimizing use of forages and fiber in dairy diets requires accurate, precise measures of the amount of NDF and NDF digestibility. The TTNDFD assay and model provide information that can be used to evaluate forage quality and optimize forage utilization by dairy cattle.

**Key Words:** dairy nutrition, fiber, forage
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**053 The next frontier in nutritional modeling and ration formulation-water.** D. P. Casper*, *Furst-McNess Company, Freeport, IL.*

Water is the most important nutrient to livestock and is often overlooked when evaluating livestock nutrient requirements and troubleshooting performance problems on the livestock operation. Water soluble nutrients and quality can vary dramatically from one livestock operation to the next, as well as, vary dramatically from one area of the country to another. In some cases, water can make a significant contribution to meeting the nutrient requirements of the animal, while in other situations, nutrient concentrations must be increased to offset the lack of nutrient supply via the water. Historically, nutrients supplied by water were not factored into the nutrient requirements of livestock, i.e., Nutrient Requirement of Livestock Species published by the National Research Council (NRC). Some nutritional models are starting to factor in this supply via the use of prediction equations of water consumption and water nutrient composition, but this area is in its infancy. Water quality and quantity can be huge issues when selecting sites for building a new dairy operation. Issues, such as mineral concentrations, nitrates, bacteria, agronomic chemicals, along with the supply volume and flow rates are just some of the issues to address when siting a new dairy operation. Several water treatment systems are commercially available to address some of these concerns, which can range from inexpensive to very expensive depending on the nature of the water issue to be solved. There is limited research information available in this area, which could ensure this being a future productive area of research. Our work has shown that the use of laboratory distilled water compared to livestock operation water supply and water treatment systems had an impact on the rate and extent of ruminal digestion using an in vitro gas production system. Therefore, the accuracy and precision of laboratory measurements combined with nutritional modeling and ration formulation for actual livestock performance can be influenced by the quality and nutrient supply of the water source. This may explain the lack of agreement between predicted and actual livestock performance via nutritional models, especially dry matter intake. These areas will be discussed in more depth using livestock applications and implications.

**Key Words:** digestibility, quality, water
doi: 10.2527/asasmw.2017.053

## EQUINE SCIENCE

**054 An investigation of the palatability of a novel ingredient fed to horses.** M. T. DeChant*, E. Powell, G. A. Apgar, E. B. Venable, *Southern Illinois University, Carbondale.*

Palatability is defined as the physical and chemical characteristics that evoke appetite but is not well understood in the horse. Palatability is best determined during the initial feed offering. Characteristics associated with palatability trigger sensory responses by olfactory, gustatory, and tactile stimuli (Scharenberg et al., 2007). Preliminary studies have reported intake is largely influenced by odor, taste, ease of prehension, and texture (van den Berg et al., 2016). Our study was designed to investigate the enhanced palatability of horse treats containing three levels of a proprietary ingredient. Treatments were: A = 0 palatant (control), B = 1x palatant, and C = 2x palatant. Institutional Animal Care and Use approval (#16-032) was obtained prior to the initiation of this study. Ten adult horses (BCS = 5.5 ± 0.5) receiving daily turnout and ad libitum access to water and white salt blocks were used for the study. Horses were trained to eat from identical buckets in identical stocks for 3 d prior to study. Horses were offered two buckets simultaneously (each containing 5 treats) and were allowed 10 s for olfactory perception and then 50 s for consumption. Each treatment period consisted of three consecutive days with three treatment periods total. The following variables were recorded: first action (sniff/eat), body weight, BCS, first choice, first sniff, aversive behavior, water consumption, and abnormal activity post-consumption. First sniff is defined as the first treatment sniffed during the first 10-s period; first choice is defined as the first treatment chosen after the 10-s sniff period. Categorical data were analyzed as a chi square using the PROC FREQ procedure of SAS while body weight was analyzed using PROC MIXED (SAS version 9.4). Body weight, BCS, and post-consumption water intake were unaffected by treatment ($P > 0.05$). Abnormal behaviors that were observed included hypersalivation, difficulty chewing, and excessive licking/chewing of the stall door. These data demonstrated a preference for Treatment A as compared to Treatments B and C when first choice was identified ($P < 0.05$). Additionally, there was a pattern observed between first choice and first sniff ($P < 0.01$). Trained observers noted that the first consumption choice tended to mirror the bucket that was sniffed first. This may indicate that first-choice consumption is strongly affected by the first offering the horse smells. The propriety ingredient utilized in this study did not enhance palatability. Further work is needed to better understand how olfactory perception affects feed selection in horses.

**Key Words:** equine, palatability, treats
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## EXTENSION—BEEF/SMALL RUMINANT

**055 Using corn gluten feed in post-partum diets of beef cows to optimize reproductive performance.** E. G. Taylor[1,*], R. P. Lemenager[1], K. R. Stewart[2], *[1]Purdue University, West Lafayette, IN, [2]Department of Animal Sciences, Purdue University, West Lafayette, IN.*

Primiparous and multiparous Angus-Simmental cows were blocked by cow weight, BCS, and age and randomly assigned to one of three treatments 11 ± 11.5 d post-calving: 1) silage-based total mixed ration (TMR; CON); 2) TMR with 3.3 kg/d DM CGF (MID); or 3) TMR with 6.7 kg/d DM CGF (HIGH), to evaluate the effects of feeding corn gluten feed (CGF) as a primary source of dietary energy on cow BW, body condition, and reproductive performance. Diets were formulated to be isocaloric and either meet or exceed all other nutrient requirements (NRC, 2000) with a postpartum ADG of 0.17 kg/d. Blood samples were collected at 7-d and 21-d intervals from trial initiation until estrous synchronization for determination of plasma progesterone concentration as an indicator of resumption of cyclicity and for plasma urea nitrogen (PUN), respectively. Milk samples were collected at 62 ± 11.5 d post-partum for composition analysis. A 5-d Co-Synch + CIDR protocol was started at 77 ± 11.5 d, and cows were bred by timed artificial insemination (TAI). Diameter of the largest antral follicle was determined at TAI via ultrasonography. Bulls were placed with cows 19 d post-TAI for the remainder of the breeding season. Pregnancy diagnosis was accomplished via ultrasonography 38 and 112 d post-TAI, respectively, for TAI and season pregnancy. Growth performance of male progeny was measured through trial termination. Data were analyzed using the GLIMMIX, MIXED, and GLM procedures of SAS. Planned orthogonal contrasts were used to test treatment effects. Final cow BW ($P \geq 0.61$), BCS ($P \geq 0.11$), cyclicity ($P \geq 0.24$), follicle diameter ($P \geq 0.42$), TAI conception ($P \geq 0.42$), and season pregnancy rates ($P \geq 0.97$) were not different among treatments. PUN concentration did not differ ($P \geq 0.64$) at trial initiation, but all treatments differed from each other ($P = 0.01$) on d 105 with HIGH the highest, MID intermediate, and CON lowest. No differences were seen in most milk components ($P \geq 0.26$); however, milk fat tended to be higher ($P \geq 0.07$) in the HIGH treatment when compared to other treatments. Calf birth weight differed with HIGH the highest, MID intermediate, and CON the lowest. Although, intermediate and end weights (60 and 101 ± 16.5 d of age, respectively) were not different ($P \geq 0.64$). In summary, feeding high or intermediate levels of CGF to beef cows during early lactation did not alter cow reproductive performance.

**Key Words:** CGF, corn co-products, reproductive performance

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**056 Influence of the Brahman breed in beef calf lots marketed through summer video auctions from 1995 through 2015.** E. D. McCabe[1,*], M. E. King[1], K. E. Fike[1], K. L. Hill[2], G. M. Rogers[3], K. G. Odde[1], *[1]Kansas State University, Manhattan, [2]Merck Animal Health, Kaysville, UT, [3]Grassy Ridge Consulting, Aledo, TX.*

The objective was to characterize the potential change in the percentage of lots of beef calves with Brahman influence among calves originating from various regions of the United States marketed through summer video auctions from 1995 through 2015. Data were available on 80,574 lots (9,685,247 total calves) of beef calves marketed through 171 summer video auctions. Lots of beef calves were categorized as English, English crosses (EX), English-Continental crosses (ECX), or Brahman influenced (BR). The Northeast region (CT, DE, MA, MD, ME, NH, NJ, NY, OH, PA, RI, and VT) was excluded from this study due to few lots representing this region. The Cochran-Armitage trend test was used to determine the presence of an increasing or decreasing trend in the percentage of lots with Brahman influence over time with a $P$-value ≤ 0.05 considered significant. There was a decrease ($P < 0.0001$) in percentage of lots with Brahman influence in the United States during the 21 yr. Percentage of lots with Brahman influence decreased ($P < 0.0001$) in four regions: West Coast (CA, ID, NV, OR, UT, and WA), Rocky Mountain/North Central (CO, IA, IL, IN, MI, MN, MT, ND, NE, SD, WI, and WY), South Central (AZ, KS, MO, NM, and OK), and Texas (TX). There was no change ($P = 0.30$ and $P = 0.07$, respectively) in the percentage of lots with Brahman influence originating from the Coastal (AL, FL, GA, LA, MS, and SC) and Sub-coastal regions (AR, KY, NC, TN, VA, and WV). Of the 80,574 lots marketed via summer video auctions from 1995 through 2015, 68,870 lots sold. Of the sold lots, BR lots had average price discounts of $9.44 and $6.81/100 kg BW when compared with EX and ECX lots, respectively. Over the 21 yr, the smallest discount of BR lots compared with EX lots was in 1996 at $4.25/100 kg BW and when compared with ECX lots in 1997 at $3.20/100 kg BW. The greatest price discount of BR lots was in 2014 at $15.43 and $11.27/100 kg BW compared with EX and ECX lots, respectively. The percentage of lots of beef calves with Brahman influence marketed via summer video auctions appears to be decreasing in the United States. However, it has remained unchanged in the Coastal and Sub-coastal regions where Brahman influenced calves are adapted to the warmer, more humid climates.

**Key Words:** beef calves, Brahman breed, video auctions

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## EXTENSION—DAIRY SYMPOSIUM:

## THE OPTIMIZATION OF THE NUTRITION OF TRANSITION DAIRY COWS

**057 The transition period in dairy cattle, physiology, and nutritional consideration, an overview.**
F. Cardoso*, *Department of Animal Sciences, University of Illinois, Urbana.*

The 6- to 8-wk period centered on parturition, known as the transition or periparturient period, is critical to welfare and profitability of individual cows. Fertility of high producing cows is compromised by difficult transitions. Deficiencies in either nutritional or non-nutritional management increase risk for periparturient metabolic disorders and infectious diseases, which decrease subsequent fertility. A primary factor impeding fertility is the extent of negative energy balance (NEB) early postpartum, which may inhibit timing of first ovulation, return to cyclicity, and oocyte quality. In particular, pronounced NEB during the first 10 d to 2 wk (the time of greatest occurrence of health problems) is critical for later reproductive efficiency. Concentrations of insulin and insulin-like growth factor-1 (IGF-1) likely link energy (and nutrient) status and reproduction, and both are lower in cows with severe early lactation NEB. Concentrations of nonesterified fatty acids (NEFA) and β-hydroxybutyrate (BHB) increase in response to NEB, are useful indicators of metabolic status, may decrease dry matter intake (DMI), and may play a direct role in decreasing fertility. Suboptimal management of non-nutritional factors before and after calving (cow comfort, overcrowding, facility design and repair, heat relief) leads to stressors that may increase systemic inflammation and decrease DMI. Nutritional management before calving should aim to promote appetite and high DMI in the early post-calving period, which is the primary determinant of postpartum NEB. Avoiding over-conditioning and preventing cows from over-consuming energy relative to their requirements in late gestation result in higher DMI and less NEB after calving. A pooled statistical analysis of previous studies in our group showed that days to pregnancy are decreased (by 10 d) by controlling energy intake to near requirements of cows before calving compared with allowing cows to over-consume energy. To control energy intake, total mixed rations (TMR) must be well balanced for metabolizable protein, minerals, and vitamins yet limit total DM consumed, and cows must uniformly consume the TMR without sorting. Dietary management to maintain blood calcium and rumen health around and after calving is also important. Opportunities may exist to further improve energy status in fresh cows. Recent research to manipulate the glucogenic to lipogenic balance and the essential fatty acid content of tissues are intriguing. High-producing cows that adapt successfully to lactation can have high reproductive efficiency, and nutritional management of the transition period both pre- and post-calving must facilitate that adaptation.

**Key Words:** nutrition, reproduction, transition period
doi: 10.2527/asasmw.2017.057

**058 Amino acids for transition cows.**
C. G. Schwab*, *Schwab Consulting, Boscobel, WI.*

A considerable shift in dairy nutrition has been to move away from formulating rations for crude protein to focusing more on rumen degradable protein (RDP) and amino acids (AA), thereby trying to ensure maximal synthesis of microbial protein and more optimal usage of rumen undegradable protein (RUP) and metabolizable protein (MP). Amino acid requirements for far-off dry cows fed typical low energy diets appear to be easily met by ensuring adequate supplies of RDP and RUP. However, such is not the case for transition cows. Due to reduced DM intake and higher AA requirements during the peripartal period, it becomes more difficult to efficiently meet the apparent requirements of the most limiting AA. For example, balancing transition cow rations for high concentrations of Lys and Met in MP can have profound effects on postpartum cow performance. Responses have included increases in DM intake both before and after calving, increases in milk yield and milk protein concentrations, and a lowered incidence of ketosis postpartum. At least part of the effect of AA balancing on postpartum cow performance, in addition to enhanced protein synthesis, appears to be due to altered metabolism and reduced inflammation and oxidative stress. For example, transition cows fed high-Lys containing protein supplements and adequate amounts of supplemental Met to achieve ratios of Lys/Met in MP of 2.8/1 (NRC, 2001) have resulted in increased blood neutrophil phagocytosis (indicative of improved immune function), greater overall plasma oxygen radical absorbance capacity, and increased hepatic concentrations of glutathione and carnitine. Increased glutathione and carnitine concentrations in the liver increase antioxidant and *B*-oxidation capacity. Also, analysis of liver tissue collected during the peripartal period has indicated that Met supplementation affects expression of genes in the Met cycle, thereby potentially increasing supplies of methyl donors, such as S-adenosylmethionine and antioxidants such as glutathione. Evidence indicates that maintaining a positive methyl donor balance is a challenge for transition cows. Combined, these observed benefits support that AA, not MP, are the required nutrients, and that AA have functions that go well beyond serving as building blocks for protein synthesis. A better understanding of more exact AA requirements of transition cows will be obtained with improved nutritional models and greater access to other rumen protected AA. Until then, it will be difficult to fully appreciate the benefits of balancing transition cow diets for AA.

**Key Words:** amino acids, protein, transition cows
doi: 10.2527/asasmw.2017.058

**059 Vitamin supplementation strategies for transition dairy cows.** G. Ferreira[1,*], B. Weiss[2], *[1]Department of Dairy Science, Virginia Polytechnic Institute and State University, Blacksburg, [2]The Ohio State University, Wooster.*

Even though clinical vitamin deficiencies are rarely observed in lactating dairy cows, we know that inadequate vitamin status can produce a wide range of more general and often subtle problems. Vitamin supplementation is critical for transition dairy cows, as supplementation of several vitamins diminishes the risk or attenuates the severity of metabolic diseases, infectious diseases, or both. Milk production generally has not responded to vitamin A supplementation, but some studies showed that cows with lower concentrations of retinol in plasma are at higher risk for retained placenta, mastitis, and lameness. Several studies reported enhanced immune function, reduced prevalence of mastitis and retained placenta, and improvements in various measures of reproduction efficiency when cows fed adequate vitamin A were also supplemented with β-carotene; although several studies showed no response to supplemental β-carotene. Vitamin D, which is known for its regulation of calcium homeostasis, has been related to improvements in innate and adaptive immunity and reductions of the severity of mastitis. A preponderance of studies has shown that adequate supplementation of vitamin E improves measures of immune function and reduces the prevalence of retained placenta, metritis, and clinical and subclinical mastitis. Vitamin E also can reduce the severity of clinical mastitis. Clinical deficiencies of B-vitamins are unlikely in functional ruminants, as they are synthesized in the gastrointestinal tract. On the contrary, vitamin degradation can also occur within the gastrointestinal tract, therefore limiting vitamin availability for absorption. The balance between synthesis and degradation within the gastrointestinal tract is not conclusive for most B-vitamins, likely due to difficulties in vitamin quantification. Overall, several studies showed that supplementation of certain B-vitamins can enhance animal production, animal health, or both. Biotin, choline, and niacin are the only water-soluble vitamins commonly supplemented to dairy cows. These three B-vitamins can have major benefits when feeding transition cows. Biotin supplementation has been related to improvements in foot health, increased milk production, and effects on gluconeogenic pathways. Niacin has been related to anti-lipolytic and thermoregulatory effects, although results for these affects are not conclusive. Choline supplementation has been beneficial attenuating metabolic disorders related to fatty acid metabolism, with beneficial effects in milk production during the transition period.

**Key Words:** dairy, transition, vitamins
doi: 10.2527/asasmw.2017.059

**060 New insights into calcium intake in transition dairy cattle.** L. L. Hernandez*, *Department of Dairy Science, University of Wisconsin, Madison.*

Calcium is the major mineral component of milk and colostrum. Circulating maternal calcium pools and dietary calcium are insufficient to support maternal physiology while simultaneously supporting milk synthesis. Dairy cows are particularly susceptible to the demand by the mammary gland for calcium due to the amount of milk they produce. This creates an enormous challenge to maintain maternal calcium concentrations within a normal physiological range. Therefore, they must rely on mobilization of calcium from bone to support maternal calcium homeostasis. Approximately 50% of dairy cows will succumb to subclinical hypocalcemia and 5 to 10% will suffer from the clinical form of the disease, milk fever, which has major economic and animal health and production impacts. Additionally, regardless of disease state, dairy cows will lose approximately 13% of bone calcium during the first 2 mo of lactation. Serotonin has emerged as a regulator of mammary gland physiology over the last decade, modulating several aspects of milk synthesis and mammary gland involution and has independently been shown to influence bone metabolism. More recently, using several mammalian models, we have demonstrated the importance of serotonin in regulating calcium mobilization from bone during lactation, as well as modulating calcium transport into the mammary gland from the circulation. Our research shows that serotonin is critical for the expression of key mammary gland calcium transporters and pumps, as well as the production of parathyroid hormone related-protein (PTHrP), which is the hormone necessary for the induction of calcium mobilization from bone during lactation. In dairy cows, serotonin concentrations are positively correlated with calcium and PTHrP status on Day 1 of lactation. Furthermore, we have demonstrated that serotonin concentrations fluctuate over the course of an entire lactation, and decrease substantially at parturition, compared to pre-partum concentrations, similar to calcium concentrations. Recently, we demonstrated in two separate studies that administration of 5-hydroxy-L-tryptophan pre-partum increases post-partum calcium concentrations in multiparous Holstein dairy cows. Combined, our research implicates the importance of serotonin for the regulation of maternal calcium homeostasis, as well as for the secretion of calcium into milk and colostrum.

**Key Words:** calcium homeostasis, dairy cow, serotonin
doi: 10.2527/asasmw.2017.060

**061 Young scholar presentation: immuno-metabolic adaptations to lactation in pasture-based transition dairy cows can be regulated by prepartum nutritional strategies.** M. Vailati Riboni[1,*], J. R. Roche[2], J. J. Loor[1], [1]*University of Illinois, Urbana,* [2]*DairyNZ, Hamilton, New Zealand.*

A successful transition into lactation determines optimum production, reproduction, and health. The peripartum is characterized by an inflammatory state that, if not controlled, could be detrimental to the cow. The first experiment examined hepatic and adipose gene expression in response to injections of a non-steroidal anti-inflammatory compound (Carprofen) on 1, 3, and 5 d postpartum. Data indicated that after calving, both tissues respond to inflammation signals, underscoring its role in the normal homeorhetic adaptations to lactation. The second experiment investigated the effect of prepartal nutrition and its interaction with BCS on hepatic and adipose tissue transcriptome. Cows were randomly allocated to one of four groups in a 2 × 2 factorial arrangement: 4.0 or 5.0 BCS prepartum (10-point scale) and dietary energy at 75 or 125% of estimated requirements during the close-up. Tissue biopsies were harvested at −1, 1, and 4 wk relative to parturition. The greater number of hepatic differentially expressed genes in BCS4 cows in response to increased prepartum feed allowance (1071 vs. 310, over the entire transition period) indicated a greater responsiveness to prepartum nutrition than optimally conditioned cows. Thus, overfeeding in late-pregnancy should be limited to underconditioned cows, while cows with optimal BCS should be maintained on an energy-restricted diet. Adipose tissue mRNA and microRNA expression further confirmed this hypothesis and indicated a relationship between the immune and metabolic response of the adipose tissue underscoring the existence of a "self-regulatory" mechanism. The third experiment examined the effect of over-feeding in both close-up and far-off periods on the adipose tissue transcriptome. Far-off over-feeding is usually a standard practice in seasonal grazing systems as, compared with TMR-fed cows, cows are thinner at the end of lactation. Adipose expression data revealed how overfed cows in the far-off period had greater adipogenesis, consistent with their rapid gain in BCS following dry-off, but a lower body fat mobilization in early lactation. The results indicated that neither strategy affected negatively the adaptations to lactation. However, to ensure a favorable transition, cows should be subjected to a small feed restriction in the close-up period, irrespective of far-off nutrition. Overall, data indicated a beneficial involvement of the immune system in the adaptation to lactation and the possibility to regulate this process through prepartal BCS and nutrition management.

**Key Words:** inflammation, liver and adipose transcriptome, transition cow nutrition
doi: 10.2527/asasmw.2017.061

## EXTENSION—DAIRY

**062 Evaluation of commercial products to improve gut health and digestibility in lactating dairy cows.** P. Poudel[1,*], D. P. Casper[2], B. St-Pierre[1], [1]*Animal Science Department, South Dakota State University, Brookings,* [2]*Formerly South Dakota State University, Brookings.*

Different feed additive technologies are commercially available to improve gut health and milk production of dairy cows. The study objective was to evaluate the gut health and nutrient digestibility in lactating Holstein dairy cows fed two commercial products: 1) a propriety blend of essential oils and cobalt lactate (EOC) and 2) active dried yeast product (ADY). The study utilized a continuous 12-wk experimental period using 78 lactating dairy cows arranged in a randomized complete block design with cows split between two robotic pens ($n$ = 40 and $n$ = 38) each equipped with Lely Astronaut A4 robotic milkers. Both treatments received the same basal total mixed ration (TMR), with the experimental treatments added to a soyhull carrier and mixed separately into the TMR at feeding time. A pelleted concentrate was provided through the robotic milking system. Each day, individual cow performance data was downloaded using Lely Time for Cows (T4C) software. All data were analyzed using the PROC MIXED procedure of SAS. Milk production (36.1 and 37.7 kg/d for EOC and ADY, respectively) was similar ($P > 0.25$) for cows fed both products. Cows fed EOC had lower ($P < 0.01$) dry matter intake than cows fed ADY (21.8 vs. 22.7 kg/d), but feed efficiency (1.65 vs. 1.66 kg/kg; FE) were similar ($P > 0.10$) for cows fed both products. There were no differences ($P > 0.10$) in milk composition, such as percentage of milk fat (3.46 vs. 3.30%), milk protein (2.98 vs. 2.98%), lactose (4.90 vs. 4.95%), MUN (13.0 vs. 12.4 mg/dL), and SCC (4.98 vs. 4.99 log10, cells/mL) for cows fed both products. Both products prevented *Aspergillus fumigatus* growth in TMR samples measured weekly. Fecal presence of *Escherichia coli* was lower ($P < 0.02$) for cows fed EOC than cows fed ADY. The digestibility of dry matter ($P < 0.05$), neutral detergent fiber ($P < 0.04$), hemicellulose ($P < 0.02$), calcium ($P < 0.02$), and phosphorus ($P < 0.03$) were higher for cows fed ADY than for cows fed EOC. These data demonstrated that milk production and FE were similar for cows fed both treatments, while digestibility was higher for cows fed ADY which contains an enzyme.

**Key Words:** dried active yeast, essential oils, lactation performance
doi: 10.2527/asasmw.2017.062

## EXTENSION—SWINE

**063 Effects of betaine and heat stress on lactation and post-weaning reproductive performance on sows.**
F. A. Cabezon*, K. R. Stewart, A. P. Schinckel, B. T. Richert, *Department of Animal Sciences, Purdue University, West Lafayette, IN.*

This study was conducted to evaluate the underlying physiological changes that occur during heat stress and the effect of betaine supplementation in lactating sows. Twenty sows were housed in two rooms (each with 10 sows) to simulate heat stress (HS: 31°C from 8:00 to 16:00 and 26°C for the rest of the day) or thermoneutral (TN: 22°C during the entire trial) conditions. Treatments were randomly allotted to each sow to receive 0.00% or 0.22% of a betaine supplement in their diets. Sows were blocked by parity as they entered the farrowing rooms at Day 110–112 of gestation. Sows housed in the HS condition had ad libitum access to feed. Sows housed in the TN condition were pair fed with sows in the HS room. Data were analyzed as a 2 × 2 factorial arrangement of treatments, with 2 levels of room temperatures and 2 dietary betaine levels. Respiration rates and rectal and skin temperatures were recorded every day (7:30 and 15:30) from the first day in the farrowing room to weaning. Blood samples from sows were taken at different days during the trial (before move in, Day 7, 14, weaning and 3 d post-weaning). Follicle size was measured every 12 h with a real time ultrasound from weaning to ovulation. Treatment by room interaction was not significant for any variable ($P > 0.11$). Betaine supplemented sows had 0.23°C lower rectal temperature than control sows ($P = 0.048$). Respiration rates and rectal and skin temperatures were 35.6 breaths/min and 0.4 and 3.6°C greater under HS than TN conditions, respectively ($P < 0.004$). Homocysteine and cortisol serum concentrations did not differ between treatments ($P > 0.44$) or environments ($P > 0.25$). Betaine supplemented sows had 0.51 mm greater follicle diameter than control sows at the same times post-weaning ($P = 0.043$). The mean follicle diameter was 0.97 mm smaller under HS than TN conditions ($P = 0.003$). Regression analysis indicated that room temperature differences in follicular size were due to differences in the time of follicular growth initiation and not in the rate of growth. The follicle size at ovulation did not differ between housing conditions ($P = 0.79$), but the time from weaning to ovulation was 2.1 d greater in HS than TN sows ($P = 0.005$). Heat stress affects follicle size at the same hours post-weaning and delays the time of ovulation but does not affect follicle's size at ovulation.

**Key Words:** follicle, betaine, sow
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**064 Development and application of a model of heat production for lactating sows.**
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The objectives of this research were to develop a model of heat production for lactating sows to estimate differences due to genetics, parity, and day of lactation and to estimate the magnitude of daily sow to sow variation. The model was developed using NRC (2012). Sow body weight (BW), mean daily litter weight gain (Cabezón et al., 2016a), and daily feed intake (DFI) data (Cabezón et al., 2016b) from 317 sows of 2 genetic lines, C-22 ($n = 164$) and L-42 ($n = 153$), were used to predict the heat production (watts) for each day of lactation. The data were sorted in 4 parity groups, parity 1 ($n = 80$, P1), parity 2 ($n = 57$, P2), parities 3 to 5 ($n = 142$, P3–5), and parity 6 and greater sows ($n = 38$, P6+). The variance of the predicted mean daily heat production (PMHP, watts, d 1 to d 21 of lactation) was calculated using the partial regression coefficients and variances for sow BW, mean daily litter weight gain, and DFI. A two-sample *t* test was performed to test for significant differences for PMHP between genetic lines and parities. Parity group differences were similar for the genetic lines ($P > 0.05$). No differences were observed for PMHP between genetic lines ($P > 0.05$). The PMHP were 459.2, 507.3, 541.3, and 554.7 W for P1, P2, P3–5, and P6+ sows, respectively. Parity 1 sows had less PMHP than all greater parity sows ($P < 0.05$). Parity 2 sows had less PMHP than P3–5 and P6+ sows ($P < 0.05$). No difference was found in the PMHP between P3–5 and P6+ sows ($P > 0.05$). The coefficients of variation were 18.4, 17.6, 17.1, and 15.5% for P1, P2, P3–5, and P6+ sows, respectively. Within a parity, variation in DFI accounted for approximately 95% of the variation in PMHP. The model was also applied to older data (Shurson et al., 1986; Noblet and Etienne, 1987) with lower sow productivity. The model estimated that the current sows produce approximately 24 to 39% more heat than past sows. Heat production increases with parity, and there is substantial variation for PMHP within sows of the same parity. Strategies to remove the excess heat production of lactating sows in high environmental temperatures should try to account for sources of variation in heat production.

**Key Words:** heat production, lactation, sow
doi: 10.2527/asasmw.2017.064

**065 Effect of gestational β-hydroxy-β-methylbutyrate supplementation and sire line on piglet quality.**
M. Parker, M. T. Knauer*, *North Carolina State University, Raleigh.*

The objective was to investigate the impact of gestational β-hydroxy-β-methylbutyrate (HMB) supplementation and sire

line on piglet quality. During gestation, second parity sows ($n$ = 63) were fed daily 2.1 kg of a diet formulated to 0.58% SID lysine and 2979 kcal ME per kg. All other nutrients met or exceeded NRC (2012) requirements. From 100 d of gestation to farrowing, sows were randomly chosen to receive either 6 g of HMB daily or no supplementation (CON). Supplementation was added to the sow's feed drop box. Genetics consisted of composite PIC Landrace × Large White females mated to either Duroc or composite Landrace × Large White (L×LW) males. Sows were housed in individual gestation stalls with ad libitum access to water and natural ventilation. Sow body condition was monitored at the last rib with the sow body condition caliper. Sows farrowed near Plymouth, NC, in the fall of 2015. Piglets were individually weighed and identified within 1 d of birth and at 21 d of age. Traits included total number born (TNB), litter birth weight (LBW), average piglet birth weight (BWT), litter birth weight CV (BWT_CV), litter size at weaning (LSW), litter weaning weight (LWW), average piglet weaning weight (WWT), litter weaning weight CV (WWT_CV), and piglet survival. All litter traits were calculated as those of the biological dam. Data were analyzed using PROC GLM in SAS. Fixed effects included HMB supplementation and sire line. Total number born and LSW were include as covariates for LBW, BWT, and BWT_CV and LWW, WWT, and WWT_CV, respectively. Supplementing HMB from Day 100 of gestation to farrowing did not impact ($P > 0.05$) LBW (15.6 vs. 15.5 kg), BWT (1.20 vs. 1.19 kg), BWT_CV (18.4 vs. 19.5%), LWW (53.1 vs. 53.0 kg), WWT (5.1 vs. 5.3 kg), WWT_CV (16.0 vs. 16.1%), or piglet survival (81.0 vs. 77.8%) when compared to CON sows. Sows mated to Duroc sires had greater ($P < 0.01$) LBW (16.0 vs. 14.3 kg), BWT (1.26 vs. 1.15 kg), LWW (55.4 vs. 49.5 kg), and WWT (5.5 vs. 4.9 kg) when compared to litters sired by L×LW. Yet Duroc sired litters had comparable BWT_CV to L×LW sires (18.6 vs. 18.2%, respectively) and WWT_CV (16.7 vs. 17.7%, respectively). Results suggest sire line, but not HMB, can substantially impact piglet quality. Hence, terminal sire lines should be evaluated for piglet quality and reproductive throughput in addition to grow-finish traits.

**Key Words:** HMB, piglet, genetic
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**066 Effects of frequency and time of feeding during gestation on sow and litter performance.** H. Manu*, P. Ren, D. Pangeni, B. Tostenson, X. Yang, A. Tekeste, L. Su Hyup, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

The aim of this study was to investigate the effect of feeding frequency and time given similar quantity of feed per kilogram $BW^{0.75}$ during gestation on sow and subsequent litter performance. One hundred and thirteen sows [(Landrace × Yorkshire); initial BW 208.75 ± 4.14 kg; parity 3.90 ± 0.58; backfat (BF) 12.88 ± 0.72 mm] were blocked by BW, BF, and farrowing date and randomly assigned to 1 of 5 treatments in a randomized complete block design. Gestating sows were provided a common corn-soybean meal-based diet once [0730 (Control, T1), 1130 (T2), or 1530 h (T3)], twice [half ration at 0730 and 1530 h (T4)], or thrice [one third portion at 0730, 1130, and 1530 h (T5)]. On average, sows were given 6834, 7206, and 7531 kcal ME $d^{-1}$ during d 30 to 60, d 61 to 90, and d 91 to 109 of gestation, respectively. The daily feed quantity during each period was calculated by multiplying the kilogram $BW^{0.75}$ of d 30, 60, and 90 by 1.25 $ME_m$ (NRC, 2012), divided by kcal of ME/kg of diet. One common lactation diet was provided to the sows during lactation. The gestation diet was formulated to contain 3188 kcal of ME/kg, 0.75% Ca, 0.59% total P, 0.57% SID Lys, 0.24% SID Met, 0.46% SID Thr, 0.14% SID Trp, and 0.47% SID Met+Cys. BW and BF were recorded on d 30, 60, 90, and 109 of gestation, 24 h after farrowing, and at weaning. The data were analyzed using MIXED procedure of SAS 9.4 with treatment as fixed effect and block as random effect. Statistical significance was set at $P \leq 0.05$, while a trend was considered at $0.05 < P \leq 0.10$. Data were presented as least squares means ± SE. Thrice feeding during gestation tended to be associated with high mummified fetuses compared with the control (0.11 ± 0.01 vs. 0.48 ± 0.01, $P = 0.06$). Sows fed twice daily in gestation lost a significant amount of backfat during lactation compared to the control (−0.34 ± 0.41 vs. −1.38 ± 0.37 mm, $P \leq 0.04$) but similar to sows fed thrice a day. Sows fed once at 1530 had a tendency to have lower reduction in body weight change from d 109 post-insemination to 24 hr postpartum relative to the control (−18.33 ± 3.5 vs. −9.83 ± 3.1 kg, $P = 0.07$), although they had similar litter size (12.28 ± 0.84 vs. 12.46 ± 0.76, $P > 0.10$) and average birth weight (1.45 ± 0.05 vs. 1.41 ± 0.04 kg, $P > 0.10$). In conclusion, feeding gestating sows more than once a day in small allotments did not influence sow reproductive performance.

**Key Words:** feeding frequency, gestation sows, performance
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**067 Effect of the lactation length of piglets on their later performance.** S. López-Vergé[1,*], D. Solà-Oriol[1], J. Bonet[2], J. Coma[2], J. Gasa[1], *[1]Animal Nutrition and Welfare Service, Department of Animal and Food Sciences, Universitat Autònoma de Barcelona, Bellaterra, Spain, [2]Vall Companys Group, Polígono Industrial El Segre, Lleida, Spain.*

The lactation period, besides being only a slight fraction of the total cycle up to slaughtering, plays an important role determining the future performance of piglets. Moreover, since weaning is normally done at a fixed day for all sows belonging to the same parturition batch, it leads to differences in d of lactation depending on the farrowing day. It is hypothesized that little variations in d of lactation could affect both BW at weaning and also at slaughtering. The objective of this study was

to observe the effect of the lactation length of sows belonging to the same batch on the subsequent performance of piglets at weaning and at 165 d of age. A total of 702 males and females crossbreed piglets [Pietrain × (Landrace × Large White)] from 70 multiparous sows (parity ranging from 2 to 10) were used and individually weighed every 3 wk (from birth to slaughter). Weight data for each pig were adjusted using the double exponential Gompertz model (BW = A*exp(-exp(b-(c*t))), and the BW at d 165 of age was estimated for each pig using this model to correct the age effect among pigs. Means were calculated as LSmeans. The BW at birth (BW0) was added as a covariate using the proc GLM of SAS. The effect of d of lactation was found to be significant at weaning ($P < 0.001$) and at the end of the cycle ($P = 0.004$). Results (in kg of BW) for weaning were $4.54^{b}$, $5.31^{a}$, $5.50^{a}$, $5.64^{a}$, and $5.53^{a}$ kg, and those for 165d of age were $93.22^{b}$, $96.54^{a,b}$, $96.75^{a}$, $98.01^{a}$, and $100.05^{a}$ for 18, 19, 20, 21, and 22 d of lactation, respectively. The consequence was that a small difference of around 1 kg at weaning increased to almost 7 kg (6.84 kg) at d 165. Increasing the length of lactation from 18 to 22 d caused a significant linear BW increase in both, at weaning (231 g/extra d of lactation; $R^2 = 0.70$; $P < 0.05$) and at 165 d of live (1151 g/extra d of lactation; $R^2 = 0.92$, $P < 0.05$). It is concluded that piglets coming from sows that farrow earlier in a batch increase the d of lactation and produce heavier pigs at 165 d of age; consequently, shortening the farrowing period within a batch without using artificial farrow synchronization could help to reduce the differences in BW at the end of the cycle and may help producers to increase the farm efficiency.

**Key Words:** lactation, piglets, efficiency
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**068 Characterization of birth weight and colostrum intake on piglet survival and piglet quality.**
J. G. Wiegert*, C. Garrison, M. T. Knauer, *North Carolina State University, Raleigh.*

The objective was to quantify the relative importance of piglet birth weight and colostrum intake on subsequent piglet survival and weaning weight. Second parity, composite Landrace × Large White females ($n = 61$) farrowed 808 piglets at the North Carolina Department of Agriculture Tidewater Research Station in summer 2016. Sows were housed in modern, environmentally controlled buildings with ad libitum access to water. At birth, piglets were individually identified and weighed (BWT). Piglets were again weighed at 24 h of age (WT24) and at 21 d of age (WWT). Colostrum intake (COLOSTRUM) was estimated as WT24 - BWT. Piglet survival (SURVIVAL) included stillborns and was recorded as 1 = alive at weaning or 0 = not alive. Data analysis was completed in SAS using PROC LOGISTIC for survival and PROC GLM for WWT. Piglet was the observational unit. Average BWT, WT24, COLOSTRUM, and WWT were 1.145, 1.257, 0.102, and 5.32 kg, respectively. Piglet survival from birth to 24 h of age and from birth to weaning was 94.7 and 83.8%, respectively. Piglet BWT had a curvilinear association ($P < 0.01$) with SURVIVAL ($R^2 = 0.14$). As BWT increased, SURVIVAL improved at a decreasing rate, with SURVIVAL plateauing at a BWT of 1.2 kg. Piglet COLOSTRUM was associated ($P < 0.01$) with SURVIVAL ($R^2 = 0.19$). As COLOSTRUM increased, SURVIVAL improved at a decreasing rate, with SURVIVAL plateauing at a COLOSTRUM of 200 g. Piglet WT24 explained 20% of the variation in SURVIVAL. Yet the component traits of WT24, BWT, and COLOSTRUM together explained 26% of the variation in SURVIVAL. A kg increase in BWT improved ($P < 0.01$) WWT by 2.8 kg ($R^2 = 0.34$). Piglet COLOSTRUM had a curvilinear association ($P < 0.01$) with WWT ($R^2 = 0.21$). As COLOSTRUM increased, WWT improved at an increasing rate. Piglet WT24 explained 42% of the variation in WWT. Yet the component traits of WT24, BWT, and COLOSTRUM together explained 43% of the variation in WWT. Results describe the relative importance of BWT, WT24, and COLOSTRUM in relation to piglet SURVIVAL and WWT. Piglet WT24 accounted for greater than 40% of the variation in WWT. Hence, strategies that increase piglet birth weight and piglet colostrum intake will substantially enhance piglet quality at weaning.

**Key Words:** survival, piglet, colostrum
doi: 10.2527/asasmw.2017.068

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**069 Troubleshooting poor litter size in a farrow-to-wean production system.**
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Large volumes of underutilized performance records are generated on swine farms. Further analysis of these data may allow for identification of performance issues and causative associations. Hence, the objective was to troubleshoot low litter size in a production system using the National Swine Reproduction Guide (NSRG). Sow records ($n = 235{,}807$) from nine farms within one production system were analyzed. Traits included total number born (TNB), number born alive (NBA), stillborns (STB), mummies (MUM), number weaned (NW), lactation length (LL), and wean-to-service interval (WSI). Decision boundary criteria (DBC) defined in the NSRG (U.S. Pork Center of Excellence, Des Moines, IA) deemed unacceptable included TNB less than 10.5 for parity 1 sows and less than 11.5 for multiparous sows, MUM greater than 2.5%, and WSI greater than 10 d. The DBC were evaluated within year (2011 to 2015), season, and parity category (1, 2, and 3+). Regression analysis utilized PROC GLM in SAS with fixed effects of farm, year, season, and parity. From 2011 to 2015, TNB increased ($P < 0.01$) from 11.93 to 12.75. By parity, TNB for parity 1, 2, and 3+ sows was 12.13, 11.98, and 12.52, respectively. For TNB, parity 1, 2, and 3+ sows failed to meet DBC 1, 24, and 6% of the time, respectively. For MUM, parity

1, 2, and 3+ sows failed to meet DBC 46, 44, and 49%, respectively. For WSI, parity 1 and 2+ sows failed to meet DBC 73 and 26%, respectively. A 1 d increase in LL improved ($P < 0.01$) subsequent TNB for parity 1 and 2+ sows by 0.045 and 0.073 piglets, respectively, and reduced WSI for parity 1 and 2+ sows by −0.060 and −0.052 d, respectively. A one piglet increase in NBA improved ($P < 0.01$) subsequent TNB for parity 1 and 2+ sows by 0.132 and 0.166 piglets, respectively. Yet increased NW reduced ($P < 0.01$) subsequent TNB for parity 1 and 2+ sows by 0.075 and 0.048 piglets, respectively. Sows mated d 7 and 8 after weaning had lower ($P < 0.01$) subsequent TNB when compared to all other sows (11.52 and 11.59 vs. 12.27). Using the NSRG, poor WSI and subsequent TNB of parity 1 sows suggest inadequate nutrition in lactation. To increase litter size, the production system should evaluate lactation nutrition, consider extending LL, allow sows displaying estrus 7 and 8 d post-weaning to be bred on the next cycle, and not cross-foster excess piglets onto parity one females.

**Key Words:** reproduction, swine, troubleshooting
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**070 Evaluation of the impact of errors in the sorting of pigs for market on sort loss at a range of marketing ages.** Y. Que*, F. A. Cabezon, A. P. Schinckel, *Department of Animal Sciences, Purdue University, West Lafayette, IN.*

The BW growth curves for 25, 4000-head finishing barns were simulated to 1) evaluate the impact of sorting errors on sort loss at different mean carcass weights (CW) and 2) demonstrate that the magnitude of sort loss due to inaccurate sorting is affected by the pigs' mean CW. Two types of errors were evaluated, BW estimation error (BWEE) and percentage of pigs not visually evaluated (PNVE). Pigs are not evaluated when the targeted number of pigs are identified and sorting stops with heavier pigs than those sorted not being evaluated. Four levels of BWEE with SD's of 0, 4, 6, and 8% of BW and 4 levels of PNVE (0, 8, 16, and 24%) were simulated. Sort loss was calculated using a market value system for a U.S. pork processor (IPC, Delphi, IN). Pigs were initially marketed in 3 marketing cuts, 25% at 169, 25% at 179, and the remaining 50% at 193 d of age. Marketing ages for the pigs were shifted in weekly intervals with mean ages of 155.5, 162.5, 169.5, 176.5, 183.5, 190.5, 197.5, 204.5, and 211.5 d of age. Two variables, number of pigs with sort loss and mean sort loss per pig in the barn, were fitted to a model including the fixed effects of level of marketing age (AGE), BWEE, PNVE, their interactions and random effect of replicate barn using the MIXED procedure of SAS®. The main effects of AGE, BWEE, and PNVE and AGE × PNVE, AGE × BWEE, and AGE × BWEE × PNVE interactions impacted both variables ($P < 0.001$). The effects of BWEE and interaction of BWEE × PNVE impacted ($P < 0.001$) both variables at all ages. The difference in sort loss/pig produced by the least accurate sorting (BWEE = 8% and PNVE = 24%) increased as the mean CW increased from $1.00 at 93 kg to $4.53 at 103 kg. Sort loss/pig increased more rapidly with increased CW at higher levels of BWEE and PNVE. The effect of inaccurate sorting to increase sort loss is minimized when the mean CW is close to the middle of the pork processor's acceptable CW range and increases as CW increases to those approaching the upper acceptable CW range and is dependent on the marketing grid.

**Key Words:** marketing, sort loss, pork
doi: 10.2527/asasmw.2017.070

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**071 Evaluation of the impact of the magnitude of errors in the sorting of pigs for market on the optimal market weight.** J. Cheng*, F. A. Cabezon, Y. Que, A. P. Schinckel, *Department of Animal Sciences, Purdue University, West Lafayette, IN.*

The objective was to estimate the impact that the accuracy in which pigs are sorted for marketing has on the optimal market carcass weight (CW) and economic returns. Two types of errors were evaluated in a stochastic model, BW estimation error (BWEE) and percentage of pigs not visually evaluated (PNVE). Pigs are not evaluated when the targeted number of pigs are identified and sorting stops with heavier pigs than those sorted not being evaluated. Four levels of BWEE with SD's of 0, 4, 6, and 8% of BW and 4 levels of PNVE (0, 8, 16, and 24%) were simulated. Initially, pigs were marketed in 3 marketing cuts (MCUT), 25% at 169, 25% at 179, and the remaining 50% at 193 d of age. The timing of marketing was shifted in 7 d intervals with mean marketing ages of 155.5 to 211.5 d with mean CW's of 75.7 to 108.7 kg. Sort loss was calculated using a market system for a U.S. pork processor (IPC, Delphi, IN). Mean for sort loss ($/pig) values for the pigs in the barn were fitted to a polynomial function of mean CW for each combination of BWEE and PNVE. The increase in mean sort loss for each unit increase in CW above 93 kg increased as BWEE and PNVE increased. Pork production costs were estimated using an industry spreadsheet. A base price of $1.433/kg of CW was used to produce a small profit per pig. Lean premium (LPREM, $/100 kg CW) for gilts was estimated as LPREM = 0.4665 – 0.00198 CW, kg ($R^2 = 0.99$) and for barrows was LPREM = 0.4176 – 0.00216 CW, kg ($R^2 = 0.99$). The optimal CW's to maximize profit/pig and daily returns above daily costs were estimated for each combination of BWEE and PNVE. With accurate sorting, (BWEE = 0, PNVE = 0%) the optimal mean age for the 3 MCUT strategy was 190.5 d (176, 186, and 200 d MCUTs) at a mean CW of 97.0 kg and profit of $3.35/pig. With less accurate sorting (BWEE = 8%, PNVE = 24%), the optimal mean age decreased to 184.5 d with mean CW of 93.4 and profit of $2.00/pig. The optimal market ages and CW's decreased as the accuracy of sorting pigs decreased. The impact of inaccurate sorting of market hogs on the optimal market BW is impacted by several

factors (marketing grid, feed costs, market prices, etc.).

**Key Words:** sort loss, pork, marketing
doi: 10.2527/asasmw.2017.071

**072 Effects of supplemental betaine to semen extenders on semen quality in boars.** D. W. Lugar[1,*], W. A. Krom[1], J. A. Proctor[1], P. D. Mings[1], K. R. Stewart[2], [1]*Purdue University, West Lafayette, IN,* [2]*Department of Animal Sciences, Purdue University, West Lafayette, IN.*

The objective of this study was to determine the effects of supplemental betaine in semen extender on estimates of semen quality. Eight intact male pigs were used in a 4×2 factorial study replicated for 3 wk. Semen was collected from each animal one time per week, diluted into a commercial semen extender (Enduraguard Plus; MOFA, Verona, WI) containing 0, 0.6, 1.2, or 2.4% betaine, and evaluated following dilution (d 1) and after 4 d of storage at 17°C (d 4). Evaluations included sperm motility and mobility estimations using computer assisted sperm assessment (Ceros II, IMV Technologies) and morphological assessment. Statistical ANOVA was performed using the mixed procedure of SAS (9.4). Main effects for statistical analysis included treatment, week, day of analysis, and all interactions. Extender pH and semen concentration were used as covariates and laboratory and collection technician as random effects, where appropriate. On d 1, motility increased with 1.2% betaine ($P = 0.045$) and tended to increase with 0.6% ($P = 0.074$) compared to 0%, whereas 2.4% betaine was lower than 0.6% and 1.2% ($P < 0.001$ and $P = 0.002$, respectively). Percent motile sperm LS means for 0%, 0.6%, 1.2%, and 2.4% on d 1 were 69.15, 76.29, 76.97, and 65.58% ± 2.95, respectively. Straight line velocity was increased for 0.6% and 1.2% compared to 0% ($P = 0.048$ and $P = 0.015$, respectively). On d 4, motility ($P < 0.001$), straight line velocity ($P < 0.001$), and percent normal sperm ($P \leq 0.023$) in the 2.4% betaine samples were reduced compared to all other treatments. There was a treatment by day of storage by week interaction for percent of sperm with tail abnormalities ($P = 0.042$). In general, the addition of 2.4% betaine caused an increase in tail abnormalities. The treatment effect LS means for tail abnormalities for 0%, 0.6%, 1.2%, and 2.4% were 4.24, 5.27, 5.20, and 11.62% ± 1.62, respectively. Regardless of day of evaluation, linearity was decreased in the 2.4% betaine treatment ($P < 0.001$) and tended to increase in the 0.6% and 1.2% compared to 0% ($P = 0.093$ and $P = 0.070$, respectively). The results of the current study indicate that the addition of 0.6 or 1.2% betaine to semen extenders can improve sperm motility and mobility without adverse effects on normal sperm morphology. In addition, supplemental betaine at 2.4% has negative effects on estimates of semen quality.

**Key Words:** betaine, boar, semen extender
doi: 10.2527/asasmw.2017.072

**073 Effect of tail docking on welfare and performance of pigs during nursery and growing-finishing periods.** Y. Li*, L. J. Johnston, *West Central Research and Outreach Center, University of Minnesota, Morris, MN.*

Tail docking of pigs is under scrutiny due to concerns about animal welfare. To reevaluate the consequences of raising pigs without tail docking under modern, commercial-like conditions, a study was conducted to compare welfare, behavior, and performance of pigs with and without tail docking. Pigs farrowed to 37 sows were used with half of each litter tail-docked (docked) after birth and remaining pigs left with tails intact (intact). During the nursery period, pigs ($n = 336$, initial wt = 7.8 ± 1.5 kg) were housed in 20 docked pens and 22 intact pens (8 pigs/pen). During the growing-finishing period, pigs ($n = 240$, initial wt = 24.9 ± 2.9 kg) were housed in 8 pens (4 pens each of docked and intact, 30 pigs/pen) for 16 wk (avg final wt = 126.2 ± 10.3 kg). Weight gain and feed intake were recorded. All pigs were assessed for tail damage and skin lesions every 4 wk and during outbreaks of tail biting. Behaviors were video-recorded twice weekly for 13 wk during the growing-finishing period. Carcass weights and incidence of carcass trim loss were recorded. More intact pigs experienced tail damage during both nursery (41% vs. 2%; chi-square = 75.7; $P < 0.0001$) and growing-finishing (89% vs. 48%; chi-square = 76.2; $P < 0.0001$) periods than docked pigs. Intact pigs spent more time tail biting (0.31% vs. 0.06%; $P < 0.001$) and tended to spend less time drinking (1.58 vs. 1.77%; $P < 0.10$) compared to docked pigs. Intact pigs experienced the first outbreak of tail biting at 11 wk of age, which occurred 6 wk earlier compared to docked pigs. Furthermore, 21% of intact pigs vs. 5% ($P < 0.001$) of docked pigs were removed due to tail damage. Tail docking did not affect ADG (nursery: 0.48 vs. 0.49 kg, SE = 0.04; growing-finishing: 0.86 vs. 0.87 kg, SE = 0.01 for docked and intact pigs, respectively) or skin lesions of pigs. For pigs that were not removed, ADFI was not different between pens with docked pigs and pens with intact pigs. As a consequence of carcass trim loss, carcass contamination, and mortality, 90% of intact pigs vs. 97% of docked pigs were harvested for full value. These data suggest that raising pigs without tail docking in a confinement housing system increases incidence of tail biting and tail damage, resulting in higher morbidity, reduced value, and compromised welfare of pigs.

**Key Words:** tail docking, performance, pigs
doi: 10.2527/asasmw.2017.073

**074 Effect of pad cooling on summer barn environment and finishing pig temperature.** J. G. Wiegert*, M. T. Knauer, S. B. Shah, *North Carolina State University, Raleigh.*

The objective was to compare tunnel ventilated finishing barns with cool cell pads (PAD) or without (CONTROL) for barn climate and pig temperature. Barns ($n$ = 4) were located at the same site in eastern North Carolina. Each barn had identical dimensions (12.5 m width × 45.5 m length) with four 1.2 m and one 0.9 m fans on the east end of the barn. Each PAD barn contained two cool cell pads (1.2 × 9.1 m) on the west end of the barn operating between 9 am and 9 pm (DAY). Barns were stocked between June (wk 0) and September (wk 13) 2016. Data loggers were hung 1.4 m above the floor at 6 (A), 23 (B), and 40 m (C) from the west end of the barn to record temperature and relative humidity (RH) every 15 min ($n$ = 115,154 observations). At wks 4, 5, 7, and 9 to 13, wind velocity (WIND) was recorded with an anemometer in the middle of the barn, and pig ear temperature (PET, $n$ = 345) was captured at locations A, B, and C using an infrared camera. Variables were analyzed using PROC GLM in SAS. Fixed effects for WIND included barn type and date. Fixed effects for PET included barn type, date, and logger location. External barn temperature, RH, and temperature humidity index (THI) were 31.1°C, 63.4%, and 78.0, respectively, during DAY and 22.8°C, 95.7%, and 65.3 at night. Compared to PAD barns, CONTROL temperature was greater ($P$ < 0.01) during DAY (28.2 vs. 30.3°C) yet was similar ($P$ = 0.15) at night (25.6 vs. 25.6°C). Greater RH ($P$ < 0.01) was observed in PAD barns compared to CONTROL during DAY (79.4 vs. 66.6%) and night (86.0 vs. 84.3%). Compared to PAD barns, THI was greater ($P$ < 0.01) for CONTROL during DAY (72.1 vs. 76.3) yet lower ($P$ < 0.01) at night (68.6 vs. 68.8, respectively). Wind velocity was greater ($P$ < 0.05) in PAD barns when compared to CONTROL (104.6 vs. 94.6 m/min). Average PET was lower ($P$ < 0.01) in PAD barns when compared to CONTROL (37.26 vs. 37.33°C). Yet there were no differences ($P$ > 0.05) between PAD and CONTROL at the base of the ear (37.72 vs. 37.67°C, respectively), tip of the ear (36.41 vs. 36.48°C, respectively), or temperature drop from the base to the tip of the ear (−1.34 vs. −1.20°C, respectively). Results suggest PAD barns, when compared to CONTROL, improved barn THI during DAY but not at night and did little to alleviate pig heat load.

**Key Words:** cooling, evaporative, pig
doi: 10.2527/asasmw.2017.074

**075 Changes in feet and leg joint angles during first gestation in gilts divergently selected for residual feed intake.** J. D. Stock[1,*], J. M. Mumm[1], J. C. M. Dekkers[1], A. K. Johnson[1], S. Azarpajouh[1], K. J. Stalder[1], J. A. Calderon Diaz[2,3], *[1]Department of Animal Science, Iowa State University, Ames, [2]Department of Animal Behavior and Welfare, Institute of Genetics and Animal Breeding, Polish Academy of Sciences, Jastrzębiec, 05-552 Magdalenka, Poland, [3]Pig Development, Teagasc Moorepark Grassland Research and Innovation Centre, Fermoy, Co. Cork, Ireland.*

Studies have suggested that feet and leg conformation can change as sows age. It has been visually observed that gilt feet and leg conformation deteriorate from the end of the finisher period to first parity. The objective of this study was to evaluate the feet and leg joint angle changes measured during gestation using objective evaluation methods from lines that were divergently selected for residual feed intake (RFI). Yorkshire gilts from the 10th generation of Iowa State University's RFI lines (low RFI $n$ = 23 and high RFI $n$ = 17) were evaluated. Prior to image capturing, gilts were subjectively classified as lame and non-lame. On Days 30, 60, and 90 of gestation, gilts were moved to an individual stall where profile digital images were obtained. Joint angles for knee, front and rear pastern, and hock were measured using the angle feature in image analysis software. Data were analyzed using linear mixed models with gestation days, RFI line, and lameness score included as fixed effects. Changes in joint angle across gestation days were observed for the knee and the front and rear pasterns ($P$ < 0.05). Angles decreased 1.1 ± 0.5, 2.7 ± 0.9, and 3.1 ± 1.0 degrees in the knee and in the front and rear pastern, respectively, from Days 60 to 90 ($P$ < 0.05). A similar tendency for these anatomical locations was observed between Days 30 and 90 ($P$ < 0.10). Low RFI gilts had straighter front pasterns (60.9 vs. 57.9 ± 0.85 degrees) and rear pasterns (66.1 vs. 58.7 ± 1.1 degrees) compared to high RFI gilts ($P$ < 0.05). Lame gilts had greater knee joint angles (160.8 lame vs. 159.8 ± 0.43 degrees sound) and front (60.1 lame vs. 58.6 ± 0.78 degrees sound) and rear pastern joint angles (63.7 lame vs. 61.1 ± 0.96 degrees sound; $P$ < 0.05). Hock joint angle was not associated with any fixed effects in the model ($P$ > 0.05). Under the conditions of this study, differences in joint angles were observed as gestation progressed in gilts; however, such differences were minimal, and their biological relevance is unclear. Nonetheless, results suggest that life events such as gestation, lameness etiology, and genetic selection play a role in gilt structural changes.

**Key Words:** joint measurements, digital imagery, feet and leg conformation
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**076 Mycotoxin prevalence in the 2016 corn crop.**
E. G. Hendel[1,*], S. M. Mendoza[1], T. Jenkins[2], G. R. Murugesan[1], *[1]BIOMIN America Inc., San Antonio, TX, [2]BIOMIN Holding, GMBH, Getzersdorf, Austria.*

Mycotoxins are harmful secondary metabolites produced by fungal species capable of infesting commercial crops. These fungal species are roughly divided into two groups: those predominantly producing mycotoxins on the field (e.g., *Fusarium* spp.) and those predominantly occurring in storage (e.g., *Aspergillus* and *Penicillium* spp.). Mycotoxin contamination of feed materials is a global concern, as exposure to mycotoxins significantly impacts animal health and productivity. BIOMIN® has been conducting annual corn surveys in the United States since 2012. The purpose of this study is to evaluate the mycotoxin contamination of the 2016 corn crop. Seventy-seven corn samples, collected from mid-August to October 2016, were analyzed utilizing LC-MS/MS. Samples came from 12 states, with 85% of samples originating from the Midwest. Samples were submitted due to reproduction concerns ($n$ = 4), surveying new crop ($n$ = 59), and non-specified reasons ($n$ = 14). Six major mycotoxin groups were analyzed including aflatoxins, type A trichothecenes, type B trichothecenes (B-TRICH) such as deoxynivalenol (vomitoxin), ochratoxin-A, fumonisins (FUM), and zearalenone (ZEN) derivatives (limit of detection in ppb: 100, 100, 1.1, 100, 51.7, respectively). Eighty-three percent of the samples contained at least one detected mycotoxin type, similar to the 2015 BIOMIN® US corn survey (84% positive, 321 samples). However, there was a 15% increase in the number of samples contaminated with multiple mycotoxins (≥2 mycotoxins, 2016: 58%; 2015: 43%). This was primarily due to increased prevalence of FUM and ZEN (2016; FUM: 64%, ZEN: 26%) compared to the previous year (2015; FUM: 50%, ZEN: 14%). Additionally, the level of FUM in positive samples was significantly higher in 2016 (2016: median: 1100 ppb, $n$ = 77 2015; 2015: median: 400 ppb, $n$ = 321; $P$ = 0.003, Mann-Whitney). The percent of positive samples of FUM over 1000 ppb (25 of 49 samples) increased by 24% compared to the 2015 harvest (43 of 161 samples). In contrast, the most prevalent mycotoxin B-TRICH had relatively unchanged prevalence and contamination levels (2016: 66% prevalence, 2015: 69%; 2015–16: 14% positive samples over 1000 ppb). The preliminary results from the 2016 corn harvest suggest an increased co-occurrence with mycotoxins produced by *Fusarium* fungal species. This includes co-occurrence with B-TRICH and FUM (2016: 34%, 2015: 28%) and with FUM, B-TRICH, and ZEN (2016: 14%, 2015: 7.5%). Because of the high frequency of multi-mycotoxin contamination in samples thus far, multiple strategies of mitigating risk are needed beyond adsorption, including biotransformation and providing support to immune and liver function.

**Key Words:** multi-mycotoxin contamination, deoxynivalenol, fumonisin
doi: 10.2527/asasmw.2017.076

**077 Metabolomic characterization of foaming manure pits in swine barns.**
Z. Bi[1,*], J. Gan[1], H. Li[1], B. Hu[1], C. Chen[2], *[1]University of Minnesota, St. Paul, [2]Department of Animal Sciences, University of Minnesota, St. Paul, MN.*

Foaming in manure pits has become a major concern in the Midwestern swine barns. Besides reducing storage capacity of manure pits, foaming has led to explosions by trapping methane gas. To understand the mechanisms of foaming and to develop prevention and mitigation treatment, chemical profiles of foaming and non-foaming manure pits were compared through liquid chromatography-mass spectrometry (LC-MS)-based metabolomics analysis. In total 101 field samples were collected from multiple farms, including 73 samples from foam (A), transition (B), slurry (C), and sludge (D) layers of foaming pits, as well as 28 samples from slurry (C) and sludge (D) layers of foaming pits. Lipid and aqueous fractions of these samples were analyzed by multiple LC-MS methods for comprehensive metabolite coverage, followed by multivariate analysis, marker identification, and characterization. The results from unsupervised principal component analysis (PCA) indicated that the chemical profile of layer A distinctly differed from that of the other three layers, while supervised partial-least squares (PLS) analysis further revealed the metabolic differences between foaming and nonfoaming pits as well as the correlations between individual metabolites and foaming heights. Significantly higher levels of long-chain fatty acids, including stearic acid (C18:0) (244.20 vs. 123.53 relative abundance, $P < 0.01$) and palmitic acid (C16:0) (285.83 vs. 178.12 relative abundance, $P < 0.01$), were detected in the samples from foaming pits. More importantly, ubiquinone 9 and ubiquinone 10 in A layer samples were found to be significantly higher than their levels in other samples from both foaming and nonfoaming pits ($P < 0.01$). Since ubiquinones function as the stabilizers of phospholipid membranes, their enrichment in layer A could improve the stability of foam. Additional lipid species, potentially from bacterial origins, have also been identified as the markers of foaming, and their chemical structures are currently under investigation. Overall, these results suggested that both nutrient supply and microbial lipid metabolism may contribute to the foaming in manure pits.

**Key Words:** metabolomic, foaming manure, swine barns
doi: 10.2527/asasmw.2017.077

## GARY ALLEE SYMPOSIUM:

## SWINE INDUSTRY EXPANSION: NEEDS AND OPPORTUNITIES WITHIN

**078 Overview of swine industry growth: Packing and production facilities needed for growth.** L. Mulberry* and D. DiPietre, *KnowledgeVentures, LLC, Columbia, MO.*

Three new major packing facilities, expansion in total sow herd size, ever greater herd productivity, and the proposed cancelation and abandonment of multilateral trade agreements such as the Trans Pacific Partnership (TPP), are combining to cause the US pork industry an unpredictable, and potentially tumultuous future. Over the past 5 years, the sow inventory held by the largest US producers increased 29.4%; and from 2015 to 2016 by 3.4% while USDA reported the total US breeding inventory rose 1%. Advances in genetics and management practices, the continued shifting of the share of the US breeding herd to the largest producers and the move to larger standard breeding herd facilities all contributed to the regular rise in sow herd efficiency. USDA reported a 1% increase in pigs weaned per litter from 2015 to 2016 and coupled with the increase in total sow numbers, sent hogs marketed to record highs. An unexpected uptick in the pork cutout late last year reversed a plunge in fourth quarter prices and stemmed the flow of red ink indicating that both domestic and export demand in the last quarter of 2016 and early 2017 firmed enough to offer profits to producers. Coupled with a global glut of feed grain production and availability, low feed costs have been enticing producers to expand their production despite the recent price slumps. The domestic market is essentially saturated with pork and total red meat which also reached a record in 2016, leaving the major driver of growth to be increased exports. Over the last decade or so exports have seen a 69% increase in volume and a 95% increase in value over the previous decade. However, from 2015 to 2016 there was a -2% decline in volume and a -16% decline in value. A strong dollar, potential trade disturbances from the shift toward unilateral over multilateral trade pacts and the potential alienation of Mexico due to immigration enforcement is presenting a troubled outlook which has not escaped the eyes of EU pork processors. Withdrawal from TPP means expanding hog production must drive new deals soon or face depressed prices. The EU has emerged as the largest exporter of pork in the world with Spain growing rapidly while powerhouse Germany is reducing production. The EU supplied China with 70% of its total imports last year and has a strong offering in Japan, two markets US growth depends on for future profitability.

**Key Words:** packing, economics, swine
doi: 10.2527/asasmw.2017.078

**079 What does growth mean for the swine industry: Economics and exports.** S. Malakowsky*, *AgStar Financial Services, Mankato, MN.*

With the U.S industry exporting between 24 and 25% of all pork produced, what impact will the anticipated growth of 5 to 8% over the next 2 yr have? Swine Expert at AgStar Financial Services, Steve Malakowsky, will present potential risks to exports, including the effect of a new U.S. presidency on trade deals such as NAFTA and TPP. He will also take time to present a unique database model that includes approximately 20% of the U.S industry. These data include all companies that utilize GAAP accounting principles and compare the performance of the group to the Iowa State Model (that assumes selling a hog, buying corn and meal every day with no marketing decisions involved).

**Key Words:** NAFTA, TPP, pork export
doi: 10.2527/asasmw.2017.079

**080 Nutritional philosophies for formulation and practical approaches to feeding during times of depressed margins.** P. M. Cline*, *Christensen Farms, Sleepy Eye, MN.*

For swine producers the next year or two will be a period of time where margins will be tight and any unnecessary costs could result in going from profitable to losing money. An area of focus should be around feed costs as feed represents between 60 and 70% of the cost of raising a pig. However, there are multiple philosophies a nutritionist can use to influence feed cost such as true least cost formulation where the main goal is feeding the cheapest diet possible, maximum performance formulation where the focus is on gain and feed efficiency with little focus on diet cost, or a blend between the two. The latter is known in Christensen Farms as "optimal" nutrition and formulation. The optimal nutrition and formulation approach involves coordination, teamwork, and trust from multiple different areas of swine production. The first area is the groundwork of knowing the nutritional requirements of your pig for each phase. Another area is knowing the nutritional value of the feed ingredients available in your geography. Specific to nutrition and formulation there are multiple additional considerations that must be taken into account beyond nutritional requirements and ingredient value. A nutritionist must choose the energy system that they believe best predicts performance (ME, ModME, or NE). Beyond the energy system, knowing the value of energy (fat and/or fiber) in terms of expected response in intake, gain, and/or feed efficiency is critical when modeling the expected performance. Nutritionists should also focus on maximizing the value out of the feed that is already going to be fed such as reducing corn grind, pelleting, using phytase, and evaluating carbohydrate enzymes as a few examples. In addition to the nutritional requirements and ingredient value a nutritionist must be able to anticipate or

predict future ingredient costs to use for modeling feed costs and expected return. A nutritionist must also know the value of space and whether the producer is in a short space or long space scenario. Once nutritional requirements, ingredient value, ingredient costs, and space are determined, then a nutritionist can model finishing performance and cost using multiple different ingredients at different inclusion levels to find the solution that may not maximize growth performance but is the optimal solution that maximizes margin over feed.

**Key Words:** diet formulation, optimal nutrition, swine
doi: 10.2527/asasmw.2017.080

**081 Technologies to reduce the reliance on antibiotics.**
C. Johnson*, *Carthage Veterinary Service, Carlyle, IL.*

Alexander Fleming, a Scottish scientist, discovered our first antibiotic, penicillin. Since their discovery, antibiotics have served as a cornerstone of human and animal medicine, preventing pain, suffering, and death in billions of patients throughout the world. Modern animal agriculture has been built around the readily available use of antibiotics, reducing mortality while improving animal well-being, caloric conversion, and growth. All antibiotic use contributes to antibiotic resistance, and the general public has become increasingly concerned about potential areas of antibiotic "overuse." Animal agriculture is increasingly credited with causing proliferation of antibiotic resistant pathogens threatening human health. While the scientific community lacks consensus on how to stack rank risk factors for antibiotic resistance development, our reality is animal agriculture is being told to reduce our reliance on antibiotics. Food animal veterinarians rely heavily on pathogen identification to influence antibiotic decisions. Advances in molecular diagnostics have provided us with technology to readily identify pathogens. Over the past 15 yr our ability to identify pathogens has greatly outpaced our understanding of their importance in disease. Acting with the animal's best interest in mind, we often employ the precautionary principle and utilize the tools in our toolbox to immediately protect diseased animals with antibiotics. Losing or reducing access to these tools will require food animal veterinarians to improve our diagnosis and management of non-infectious disease. Technological resources will be required to more rapidly identify metabolic, autoimmune, traumatic, and musculoskeletal disease and avoid antibiotic use in inappropriate cases. The principles of precision agriculture should be employed to reduce antibiotic use. The vast majority of antibiotics ingested by animals are either converted into non-effective metabolites or distributed to non-target tissues. Technology to identify specific animals with infectious disease and administer therapy in low doses directly to target tissues will result in a dramatic decrease in total antibiotic usage. Improving health management will require improved cross-functional problem solving. Veterinarians, nutritionists, and geneticists must work collaboratively to solve problems in a world with reduced antibiotic use. There is not only a technology resource need but also an academic resource need. Cross-functional programs must be developed to supplement the existing disciplines which have been rigidly defined over the last 50 yr. The true leaders in health management in a world of limited antibiotic access will be those who best understand the complex interactions of genotype and environment.

**Key Words:** antibiotics, health management, non-infectious disease
doi: 10.2527/asasmw.2017.081

## GRADUATE STUDENT ORAL COMPETITION: M.S.

**082 Growth performance responses of growing pigs when fed corn-soybean meal diets with corn DDGS treated with fiber degrading enzymes with or without extended steeping.**
Y. Rho[1,*], K. Moran[2], D. Wey[1], C. Zhu[1], M. C. Walsh[3], E. Kiarie[1], E. van Heugten[2], C. F. M. de Lange[1], *[1]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, [2]North Carolina State University, Raleigh, [3]Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK.*

Steeping high fiber ingredients like DDGS with carbohydrases may potentially improve their feeding value. We investigated growth performance of growing pigs fed diets containing DDGS treated with a blend of β-glucanase and xylanase (XB) with or without extended steeping. Treatments were 1) corn- soybean meal based diet with 30% DDGS (C), 2) C + XB without steeping (XBNS), and 3) C + XB with the DDGS steeped with XB (16% DM) for 3 to 8 d at 40°C (XBS). All diets had phytase (750 FTU/kg) and met nutrient requirements for growing pigs. The target activities for XB were 1050 and 5500 U/g of DDGS for β-glucanase and xylanase, respectively. Samples were taken during DDGS steeping and at feeding for pH analyses. A total of 144 pigs (25 kg BW) were assigned to pens (3 barrows and 3 gilts) based on initial weight and allocated to the three treatments in a 2-phase feeding program (3-wk/phase). Diets were delivered by computer controlled liquid feeding system at a feed to water ratio of 1:4, four times per day. Pigs had free access to water. At the end of the experiment, 1 pig per pen was sacrificed for gastrointestinal measurements. The average pH of steeped DDGS on d 0, 1, 3, 5, and 8 was 4.42, 3.65, 3.86, 3.89, and 3.92, respectively. The pH of diets at feeding time was lower ($P < 0.01$) for XBS (4.7) compared to C and XBNS (5.5). Pigs fed XBNS had higher ($P = 0.02$) ADG than C in phase 1 and in phase 2. Overall ADG was higher ($P < 0.05$) for XBNS than XBS, while pigs receiving C were similar to XBS pigs. There were no effects ($P > 0.05$) on ADFI throughout the experiment. However, pigs fed XBS had numerically lower ADFI in phase 1 (−4.0%) and phase 2 (−5.2%) relative to XBNS pigs. Pigs receiving XBNS (1.68) and XBS (1.69) had better feed:gain ($P = 0.001$) than C (1.78)

during phase 1. Treatments did not influence ($P > 0.05$) empty gastrointestinal weight. In conclusion, treating DDGS with XB with or without steeping resulted in improved feed efficiency for the first 3 wk, suggesting degradation by XB of dietary fibrous components that may limit nutrient utilization in younger pigs. Supplementation with XB improved ADG when DDGS were not steeped; however, steeping appeared to reduce feed intake, resulting in poorer ADG.

**Key Words:** pigs, corn DDGS, xylanase, β-glucanase, steeping
doi: 10.2527/asasmw.2017.082

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**083 Effects of yeast-derived rumen escape microbial protein on lactational performance and metabolic status of transition dairy cows.** V. Higginson*, B. Baurhoo, Y. Schuermann, M. Taibi, A. St-Yves, R. Duggavathi, A. Mustafa, *McGill University, Ste-Anne De Bellevue, QC, Canada.*

In dairy cows, the transition period is the most critical time that is often marked by negative nutrient balance due to high nutrient demands but low dry matter intake. Ruminal-escape protein derived from yeast (YMP) has shown to increase DMI and milk fat percentage in midlactation cows. However, the effects of YMP in transition cows are still unknown. Therefore, the objectives of this study were to evaluate the effects of YMP on dry matter intake, milk yield and components, and blood metabolites in transition cows. Twenty-seven primiparous and multiparous Holstein cows were blocked according to anticipated calving date and parity (1 to 7) and randomly assigned to receive either a control (0 g YMP) or treated (50 g YMP prepartum followed by 200 g YMP postpartum) pellet containing molasses and beet pulp. The pellets were given to individual cows 30 min prior to morning feeding. The experiment started 21 d prior to predicted calving date and ended 28 d postpartum. Blood samples were collected on d −21, −14, −7, −3, −1, 1, 3, 7, 14, 21, and 28 and were analyzed for metabolites, macrominerals, and proteins. In addition, DMI was recorded daily throughout the experimental period. Milk yield was measured daily, and milk samples were collected twice weekly on two non-consecutive days and were analyzed for fat, protein, lactose, somatic cell count, and urea. Supplementing YMP significantly lowered ($P < 0.05$) serum concentrations of non-esterified fatty acids from d 3 postpartum until the end of the study. Serum concentrations of β-hydroxybutyrate were also lower ($P < 0.05$) in YMP supplemented cows at d 3 and 7 postpartum. Moreover, YMP supplementation increased ($P < 0.05$) serum glucose levels at d 3 and 7 postpartum and lowered ($P < 0.05$) serum aspartate transaminase levels at d 14 and 21 postcalving. Both groups had similar DMI and lactational performance. Overall, our results suggest that YMP supplementation to transition cows may not influence their lactational performance but may significantly improve cow metabolic status during the postpartum period.

**Key Words:** transition cow, metabolic status, yeast-derived rumen escape microbial protein
doi: 10.2527/asasmw.2017.083

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**084 Effect of diet complexity and multicarbohydrase on growth performance and intestinal morphology in weaned pigs.** B. Koo[1,*], C. F. M. de Lange[2], C. M. Nyachoti[1], *[1]University of Manitoba, Winnipeg, MB, Canada, [2]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada.*

An experiment was conducted to investigate the effects of diet complexity and multicarbohydrase (MC) on growth performance and intestinal morphology in newly weaned pigs. One hundred and forty-two piglets (Yorkshire-Landrace × Duroc, initial BW 6.70 ± 0.81 kg) weaned at 21 d of age (1:1 male to female ratio) were assigned to 1 of 6 diets in a 3 × 2 factorial arrangement of treatments based on diet complexity (complex1, complex2, and simple) and MC addition (0 vs. 0.1g/kg), giving 8 replicates per treatment with 3 pigs per pen. Diets were provided in a 2-phase feeding program with phase I (d 0 to 14) and phase II diets (d 15 to 28). Complex1 contained conventional levels of animal protein sources and dairy products (i.e., whey, skim milk powder, fishmeal, and spray-dried animal plasma), whereas complex2 contained a variety of plant-based ingredients such as distillers dried grains with solubles, millrun, canola meal, peas, and flaxseed meal. The simple diet comprised primarily of corn, wheat, and soybean meal. No interactions were found between diet complexity and MC supplementation ($P > 0.10$). Pigs fed complex1 had higher ($P < 0.01$) ADG, ADFI, and G:F than those fed the other diets during the first wk post-weaning. However, no difference in BW was observed for pigs fed complex1 and the simple diet at the end of the experiment ($P > 0.10$), whereas pigs fed complex1 were heavier than those fed complex2 ($P < 0.05$). Also, no differences in ADG or ADFI of pigs fed the complex1 and simple diets were observed during the overall experimental period ($P > 0.10$), but complex2 led to poorer ADG and ADFI than complex1 ($P < 0.05$). Overall, G:F was higher for pigs fed the simple diet compared to those fed the complex1 ($P < 0.01$). Pigs fed complex1 had higher ileal villus height:crypt depth (VH:CD) ratio compared to those fed the complex2 or simple diets. Dietary supplementation with MC had no effect on ADG or ADFI ($P > 0.10$), but it did improve G:F during the overall experimental period, ileal VH, and ileal VH:CD ratio ($P < 0.05$). In conclusion, weaned pigs fed a simple diet had greater G:F than those fed a conventional complex diet (complex1) without compromising BW, although complex1 improved intestinal morphology in weaned pigs. Also, the addition of MC could be a beneficial feeding strategy for weaned pigs, improving G:F and intestinal morphology.

**Key Words:** diet complexity, multicarbohydrase, weaned pigs
doi: 10.2527/asasmw.2017.084

**085 Assessment of growth and health performance of pigs born from magnetically nanopurified boar spermatozoa.** C. L. Durfey[1,*], S. F. Liao[1], D. D. Burnett[1], M. A. Crenshaw[1], C. S. Steadman[1], S. T. Willard[1], P. L. Ryan[1], H. Clemente[2], J. M. Feugang[1], [1]*Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State,* [2]*Clemente Associates, Madison, CT.*

Semen ejaculates contain an assorted population of viable and non-viable spermatozoal cells, whose proportions can greatly jeopardize male fertility. Although non-viable spermatozoa carry measurable damages, their specific elimination from semen using current techniques remains unsatisfactory. Recently, a nanotechnology-based technique (nanopurification) has been developed to allow non-invasive targeting and removal of moribund spermatozoa. Through interactions with specific magnetic nanoparticles, the nanopurification process has the potential to enrich insemination doses with viable spermatozoa for breeding enhancement. However, this technique lacks sufficient information regarding post-natal development of offspring. The objective of this study was to assess growth and health performance of pigs born from sows inseminated with standard or nanopurified spermatozoa. Boar semen doses were harvested from a local stud and mixed with or without (control) magnetic nanoparticles (NP) designed to specifically interact with damaged spermatozoa. After incubation, NP-exposed semen was placed under a magnetic field trapping moribund spermatozoa, to collect viable (or nanopurified) spermatozoa through elution. Six gilts were bred with control ($n$ = 3) or nanopurified ($n$ = 3) semen, with pregnancies leading to full-term birth of viable offspring. At weaning, pigs of equal genders (5 males and 5 females) were randomly selected from control ($n$ = 10) and nanopurified ($n$ = 10) litters. Pigs were weighed every month until market size, with blood collected from weaning and every consecutive month following until market (Day 164). Data (mean ± sem) were analyzed with Student□s $t$ test using Statistical Analyzing Software (SAS). $P < 0.05$ was defined as the threshold of significance. From birth until market, pigs born from nanopurified semen (treated) continuously grew heavier but not significantly than the control ($P > 0.05$). At weaning, immunoglobulin G (IgG) concentrations were significantly lower in treated pigs compared to control (5146.33 μg/ml ± 1684.43 and 13,105.14 μg/ml ± 1883.50, respectively; $P < 0.05$) but comparable at market. A month after weaning, hematocrit percentages were found significantly higher in treated pigs (33.5% ± 1.0) compared to the control (29.75% ± 1.0) but remained similar until market ($p > 0.05$). Blood glucose and leukocyte (neutrophil, basophil, eosinophil, monocyte, and lymphocyte) concentrations in both groups remained within normal ranges during post-weaning growth. Results indicate nanopurification of boar semen does not impair offspring growth and performance. However, large-scale studies are needed for better investigation of more parameters, including hematocrit and IgG concentrations. Work supported by the USDA-ARS Grant#58–6402–3-018

**Key Words:** growth, health, boar semen

doi: 10.2527/asasmw.2017.085

**086 Timely on-farm euthanasia of pigs: Development of an innovative and interactive training program for caretakers.** C. R. Mullins*, M. Pairis-Garcia, M. R. B. Campler, *The Ohio State University, Columbus.*

Equipped with a unique skill set in understanding and disseminating knowledge of best animal husbandry practices, animal scientists engaged with livestock industries as Extension professionals or educators are well poised to provide needed guidance for those employed in animal care roles. In the swine industry, animal scientists work collaboratively with farm managers to assist in training both new and seasoned livestock caretakers on the importance of timely euthanasia decision-making as a means to end pain and suffering in severely injured or ill pigs. To provide an adjunctive educational tool for use by Extension agents, veterinarians, Pork Quality Assurance Plus (PQA Plus) advisors, and animal scientists, an interactive computer-based training program was created utilizing short, multimedia-rich, experiential learning segments. Three modules corresponding to different pig production stages (breeding stock, piglets, and wean to grower-finisher pigs) were developed with five case studies per module. Euthanasia criteria defined in the 2015 Common Swine Industry Audit served as guidance for selection of compromised pigs and subsequent development of the program. Most case studies challenge learners to identify the sick or injured pig by providing video clips and images. The case study structure provides a chronological timeline which highlights a combination of information related to a pig's treatment history, clinical signs, and condition severity. Utilizing this information, learners are prompted to select from available management decisions on treatment and care of the individual animal. Feedback regarding the appropriateness of all possible decisions is provided to allow learners the opportunity to understand the benefits and challenges associated with various options in the context of current industry guidelines and good swine welfare practices. Though intended largely for use by swine farm caretakers, this program may also be a valuable resource if incorporated into veterinary, graduate, and continuing education curriculum. Recognizing that improving animal care decision-making nationwide will require a concerted effort from multiple groups of stakeholders, familiarizing animal care educators with this novel training tool will provide those in the swine industry with a group of professionals with whom they can work to ensure good livestock husbandry. This innovative tool represents the first interactive euthanasia-specific training program in the swine industry and offers the potential to reduce the incidence of untimely euthanasia decisions

on-farm.

**Key Words:** computer training, pig welfare, timely euthanasia
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**087 Determining the phosphorus release for Natuphos E 5000 G phytase for nursery pigs.** K. M. Gourley*, J. C. Woodworth, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 286 pigs (PIC 327 × 1050; initially 11.1 ± 0.1 kg, and d 42 of age) were used in a 21-d growth trial to determine the available P (aP) release curve for a novel phytase source (Natuphos E 5000 G, BASF Corporation, Florham Park, NJ). Pigs were randomly allotted to pens at weaning. On d 0 of the experiment (d 18 after weaning), pens were allotted in a randomized complete block design to 1 of 8 treatments. There were 4 pigs/pen and 9 pens/treatment. Pigs were fed a corn-soybean meal-based diet formulated to 1.25% standardized ileal digestible Lys. Experimental diets were formulated to contain 0.64% Ca and increasing aP supplied by either monocalcium P (0.12, 0.18, and 0.24% aP) or from increasing phytase (150, 250, 500, 750, and 1000 FTU/kg) added to the 0.12% aP diet. Diets were analyzed for phytase using the AOAC method, and analyzed concentrations were 263, 397, 618, 1100, and 1350 FTU/kg, respectively. On d 21 of the study, 1 pig per pen was euthanized, and the right fibula was collected for bone ash and percentage bone ash calculations. From d 0 to 21, increasing P from monocalcium P or increasing phytase improved (linear, $P < 0.01$) ADG and G:F. Bone ash weight and percentage bone ash increased (linear, $P < 0.01$) with increasing monocalcium P or phytase. When formulated phytase values and percentage bone ash are used as the response variables, aP release for up to 1000 FTU/kg of Natuphos E 5000 G phytase can be predicted by the equation aP release = 0.000212 × FTU/kg phytase.

**Key Words:** nursery pig, phytase, bone ash
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**088 Effects of cow-calf production system and post-weaning management on finishing performance and carcass characteristics of calves produced from an intensively managed cow-calf production system.** S. E. Gardine*, *University of Nebraska, Lincoln.*

Research has indicated that corn residue grazing can be integrated into a partial intensively managed cow-calf production system. Furthermore, post-weaning management can affect finishing performance, as well as carcass characteristics of beef cattle. The objective of this study was to evaluate the effects of cow-calf production system and post-weaning management on finishing performance and carcass characteristics of calves produced from an intensively managed cow-calf production system. Cows with summer-born calves at side were wintered either in a dry-lot or on cornstalks. Cow-calf pairs in the dry-lot were fed a distillers and corn residue based diet formulated to maintain a lactating cow. Cow-calf pairs grazing cornstalks were supplemented with distillers based cubes at a rate designed to provide the cornstalk grazing pairs with an equivalent energy intake to that of the dry-lot pairs. Following the cornstalk grazing period from November to mid-April, all calves were weaned and received into the feedlot. Calves ($n = 47$; BW = 265 44 kg) were allocated by previous cow-calf production system, stratified by initial BW, and assigned randomly to one of four treatments with two replications per treatment. The trial was designed as a 2 × 2 factorial. Treatment factors included 1) cow-calf production system: dry-lot feeding (DLOT) or cornstalk grazing (STALK) and 2) post-weaning management: finishing (FINISH) or pre-finishing growing (GROW). In the FINISH treatment, weaned calves were directly adapted to a finishing diet (50% HMC, 30% sweet bran, 10% MDGS, 5% wheat straw, and 5% supplement). Calves in the GROW treatment were placed on a growing diet (30% Sweet Bran, 35% MDGS, 31% wheat straw, and 4% supplement) for 79 d before being adapted to the same finishing diet. Cattle were fed to a common compositional endpoint, and 12th rib fat thickness did not differ among treatments ($P > 0.70$). No cow-calf production system by post-weaning management interactions ($P > 0.22$) were observed for finishing performance, nor was there a cow-calf production system effect on finishing

**Table 087.**

| | Inorganic P, % aP | | | Phytase, FTU/kg | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | 0.12 | 0.18 | 0.24 | 150 | 250 | 500 | 750 | 1000 | SEM |
| BW, kg | | | | | | | | | |
| d 0 | 11.2 | 11.1 | 11.1 | 11.0 | 11.1 | 11.1 | 11.2 | 11.2 | 0.19 |
| d 21[1,4] | 20.4 | 22.3 | 23.3 | 21.3 | 21.6 | 21.7 | 22.6 | 23.3 | 0.38 |
| d 0 to 21 | | | | | | | | | |
| ADG, g[1,4] | 436 | 537 | 583 | 487 | 495 | 504 | 544 | 576 | 13.3 |
| ADFI, g[1,4] | 860 | 936 | 981 | 916 | 902 | 897 | 968 | 971 | 21.3 |
| G:F, g/kg[1,2,4] | 505 | 573 | 595 | 532 | 546 | 561 | 560 | 592 | 9.4 |
| Bone ash weight, g[3,4] | 0.680 | 0.850 | 0.855 | 0.713 | 0.667 | 0.772 | 0.821 | 0.941 | 0.044 |
| Bone ash, %[3,4] | 38.2 | 41.2 | 42.0 | 38.7 | 39.6 | 41.2 | 43.1 | 45.5 | 0.99 |

[1]Inorganic linear: $P < 0.001$; [2]Inorganic quadratic: $P < 0.05$; [3]Inorganic linear: $P < 0.05$; [4]Phytase linear: $P < 0.001$.

performance or carcass characteristics ($P > 0.10$). Initial body weight, final body weight, corresponding HCW, and DMI were greater for cattle in the GROW treatment ($P < 0.04$). Cattle directly adapted to a finishing diet had greater G:F ($P < 0.01$). When harvested at similar back fat, cattle that were fed a growing diet prior to the finishing phase had 25 kg more HCW when compared to cattle that were directly adapted to a finishing diet.

**Key Words:** cornstalk grazing, post-weaning, feedlot
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**089 The effects of hydroponic wheat fodder on fecal metabolites in equines.** J. M. Francis*, G. C. Handlos, G. A. Apgar, E. B. Venable, *Southern Illinois University, Carbondale.*

The use of hydroponic feeding systems for horses has gained popularity during recent years. Typically, this feeding system allows for a more efficient use of the whole plant, including the shoot, root, and seed remnants rather than traditional grazing in which only the shoot of the plant is consumed. Vertical systems have practical uses in largely developed areas where traditional forage sources are limited, in arid countries, or in areas with severe droughts where forage growth is minimal. Though there is some research on fodder utilization in production animals, there are currently no published data on the effects of fodder in horses. Our study, approved by the Southern Illinois University Institutional Animal Care and Use Committee (#13–043), utilized eight Quarter Horse mares randomly assigned to one of two diets. Control (C) horses were offered 2% of their body weight in hay (DM basis), and Fodder (F) horses received 1% of their body weight in hay (DM basis) and 1% of their body weight in fresh wheat fodder (AF Basis) twice daily. Body weight and hoof temperature data were recorded weekly. Fecal samples were collected weekly and analyzed for pH, ammonia, and volatile fatty acid concentration. Hay and fodder samples were also collected weekly to monitor nutrient profiles of the two forage types for the duration of the study. Additionally, nutrient profiles from seed to mature (8 d growth) were developed for treatment F. Data were analyzed as a completely randomized design using PROC MIXED of SAS (v. 9.4), and significance was established at $P < 0.05$. Both fecal pH ($P \leq 0.01$) and ash content ($P < 0.0001$) were higher for C as compared to F. Isobutyric acid was also significantly ($P < 0.05$) in F as compared to C. A comparison of the nutrient values of the two forages demonstrated significantly higher DM, ash, NDF, and ADF ($P < 0.0001$) in C while nitrogen, protein, and fat ($P < 0.0001$) were significantly higher in F overall. Daily growth of the fodder decreased DM content ($P < 0.0001$) while ash, NDF, ADF, nitrogen, protein, and fat ($P < 0.0001$) increased as the fodder reached maturity. These results indicate that utilizing fodder affects fecal metabolites associated with digestion.

**Key Words:** equine, hydroponics, fodder
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**090 Effect of essential oils or tylosin on performance, liver abscesses, carcass characteristics, and meat quality in feedlot steers.** J. R. Pukrop[1,*], B. T. Campbell[2], J. P. Schoonmaker[1], *[1]Purdue University, West Lafayette, IN, [2]DSM Nutritional Products, LLC., Parsippany, NJ.*

Use of antibiotics for liver abscess prevention has been hindered by the implementation of the veterinary feed directive. Essential oils (EO) are secondary metabolites derived from plants that have antimicrobial properties that may prevent liver abscesses. Seventy-two crossbred steers (358 ± 7.6 kg initial BW) were blocked by weight and breed composition and randomly allocated to 3 treatments (4 pens/treatment, 6 steers/pen) to determine the effects of an EO blend or tylosin on performance, liver abscesses, carcass characteristics, and meat quality. Treatments were delivered in a premix with dried distillers grains with solubles (DDGS) that was top dressed daily at a rate of 0.45 kg/steer daily (CON: no additives, TYL: 90 mg/steer daily tylosin, and EO: 1 g/steer daily essential oil blend). The basal diet contained (DM basis) 54% cracked corn, 26% DDGS, 14% corn silage, and 6% supplement. Steers were slaughtered at two different time points when a target average pen weight of approximately 624 kg was achieved. Longissimus muscle samples were taken caudal from the last rib on the right side of each carcass for tenderness and purge loss analyses. Statistical analyses were conducted using the MIXED procedure of SAS. Performance characteristics, including weight, days on feed, ADG, DMI, and gain:feed did not differ among treatments ($P \geq 0.37$). No differences were observed in carcass characteristics ($P \geq 0.19$). Steers fed EO tended to have an increased prevalence of liver abscesses in the A category ($P = 0.10$) as compared to CON and TYL. Purge loss was decreased ($P = 0.02$) for EO steaks compared to CON and TYL. There were no differences in Warner-Bratzler shear force among treatments ($P = 0.32$). In conclusion, inclusion of an EO blend or tylosin in the diet of finishing steers did not affect growth performance or carcass characteristics, and little difference was observed in liver abscess data or meat quality attributes.

**Key Words:** essential oils, tylosin, liver abscesses
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**091 Assessment of an alternative technique for measuring body temperature in pigs.** A. L. Petry[1,*], W. S. McGilvray[1], A. R. Pendleton[2], A. Rakhshandeh[1], *[1]Texas Tech University, Lubbock, [2]South Plains College, Lubbock, TX.*

Body temperature (BT) is one of the main vital signs that is used to evaluate the health status of pigs. The most commonly practiced method for measuring BT in pigs is rectal temperature (RT) since many have assumed that rectal temperature is the best indicator of core BT (CBT). Obtaining rectal

temperature can be stressful for animals, may generate inaccurate results due to the presence of feces in the rectum, and has the risk of spreading disease. Infrared imaging (IR) of the eye may be used as a safer and less stressful alternative to RT. However, to our knowledge the relationship between eye temperature and CBT has not yet been established. Therefore, the objective of the current study was to evaluate the feasibility of using IR imaging as an alternative to rectal temperature for monitoring CBT in pigs. A total of twenty-three gilts (initial BW 30.5 ± 5.62 kg) were housed in metabolism crates in an environmentally controlled facility and slightly feed restricted to ensure equal DM intake and to minimize the variability in temperature readings caused by the heat of digestion. After 4 d of adaptation, febrile response was induced by intramuscular injection of *E. coli* lipopolysaccharide (LPS; 25 μg/kg BW). BT of each pig was recorded at time 0, 2, 4, 6, 8, 10, and 24 h post-LPS challenge, using the following three methods: (I) RT, (II) IR imaging of the eye using an IR thermography camera, (III) BCT using a CorTemp disposable sensor and a miniature digital recorder. Statistical analysis was performed using MIXED and CORR Procedures in a Completely Randomized Design using SAS. Reg Procedures in SAS were used to estimate regression parameters. LPS increased the eye temperature, BCT, and RT by 0.92, 1.32, and 1.48°C, respectively ($P < 0.01$). Eye temperature, RT, and BCT were highly correlated during the course of the study ($\rho \geq 0.96$; $P < 0.01$). Estimated regression parameters ($\alpha$ and $\beta$) for predicting BCT using eye temperature were −28.2 ± 8.70 and 1.76 ± 0.221 and for RT were −24.5 ± 7.69 and 1.65 ± 0.196 ($r^2 \geq 0.96$; 95% confidence interval). Collectively, these results indicated a strong relationship between eye temperature and BCT in pigs. Therefore, IR imaging can be used as a precise, non-contact alternative to rectal temperature measurements for monitoring CBT in swine and possibly other species.

**Key Words:** core body temperature, eye temperature, pig
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**092 Influence of GnRH supplementation at CIDR removal on estrus expression and interval to estrus in beef cattle.** J. J. J. Rich*, E. J. Northrop, E. L. Larimore, G. A. Perry, *Department of Animal Science, South Dakota State University, Brookings.*

Previous research has indicated that small doses of GnRH after CIDR removal increased circulating estradiol concentrations. Thus, our objective was to determine if a single dose of GnRH (5 or 10 μg) at CIDR removal would impact estrus expression and/or interval to estrus (IE). Beef cows/heifers ($n$ = 1620) were synchronized using the 7-d CIDR protocol and randomly assigned to one of three treatments (0, 5, or 10 μg of a GnRH analog at CIDR removal). Animals were observed for estrus and inseminated following estrus detection. Interval to estrus was calculated for each animal that exhibited estrus (Interval1). Animals that did not exhibit estrus (DSS) were given 2 cc of GnRH at AI, and 120 h was recorded as their IE (Interval2). Interval to estrus was analyzed using the MIXED procedure of SAS. Expression of estrus and pregnancy success were analyzed using the GLIMMIX procedure of SAS. There was an effect of age ($P < 0.01$) and a treatment by age interaction ($P = 0.05$) on Interval1. Heifers had a shorter IE than cows ($P < 0.01$; 50 ± 1.1 vs. 54 ± 1.1 h, respectively). Furthermore, heifers given 5 μg of GnRH tended to have a shorter IE ($P = 0.07$; 47 ± 1.4 h) compared to 0 μg (50 ± 1.5 h) and had a shorter IE compared to 10 μg ($P < 0.01$; 53 ± 1.2 h). Among cows, there were no differences between treatments on IE ($P > 0.34$). When DSS animals were included in the analysis, there was no treatment by time interaction ($P = 0.49$). This is likely due to treatment ($P < 0.01$), not age ($P = 0.96$) or treatment by age ($P = 0.74$), influencing estrus expression, with 5 μg tending to induce estrus in more animals ($P = 0.10$; 79 ± 4%) compared to 0 μg (74 ± 5%) and 10 μg inducing estrus in fewer animals compared to 0 and 5 μg ($P < 0.04$; 68 ± 6%). Estrus ($P < 0.01$) and age ($P < 0.01$) influenced pregnancy success with heifers having greater success (49 ± 5% vs. 38 ± 4%) and animals exhibiting estrus having greater success compared to DSS animals (57 ± 4% vs. 32 ± 4%). There was no difference in pregnancy success between treatments among cows that exhibited estrus ($P > 0.30$); however, among DSS cows, 0 μg had increased pregnancy success ($P \leq 0.05$; 41 ± 6%) compared to 5 and 10 μg. In summary, 5 μg of GnRH at CIDR removal tended to decrease IE and increase estrus expression among heifers but not cows, and both 5 and 10 μg of GnRH at CIDR removal decreased pregnancy success among DSS cows.

**Key Words:** artificial insemination, estrus, gonadotropin releasing hormone
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**093 Influence of ethanol co-products and barley on growth performance and carcass characteristics of growing-finishing pigs in liquid or dry feeding systems.** B. Tostenson*, A. Tekeste, D. Pangeni, H. Manu, P. Ren, X. Yang, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

A study was conducted to investigate the effects of ethanol co-products and including barley in late finishing phase on growth performance, carcass characteristics, and belly firmness of growing-finishing pigs. A total of 480 crossbred pigs were used in this study: 240 pigs on dry feed (BW 27.2 ± 3.5 kg) and 240 pigs on liquid feed (BW 24.4 ± 3.5 kg). Pigs were blocked by body weight and randomly assigned to 1 of 3 dietary treatments with 8 pens of 10 pigs (5 barrows and 5 gilts) per treatment. In the dry feed group, pigs received (1) corn-soybean meal based diet (COND), (2) 20 to 30% DDGS (BPD1), or (3) same as BPD1 except 15% DDGS + 15% barley

in the last 21 d before marketing (BPD2). In liquid fed group, pigs were given (1) corn-soybean meal based diet (CONL), (2) 16 to 24% corn condensed distiller's solubles (CCDS) + 24 to 36% corn whole stillage (CWS) on 88% dry matter basis (BPL1), or (3) same as BPL1 except 15% CCDS + 30% CWS + 15% barley in the last 35 d before marketing (BPL2). The COND pigs had higher ($P < 0.05$) final BW, overall ADG, and muscle depth than the BPD2 pigs but lower ($P < 0.05$) iodine value in leaf fat and greater ($P < 0.05$) belly firmness score compared with the other two treatments. Furthermore, the COND pigs tended ($P < 0.10$) to have greater final BW, overall ADG, and muscle depth than the BPD1 pigs. Moreover, the COND pigs had greater ($P < 0.05$) overall G:F than the BPD1 pigs. There were no differences ($P > 0.05$) in ADFI and other carcass traits among treatments in the dry feeding group. In liquid fed group, the BPL2 pigs tended ($P < 0.10$) to have lighter final BW compared with the other two treatments, while the CONL pigs ate less ($P < 0.05$) and had higher ($P < 0.05$) belly firmness score and lower ($P < 0.05$) iodine value in leaf fat in comparison with pigs in the other two treatments. Furthermore, the CONL pigs had greater ($P < 0.05$) overall G:F than pigs in the BPL2 group. Carcass characteristics were not affected ($P < 0.05$) among treatments. Collectively, our data suggested that inclusion of 15% barley in the late finishing phase did not improve growth performance, carcass traits, and belly firmness of pigs fed ethanol co-products.

**Key Words:** barley, carcass traits, ethanol co-products
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**094 Selection of pigs for lean gain when fed high fiber diets to improve fiber, N, and energy digestibility and digestive tract characteristics.** J. A. Erceg*, K. Moran, M. T. Knauer, E. van Heugten, *North Carolina State University, Raleigh.*

The objective of this study was to determine the impact of high fiber diet and genetic line, developed using either a low or high fiber diet, on digestibility of fiber, N, and energy and digestive tract characteristics. Barrows ($n = 32$; 50.4 ± 3 kg) were used in a 14 d metabolism study with a 2×2 factorial design with genetic line (high fiber selected and control selected lines) and diet (high fiber or control) as factors. Genetic lines were selected for lean growth over 3 generations while consuming the high fiber or control diets. Barrows were separated into 2 replicate groups of 16 consisting of 4 littermate pairs from each genetic line. Diets were randomly assigned within littermate pairs. High fiber diets were formulated to include 15% of each DDGS, wheat middlings, and soy hulls, and control diets were corn-soybean meal based. Diets were formulated to contain equal SID lysine to net energy ratios (0.93 and 0.82% SID lysine and 2484 and 2187 kcal/kg NE for control and high fiber diets, respectively). Pigs had ad libitum access to feed for an 11 d adaptation period and were restricted to 90% ad libitum on d 12, 13, and 14 while fecal samples were collected to determine digestibility of ADF, NDF, N, and energy, using titanium dioxide as indigestible marker. Total transit time was measured by feeding a color marker (chromic oxide) and recording time until first fecal appearance of marker. Pigs were euthanized on d 14; pH was measured in the ileum and cecum along with cecum weights. Data were analyzed using MIXED procedures of SAS. There were no interactions between diet and genetic line ($P > 0.05$). Digesta transit time and cecal and colon pH were not impacted by diet. No effects of genetic line on digesta pH or digestibility were observed. High fiber genetic selection tended to increase ($P = 0.09$) digesta transit time (1704.4 vs. 1521.3 ± 75.5 min). Pigs fed high fiber diets had increased ($P < 0.05$) ileal pH (6.61 vs. 6.32), ADF (56.3 vs. 41.7%) and NDF digestibility (61.0 vs. 41.6%) and had decreased ($P < 0.05$) N (77.8 vs. 84.5%) and gross energy (GE) digestibility (78.3 vs. 84.2%). Genetic selection for lean gain of pigs when fed high fiber diets increased total transit time but did not impact digestibility. Feeding high fiber diets decreased N and GE digestibility while increasing ileal pH and fiber digestibility, regardless of whether pigs had been selected on high fiber diets or not.

**Key Words:** digestibility, fiber, genetics
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**095 Comparison of expression of glucose, fructose, and cationic amino acid transporters in bovine caruncular and inter-caruncular tissue between the pregnant and non-pregnant uterine horn from days 16 to 50 of gestation.** M. S. Crouse[1,*], K. J. McLean[1], N. P. Greseth[1], M. R. Crosswhite[1], N. Negrin Pereira[1], A. K. Ward[1], L. P. Reynolds[1], C. R. Dahlen[1], B. W. Neville[2], P. P. Borowicz[3], J. S. Caton[3], *[1]Department of Animal Sciences, North Dakota State University, Fargo, [2]Central Grasslands REC, North Dakota State University, Streeter, [3]Department of Animal Science, North Dakota State University, Fargo.*

We hypothesized that day of gestation, maternal nutrition, and uterine horn influence the mRNA expression of glucose, fructose, and cationic amino acid transporters in caruncular and inter-caruncular tissue from d 16 to 50 of gestation. Crossbred Angus heifers ($n = 43$) were estrus synchronized, bred via AI, assigned to nutritional treatment (CON = 100% of requirements for 0.45 kg/d gain and RES = 60% of CON), and ovariohysterectomized on d 16, 34, or 50 of gestation ($n = 6$ to 9/d). The resulting arrangement was a 2 × 3 factorial. Caruncles from the pregnant horn (P-CAR) and non-pregnant horn (NP-CAR) and inter-caruncular tissue from pregnant horn (P-ICAR) and non-pregnant horn (NP-ICAR) were obtained immediately following ovariohysterectomy. Relative gene expression of glucose transporters *GLUT1*, *GLUT3*, and *GLUT14*, fructose transporter *GLUT5*, and cationic amino acid transporters *CAT-1*, *CAT-2*, and *CAT-3* was determined utilizing a non-bred heifer uterine sample as the baseline. No transporters were

influenced by a day × horn × treatment interaction; therefore, data are reported for a day × horn interaction in caruncular and inter-caruncular tissue. Expression of *GLUT1* was greater ($P < 0.01$) in P-CAR on d 16 compared with 34 and 50 and NP-CAR on all days. Relative expression of *GLUT3* was greater ($P < 0.01$) in P-CAR on d 50 compared with 16 and 34 and NP-CAR on all days. Expression of *GLUT14* was greater ($P < 0.01$) in P-CAR on d 50 compared with 16 and 34 and NP-CAR on all days. Relative expression of *GLUT1* was greater ($P = 0.04$) in P-ICAR and NP-ICAR on d 16 compared with d 34 tissues. Expression of *GLUT3* was greater ($P = 0.04$) in d 50 P-ICAR compared with NP-ICAR on d 16 and 50. Relative expression of *CAT-1* was greater ($P < 0.01$) in NP-CAR on d 50 and P-CAR on d 34, compared with P-CAR and NP-CAR on d 16. In inter-caruncular tissue, *CAT-1* was greater ($P < 0.01$) in P-ICAR on d 34 and 50, compared with P-ICAR and NP-ICAR on d 16. Expression of *CAT-2* was greater ($P = 0.05$) in NP-ICAR on d 16 compared with NP-ICAR on d 34. Relative expression of *CAT-3* was greater ($P = 0.02$) in NP-ICAR on d 50 compared with NP-ICAR on d 34. We interpret these data to imply that day of gestation and presence of the embryo more greatly influenced gene expression than nutritional treatment.

**Key Words:** mRNA, transporters, utero-placenta
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**096 Influence of thermally peroxidized soybean oil on growth performance and oxidative status in growing pigs.** S. C. Lindblom[1,*], N. K. Gabler[1], B. J. Kerr[2], *[1]Iowa State University, Ames, [2]USDA-ARS, Ames, IA.*

The objective of this study was to evaluate the effect of feeding peroxidized soybean oil (SO) on growth performance and oxidative status in growing pigs. Fifty-six barrows (25.3 ± 3.3 kg initial BW) were randomly assigned to one of four diets containing either 10% fresh SO (22.5°C) or SO exposed to heat (45°C for 288 h, 90°C for 72 h, or 180°C for 6 h), each with an air infusion of 15 L/min. Peroxide values for the 22.5, 45, 90, and 180°C processed SO were 2.0, 96, 145, and 4.0 mEq/kg, respectively. Anisidine values for 22.5, 45, 90, and 180°C processed SO were 1.2, 8.4, 261, and 174, respectively. Pigs were individually housed and fed ad libitum for 49 d to measure growth performance, including a metabolism period to collect urine and serum for analysis of oxidative stress markers. Oxidative stress markers included serum and urinary thiobarbituric acid reactive species (TBARS) and urinary $F_2$–isoprostanes (ISP) as markers of lipid damage, serum protein carbonyls (PC) as a marker of protein damage, and urinary 8-hydroxy-2'-deoxyguanosine (8-OH-2dG) as a marker of DNA damage. Glutathione peroxidase activity (GPx) was measured in serum, and ferric reducing antioxidant potential (FRAP) was measured in urine as determinants of antioxidant status. Although there were no differences in final BW 70.8 ± 5.7 kg ($P = 0.11$) and ADFI ($P = 0.19$), ADG was decreased in pigs fed 90°C SO diet ($P = 0.01$), while G:F was increased ($P = 0.02$) in pigs fed 45°C SO diet compared to the other SO diets. Compared to the other treatments, urinary ISP was increased in pigs fed the 90°C SO diet ($P = 0.02$), while pigs fed the 45°C SO diet had increased urinary TBARS ($P = 0.02$), with no differences found in urinary FRAP and 8-OH-2dG. Dietary lipid peroxidation had no effect on serum TBARS ($P = 0.51$); however, pigs fed the 90°C SO diet had significantly higher serum PC ($P = 0.01$) compared to the other SO diets. In addition, pigs fed the 90°C and 180°C SO diets had significantly lower serum GPx ($P = 0.01$) in comparison to the 22.5°C and 45°C SO diets. The presence of peroxidation compounds as measured by PV and AnV found in the 90°C SO diet were shown to decrease performance by reducing ADG and metabolically inducing oxidative stress by increasing urinary ISP and TBARS and increasing serum PC while diminishing serum GPx.

**Key Words:** oxidative stress, lipid peroxidation, growing pigs
doi: 10.2527/asasmw.2017.096

## GRADUATE STUDENT ORAL COMPETITION: PH.D.

**097 The effect of isoflurane and meloxicam on behavior of dairy goat kids following cautery disbudding.** M. N. Hempstead[1,2,*], M. Stewart[3], J. R. Waas[2], V. M. Cave[1], M. A. Sutherland[1], *[1]AgResearch, Hamilton, New Zealand, [2]The University of Waikato, Hamilton, New Zealand, [3]InterAg, Hamilton, New Zealand.*

The effects of meloxicam (a non-steroidal anti-inflammatory drug) and isoflurane (a general anesthetic) on the behavior of dairy goat kids following cautery disbudding were examined. Seventy-two female Saanen dairy goat kids (2–7 d old) were randomly assigned to one of six treatment groups ($n = 12$/treatment): 1) cautery disbudded (CAUT), 2) meloxicam administered orally (0.2 mg/kg BW) and disbudded (O-MEL), 3) meloxicam injected s.c. (0.5 mg/kg BW) and disbudded (I-MEL), 4) isoflurane gas administered and disbudded (ISO), 5) isoflurane, meloxicam s.c. and disbudded (MEL+ISO), and 6) sham-handled (simulated disbudding; SHAM). Frequency of behaviors (head shaking, head scratching, self-grooming, feeding, and body shaking) was continuously recorded with video cameras 24 h pre- and post-treatment. The average change in behavior (post - pre) per hour post-treatment is presented (mean ± SED). CAUT and SHAM kids were similar for all behaviors ($P > 0.05$). Head shaking was exhibited more often in O-MEL, I-MEL, and ISO kids than SHAM kids (1.6 ± 0.42, 1.7 ± 0.42, 1.7 ± 0.42, and 0.6 ± 0.42 for I-MEL, O-MEL, ISO, and SHAM, respectively; $P \leq 0.05$). Head scratching was most frequent in I-MEL and MEL+ISO kids compared to SHAM kids (1.4 ±

0.29, 1.1 ± 0.29, and 0.2 ± 0.29 for I-MEL, MEL+ISO, and SHAM, respectively). Self-grooming was exhibited more often in I-MEL kids compared to SHAM kids (1.3 ± 0.31 vs. 0.4 ± 0.31). O-MEL and ISO kids visited the feeder more often than SHAM kids (1.5 ± 0.47, 1.7 ± 0.47, and 0.4 ± 0.47 for O-MEL, ISO, and SHAM, respectively). Body shaking was highest in O-MEL and ISO kids compared to SHAM kids (0.7 ± 0.16, 0.6 ± 0.16, and 0.18 ± 0.16 for O-MEL, ISO, and SHAM, respectively). Interestingly, there appeared to be no advantage of combining meloxicam with isoflurane within 24 h post-treatment, as behaviors were performed at the same frequency as CAUT kids for all behaviors measured ($P > 0.05$); however, MEL+ISO kids did visit the feeder and head scratch more often than SHAM kids ($P \leq 0.05$). These changes in behavior suggest that administration of either subcutaneous meloxicam or isoflurane gas was effective for reducing post-operative pain and distress associated with cautery disbudding in dairy goat kids.

**Key Words:** Disbudding, Behavior, Goat kids
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**098 Impact of maternal protein restriction on meat quality and fatty acid profile of progeny.**

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Carcass composition and meat quality attributes may be altered by developmental changes that occur in the fetus due to maternal nutrient restriction. The objective of this study was to evaluate the impact of metabolizable protein (MP) restriction in mid- and late-gestation on meat quality and fatty acid profile of progeny. One hundred eight primiparous Angus × Simmental heifers were blocked by BW, conception type (AI or natural service), and calf sex and allocated to 12 pens in a randomized complete block design with a 2 × 2 factorial structure including 2 stages of gestation (mid- and late-) and 2 levels of dietary protein (control [CON], approximately 102% of MP requirements and restricted [R], approximately 80% of MP requirements). Following weaning, calves were finished in a GrowSafe feeding system on a common diet, and individual carcass data were collected. At harvest, 9–10–11 rib sections were removed for carcass composition analysis, and strip loins were collected for fabrication of steaks at 3, 7, 14, and 21 d postmortem for tenderness evaluation. Raw steaks were weighed, cooked to 71°C, re-weighed, and cooled before removing cores for Warner-Bratzler shear force (WBSF) analysis. Additional steaks were analyzed to determine fatty acid (FA) percentage (% of total FA content). As previously reported, there were no differences in hot carcass weight, adjusted 12th rib fat thickness, KPH, marbling score, or USDA quality grades ($P > 0.05$). The LM area was greater ($P = 0.05$) for progeny from dams that were restricted during late-gestation vs. CON (92.3 vs. 89.3 ± 1.09 cm$^2$); however, means were similar ($P > 0.05$) when using HCW as a covariate. A mid- × late-gestation treatment interaction ($P = 0.0008$) for WBSF showed improved tenderness for progeny from dams on R and CON diets throughout gestation (R-R and CON-CON; mean 2.8 ± 0.08) vs. progeny from dams restricted in mid-gestation only (R-CON; mean 3.2 ± 0.08). Steak cook loss, percent ether, and carcass edible and inedible compositions were not different ($P > 0.05$) among treatments. Progeny from dams on the R treatment during mid-gestation produced steaks with greater ($P = 0.05$) percentage of polyunsaturated FA (4.6% ± 0.22) compared with progeny from dams on the CON diet in mid-gestation (4.0% ± 0.22). No differences ($P > 0.05$) in percent monounsaturated or saturated FA were observed. Differences in tenderness and FA profiles indicate MP restriction during mid- and late-gestation may influence progeny meat characteristics.

**Key Words:** beef cattle, metabolizable protein restriction, meat characteristics
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**099 Effect of dietary lysine on the skeletal muscle intramuscular fat content and fatty acid composition of late-stage finishing pigs.**

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Pork eating quality can be largely influenced by the intramuscular fat (IMF) content and its fatty acid (FA) composition in the skeletal muscle. This study was conducted to investigate if dietary lysine at different levels could affect the IMF content and its FA composition of longissimus muscle in late-stage finishing pigs. Nine crossbred barrows (94.4 ± 6.7 kg BW) were randomly allotted to three dietary treatments (3 pigs/treatment). Three corn and soybean-meal based diets were formulated to meet the NRC (2012) recommended requirements of various nutrients for late-stage finishing pigs, except for the lysine content, which was 0.43, 0.71, and 0.98% (as-fed basis) for Diets 1 (lysine-deficient), 2 (lysine-adequate), and 3 (lysine-excess), respectively. During the 5 wk feeding trial, pigs were allowed ad libitum access to their respective diets assigned and fresh water. At the end of the trial, pigs were harvested, and muscle samples were collected from the middle portion (between the 10th and 12th ribs) of longissimus dorsi. Fatty acids in the samples were directly derivatized and measured using a gas chromatographic method. The IMF content of the longissimus muscle, calculated as total FA, was increased ($P < 0.05$) with the decreased dietary lysine content (from Diet 3 to Diet 1). Dietary lysine level did not affect the percentages of individual and total saturated FA, except for that of stearic acid (C18:0), which tended to be reduced with Diet 1 ($P = 0.09$). In terms of unsaturated FA, the percentages of oleic acid (C18:1 n-9) and total

mono-unsaturated FA were greater ($P < 0.05$), whereas that of linolenic acid (C18:3 n-3) was less ($P < 0.05$), in the pigs fed Diet 1 than the pigs fed Diet 2. These results suggest that the IMF content of longissimus muscle of late-stage finishing pigs can be increased with reduced level of dietary lysine. Dietary lysine level can also alter the proportions of FA, especially that of mono-unsaturated FA, which improves pork nutritive values and eating quality. Further research, however, is needed to study if transient use of a lysine-deficient diet can improve pork eating quality via altering the IMF content and its FA composition without compromising the growth performance of pigs at their late finishing stage. This project was supported by USDA Hatch/ Multistate Project 1007691.

**Key Words:** intramuscular fatty acid composition, lysine, finishing pig

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## 100 Evaluating the efficacy of commercial feed additives as potential porcine epidemic diarrhea virus (PEDV) mitigation strategies in complete feed and spray-dried porcine plasma as determined by polymerase chain reaction analysis and bioassay.

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Potential strategies to mitigate the risk of porcine epidemic diarrhea virus (PEDV) transmission in feed and feed ingredients would be valuable for swine producers and feed manufacturers. Research has been conducted assessing potential PEDV mitigation techniques, including the use of medium chain fatty acids, essential oils, organic acids, or formaldehyde and thermal processing during pelleting of complete diets. Some of these strategies are currently cost prohibitive and not available commercially. A commercial essential oil-based product and a benzoic acid product (CRINA, VevoVitall, respectively; DSM Nutritional Products Inc., Parsippany, NJ) are marketed to improve growth performance. Their chemical composition suggests potential efficacy as a practical, cost-effective PEDV mitigation strategy. Therefore, the objective of this study was to determine the impact of VevoVitall (5000 mg/kg) and/or CRINA (200 mg/kg) as potential chemical mitigation strategies of PEDV in feed and a feed ingredient as determined by qRT-PCR and swine bioassay. Swine gestation diet (FEED) and spray-dried porcine plasma (SDPP) were treated with CRINA and VevoVitall in a 2 × 2 factorial treatment structure, inoculated with PEDV, stored at room temperature (21°C), and analyzed on 7 sampling days after inoculation (d 0, 1, 3, 7, 14, 21, 42). On each day of analysis, samples were eluted with PBS, and an aliquot was submitted for qRT-PCR analysis for PEDV RNA and stored (−80°C) until determination of infectivity via 10 d old pig bioassay. Data were analyzed using PROC GLIMMIX (SAS Institute, Inc., Cary, NC) to determine main and interactive effects for treatment, feed matrix, and day after inoculation on PEDV Ct values. A marginally significant treatment × feed matrix × day interaction ($P = 0.082$) was observed in which the cycle threshold (Ct) increased over time in FEED when treated with the combination of products (COMBO), whereas there was no increase over time observed in SDPP (d42 Ct = 45.0 vs. 29.7, respectively; $P < 0.001$). There was a feed matrix × day interaction ($P < 0.001$) in which the Ct increased over time in FEED, whereas no increase over time was observed in SDPP. Virus shedding was observed in the d 7 post-laboratory inoculation SDPP COMBO treatment, as well as d 0 FEED COMBO treatment. No additional infectivity was observed in FEED (d 1, 3, 7, 14, 21 COMBO treatments). In summary, the combination of CRINA and VevoVitall enhanced degradation of PEDV RNA in FEED but had no impact on RNA degradation in SDPP. Over time, the infectivity was maintained for a longer duration after inoculation in SDPP than FEED.

**Key Words:** chemical mitigation, PEDV, risk mitigation

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## 101 Comparison of digestibility of amino acids in full-fat soybean, soybean meal, and peanut flour between broiler chickens and pigs.

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The objective of this experiment was to compare the apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of CP and AA for broiler chickens and pigs fed full-fat soybean (FFSB), soybean meal containing 430 g/kg CP (SBM-43), soybean meal containing 470 g/kg CP (SBM-47), and peanut flour (PNF). Four semi-purified diets were formulated to contain FFSB, SBM-43, SBM-47, and PNF, respectively, as the sole source of nitrogen. One nitrogen-free diet was also formulated to determine the basal ileal endogenous losses of CP and AA for broilers and pigs. In Exp. 1, a total of 416 twenty-one-d-old male broiler chickens were assigned to 5 dietary treatments in a randomized complete block design with BW as a blocking factor. Each dietary treatment contained 8 replicates with 10 birds per cage except for the nitrogen-free diet, which contained 12 birds per cage. On d 26 post-hatching, birds were euthanized by $CO_2$ asphyxiation, and ileal digesta samples were collected from distal ileum. In Exp. 2, twenty barrows (initial BW = 62.0 ± 6.89 kg) surgically fitted with T-cannula at the distal ileum were individually housed in metabolism crates and assigned to quadruplicate 5 × 2 incomplete Latin square design with 5 diets and 2 periods. Each period consisted of 5 d of adaptation and 2 d of ileal digesta collection periods. Interactions between ingredients and species were not observed

except for Cys ($P < 0.01$). Pigs had the greater ($P < 0.01$) AID of CP and indispensable AA in test ingredients compared with broiler chickens. In both broilers and pigs, the AID of CP and indispensable AA in SBM-47 were greater ($P < 0.05$) than those in FFSB, and the AID of Lys in PNF was less ($P < 0.05$) than FFSB, SBM-43, and SBM-47. Except for Trp, pigs also had greater ($P < 0.01$) SID of CP and indispensable AA in test ingredients compared with broilers. Birds fed SBM-43, SBM-47, and PNF had greater ($P < 0.05$) SID of CP, Ile, Leu, Thr, Trp, and Val than those fed FFSB. Pigs fed SBM-43, SBM-47, and PNF had greater SID of Arg, Ile, Leu, Met, Phe, and Val than those fed FFSB. In conclusion, pigs had greater SID of CP and most AA in test ingredients compared with broilers, but the pattern of differences in SID of CP and AA among ingredients was similar between broiler chickens and pigs.

**Key Words:** amino acids, pig, poultry
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**102 Effect of Rapeseed Meal Supplementation to Gestation Diet on Reproductive Performance, Blood Profiles and Milk Composition of Sows.**

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A total of 55 mixed-parity sows (Yorkshire × Landrace, average parity 3.82) were used in this experiment to determine the effect of rapeseed meal (RSM) supplementation to gestation diet on reproductive performance, blood profiles and milk composition of sows. Sows with an initial body weight (BW) of 193.0 kg were used allotted to five treatments at breeding based on BW and BF thickness in a completely randomized design. Five different levels of RSM (0, 3, 6, 9 or 12%) were supplemented in each experimental diet. Lactating sows were fed common lactation diet without RSM. Body weight, backfat thickness, litter size, lactation feed intake, milk composition of sows, and growth of their progeny in this experiment were not differed among dietary treatments. In blood profiles, a quadratic increase ($P < 0.05$) of serum triiodothyronine (T3) concentration and a linear increase ($P < 0.01$) of serum thyroxine (T4) concentration in sows were observed at d 110 of gestation as dietary RSM supplementation levels in gestation diets increased. However, serum T3 and T4 concentrations in lactating sows and their piglets were not affected by RSM supplementation to gestation diets. Concentrations of serum total cholesterol and low density lipoprotein cholesterol (LDL) in sows were not influenced by dietary treatments while serum glucose level in sows was decreased linearly at d 110 of gestation ($P < 0.05$) by increasing dietary RSM supplementation levels in gestation diets. The effect of RSM supplementation to gestation diets up to 12 % in this experiment with no detrimental effects on reproductive performance and growth of their progeny, but it had little effect as increasing supplementation levels of RSM in gestation diets affect to increase serum T3 and T4 concentrations and decrease serum glucose concentration of sows in late gestation.

**Key Words:** pig, gestation, diets
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**103 Lipid peroxidation decreases performance and viability of nursery pigs.**

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The objective of this study was to investigate the impact of lipid peroxidation in a dose-dependent manner on performance, health, medical treatment, viability, and oxidative status of nursery pigs. Pigs ($n = 2200$; BW = 5.95 ± 0.2 kg) were housed in 100 pens with 22 pigs/pen in a RCBD based on initial BW and sex and assigned to 5 dietary treatments. Treatments consisted of corn-soybean meal based diets supplemented with 5% of either control corn oil (FFA = 0.06%, anisidine value = 2.5, peroxide value = 4.8 mEq/kg oil) or corn oil peroxidized with air at 20 L/min at 60°C for 12 d (FFA = 0.35%, anisidine value = 30.4, peroxide value = 162.6 mEq/kg oil). Diets were blended to obtain 0, 25, 50, 75, and 100% degrees of peroxidation. Pigs were fed a 3-phase nursery diet program (7, 13, and 23 d, respectively). Pigs were vaccinated with PRRS and *Mycoplasma hyopneumoniae* (Mhyo) mixed vaccine at placement and PCV2 and Mhyo combination vaccine at 9 wk of age. Blood samples were collected from 10 light- and 10 heavy-weight pigs per treatment prior to and 14 d after the second vaccine dose to determine serum antibody titers, oxidative stress, and vitamin E concentrations. There were no differences in ADG and ADFI among treatments. Gain:feed decreased linearly with increasing peroxidation ($P = 0.02$) during the first 20 d and overall (665, 669, 664, 659, 652 g/kg for 0, 25, 50, 75, and 100% peroxidation). Pigs pulled, culled, treated and mortality increased linearly ($P < 0.05$), while percentage of full-value pigs (98.9, 97.8, 96.6, 95.2 and 95.9%, for 0, 25, 50, 75, and 100% level) decreased linearly ($P < 0.05$) with increasing peroxidation. Final pen gain, which considers mortality and culls, decreased linearly ($P < 0.01$) with increasing peroxidation (341, 317, 311, 303, and 305 kg, for 0, 25, 50, 75, and 100% level). Antibody titers to Mhyo and PCV2 increased post-vaccination ($P < 0.01$) but were not affected by peroxidation. Serum MDA was 19% higher in heavy pigs than light weight pigs ($P < 0.01$) but was not affected by peroxidation. Total antioxidant capacity and vitamin E concentrations were 10% higher ($P < 0.04$) in heavy weight pigs ($P < 0.03$) than light weight pigs and decreased ($P = 0.05$) linearly (1.24, 1.32, 1.23, 0.99, 1.15 ppm serum vitamin E for 0, 25, 50, 75, and 100% peroxidation) as peroxidation increased. Data indicate a progressively negative impact of lipid peroxidation on pig

productivity measured under field population conditions, which was primarily related to increased mortality, number of pigs medicated, and number of pigs that were excessively light.

**Key Words:** peroxidation, pig, lipid
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**104 Genetic, heterosis, and maternal effects on voluntary water consumption in mice.** M. T. Haag*, K. D. Wells, W. R. Lamberson, *Division of Animal Sciences, University of Missouri, Columbia.*

Managing natural resources, particularly water, is a prominent issue for animal agriculture. Due to such challenges livestock producers are always looking to lessen resource consumption. The objective of our study is to contribute to improving water management by identifying the genetic control of water consumption. In standard laboratory conditions inbred mouse strains, with unaltered kidney function, show a three-fold range of daily water consumption. This study used C57BL10J (BL $n = 47$) and C57BRCDJ (BR $n = 29$) mice, identified to be in the high and low ends of this range, respectively, and reciprocal F1 crosses. Using BL males x BR females (F1BR $n = 21$) and BL females x BR males (F1BL $n = 92$), daily consumption data were collected for 4 d during the fourth, fifth, and sixth wk using custom water bottles. Animals were weighed at the beginning of the fourth, fifth, and sixth wk and at the end of the sixth wk. Consumption data were corrected for metabolic body weight ($wt^{0.67}$) prior to analysis, so water consumption is expressed in milliliters consumed per gram of metabolic body weight per day. Final weight was the dependent variable for weight analyses. Dependent variables were fitted to a mixed model including the effects of sex, strain, and their interaction with sire within strain fitted as a random effect. Orthogonal contrasts were used to test the direct genetic, maternal genetic, and heterosis effects. An interaction ($P < 0.0001$) was observed between sex and strain with females in all strains consuming more than males and the sex difference increasing as consumption increased among strains. Animals from the BR strain consumed 40% more water per day ($P < 0.001$) than BL animals (1.32 vs. 0.65 mL/g, respectively). A maternal effect ($P < 0.03$) was observed as F1BL consumed about 9% less water per day than F1BR (0.95 mL/g vs. 1.01 mL/g, respectively). Finally, a heterosis effect of −4% was observed for water consumption ($P < 0.10$). For final weight, BR animals (20.6 g) were heavier ($P < 0.02$) than BL animals (19.2 g). No maternal effect for weight was observed. Animals from the reciprocal F1 crosses showed an increase in body weight of nearly 10% over pure strains ($P < 0.001$). These strains form the foundation stock of an experiment to isolate genes influencing water consumption by reciprocal backcrossing and selection.

**Key Words:** mice, water consumption, heterosis
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**105 A meta-analysis on the effects of backgrounding strategy on feedlot and carcass performance.** H. E. Johnson*, A. DiCostanzo, *University of Minnesota, St. Paul.*

Utilizing a meta-analysis approach, we modeled how backgrounding (BK) strategies, high energy feeding (HE), ad libitum forage or restricted energy feeding (RE), grazing dormant (G) or wheat pastures (WW) affected feedlot and carcass performance. Data were derived from 32 manuscripts (20 drylot and 12 grazing studies) containing 158 treatment means. Multiple regressions were conducted using mixed models to describe effects of BK ADG, days on feed (DOF), and strategy on finishing phase DMI, ADG, final BW, HCW, marbling score, LMA, and fat depth. Greater BK ADG and longer DOF resulted in greater ($P < 0.05$) DMI during finishing ($R^2 = 0.62$). Cattle fed HE during BK had lower ($P < 0.05$) DMI during finishing than those consuming RE during BK or those grazing G or WW pastures ($P < 0.05$). Greater ADG or longer DOF during BK resulted in lower ADG during finishing ($R^2 = 0.294$). A change in BK ADG of 0.1 kg or 15 DOF had an equivalent impact on ADG during finishing. The relationship between DMI and ADG during finishing was best represented ($P = 0.03$) by equations for each BK strategy. Gain during BK interacted with strategy to impact final BW and HCW ($R^2 = 0.453$ and 0.463). In spite of greater BK ADG, cattle fed HE during BK had lighter ($P < 0.03$) final BW than those fed RE or grazing. Similarly, cattle fed RE during BK had lighter final BW than those grazing G ($P = 0.0014$) or WW ($P = 0.0104$). Correspondingly, cattle fed HE or RE during BK had lighter ($P < 0.001$) HCW than those that grazed. Differences observed for HCW were mirrored by differences in LMA; carcasses of cattle fed HE during BK had smaller ($P < 0.04$) LMA than those that grazed while RE trended ($P = 0.0579$) smaller ($R^2 = 0.385$). Fat depth responded inversely to BK energy supply; cattle that grazed had carcasses with greater ($P < 0.05$) fat depth than those of cattle that were fed RE or HE ($R^2 = 0.314$). Strategy during BK had no impact on marbling score, but end weight after BK did. Cattle fed to weights greater than 385 kg during BK, regardless of strategy, had carcasses with lower ($P = 0.043$) marbling scores ($R^2 = 0.343$). Therefore, restricting energy intake during backgrounding resulted in greater carcass weight, but prolonging backgrounding resulted in lower marbling.

**Key Words:** backgrounding, finishing, meta-analysis
doi: 10.2527/asasmw.2017.105

**106 Determination of net energy content of hemp hulls and processed hemp hull products fed to growing pigs using indirect calorimetry.** J. W. Kim*, C. M. Nyachoti, *University of Manitoba, Winnipeg, MB, Canada.*

The production of hemp hulls (HH), a by-product of shelled hempseed, has gradually increased because of increased human consumption of shelled hempseed. Due to its high protein and

oil contents, HH has potential as a protein and energy source for swine diets. However, the nutritive value of HH for swine has yet to be evaluated. Therefore, this study was conducted to determine the NE contents of HH, extruded HH (EHH), and a blended product of HH with pea (HHP) fed to growing pigs using indirect calorimetry (IC). Twenty-four growing male pigs [(Yorkshire ×Landrace) × Duroc] with an average initial BW of 22.9 ± 1.75 kg were individually housed in adjustable metabolism crates. Pigs were randomly allotted to 1 of 4 dietary treatments to give 6 replicates per treatment. A corn-soybean meal (SBM) basal diet was prepared, and three additional diets were formulated to contain a 70:30 ratio of the basal diet and each of test ingredients (HH, EHH, and HHP). Pigs were fed experimental diets for 16 d including 10 d for adaptation and 6 d for total collection of feces and urine to determine DE and ME contents. Pigs were then moved into indirect calorimetry chambers to determine heat production (HP) and fasting heat production (FHP) based on $O_2$ consumption, $CO_2$ production, and urinary N excretion. The DE, ME, and NE contents of the basal diet were greater ($P < 0.01$) than the HH, EHH, and HHP diets. No significant differences were observed for the HP (on average 1904 kcal/kg DM) and FHP (on average 1320 kcal/kg DM) among treatments. However, the retained energy of pigs fed the basal diet (1763 kcal/kg DM) was greater ($P < 0.05$) than those fed the HH (1501 kcal/kg DM) and HHP (1482 kcal/kg DM) diets. The NE:ME ratio tended to be greater for the basal diet (0.85) than for the HH (0.82), EHH (0.82), and HHP (0.83) diets. The NE contents of HH, EHH, and HHP were determined to be 2341, 2315, and 2407 kcal/kg DM, respectively. In conclusion, the HH, EHH, and HHP contain relatively high levels of NE contents due to their high oil content and therefore can be a potential alternative energy source for swine.

**Key Words:** hemp hulls, indirect calorimetry, NE
doi: 10.2527/asasmw.2017.106

## GRADUATE STUDENT POSTER COMPETITION: M.S.

**107 Effect of original XPC in receiving diets on newly weaned beef steer performance.** E. L. Deters*, R. S. Stokes, O. N. Genther-Schroeder, S. L. Hansen, *Iowa State University, Ames.*

The objective of this study was to determine the effect of Original XPC, a *Saccharomyces cerevisiae* fermentation product (Diamond V, Cedar Rapids, Iowa) on growth performance and immune function of newly weaned beef cattle. One hundred eighty single-source newly weaned beef steers (278 ± 21.7 kg SD) were adapted for 7 d, blocked by BW, and randomly assigned to treatments: Original XPC at 0 (CON), 14 (XPC14), or 28 g·steer·$d^{-1}$ (XPC28). Pen was the experimental unit ($n$ = 10 per treatment, 6 steers per pen). Weights were collected on d −1, 0, 14, 28, 42, 55, and 56. Cattle were boostered against BVDV Type 1 and 2 (Vista Once, Merck, Madison, NJ) on d 0. One steer per pen was bled on d 0, 14, 28, 42, and 56 for analysis of antibody titers. and blood from d 0, 28, and 56 was analyzed for red blood cell lysate superoxide dismutase (SOD) activity and glutathione concentration, plasma malondialdehyde (MDA) concentration, and serum lysozyme activity. Data were analyzed as a randomized complete block design using Proc Mixed of SAS; treatment and block were fixed effects. Performance and antibody titers were analyzed as repeated measures with the repeated effect of day; however, there were no treatment by day effects ($P \geq 0.41$). Linear and quadratic contrast statements were constructed. There were no linear or quadratic effects of XPC on final BW, DMI, ADG, G:F, antibody titers, percentage of animals treated with antibiotics, or lysozyme activity ($P \geq 0.05$). There was a quadratic effect of XPC on d 56 SOD activity ($P = 0.004$) driven by lesser activity in XPC14-fed steers. There was a tendency for a linear increase in MDA concentration on d 28 ($P = 0.09$). There was a quadratic effect of XPC on the d 28 oxidized to reduced glutathione ratio ($P = 0.05$), driven by a smaller ratio for XPC14. Greater reduced glutathione concentrations for XPC14 caused a tendency for a quadratic effect on d 28 and 56 ($P = 0.09$ and 0.07). A tendency for a linear increase in total glutathione concentrations in XPC-fed steers was noted on d 56 ($P = 0.09$). These results could indicate lesser levels of oxidative stress for animals receiving Original XPC at 14 g/d.

**Key Words:** *Saccharomyces cerevisiae* fermentation product, antioxidants, cattle
doi: 10.2527/asasmw.2017.107

**108 Mortality and survival probability of breeding-female pigs in southern European commercial herds.** S. Tani[1,*], C. Pineiro[2], Y. Koketsu[1], [1]*Meiji University, Kawasaki, Japan,* [2]*PigCHAMP Pro Europa, Segovia, Spain.*

Decreasing the mortality risk in breeding-female pigs is critical to enhance maternal health and animal welfare in commercial herds, and it also helps prevent decreased productivity, economic losses, and reduced worker morale. The objectives of the present study were to characterize death occurrences in female pigs, to examine the survival probability for gilts and sows in commercial herds, and to quantify factors associated with by-parity mortality risks for farrowed sows. The data included 558,486 first service records of 113,517 females in 121 herds, served between 2008 and 2013. Two herd categories were defined on the basis of the lower 25th percentiles of the herd means of annualized lifetime pigs weaned per sow: low-performing herds (<21.7 pigs) and ordinary herds (>21.7 pigs). By-parity annualized mortality incidence rates for pregnant pigs and farrowed sows were calculated by using pig days as the denominator. Two-level survival analysis was performed for served female pigs to obtain by-parity survival

probabilities. Also, log-binomial regression models were used to examine risk factors and risk ratios associated with by-parity mortality risks for farrowed sows. The mortality rate of the 113,517 removed females was 14.4%, with overall mean annualized mortality incidence rates (%) of 4.5 and 19.3% for pregnant female pigs and farrowed sows, respectively. Survival probabilities for served females rapidly decreased at around farrowing in all parity groups. Also, lower survival probabilities for served female pigs were associated with increased age at first mating, females fed in low-performing herds, females that farrowed more stillborn piglets, and females having WMI of 7 d or higher ($P < 0.05$). Increased mortality risks for farrowed sows were associated with summer farrowing, being fed in low-performing herds, and having more stillborn piglets ($P < 0.05$). The relative risk ratios of parity 1 to parity 5 farrowed sows dying were 1.33–1.59 if they were being fed in low-performing herds, compared to those being fed in ordinary herds. Also, the relative risk ratios of sows that farrowed stillborn piglets dying were 1.56–2.67 across parity, compared to sows that had not farrowed stillborn piglets. However, herd size was not associated with mortality risk ($P > 0.88$). In conclusion, to prevent female pig death occurrences, producers need to provide more care and attention to female groups at high risk of dying, such as females in peripartum periods, pregnant gilts in late gestation, sows farrowing in summer, and those being fed in low-performing herds.

**Key Words:** relative risk, mortality incidence rate, death interval
doi: 10.2527/asasmw.2017.108

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**109 Cows with follicular fluid androgen excess exhibit anovulation and have altered circulating sex hormone binding globulin, gonadotropin secretion, and plasma and follicular fluid composition.**

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Our laboratory identified a group of cows with excess intrafollicular concentrations of androstenedione (A4; >30 fold), reduced calving rates, and theca gene expression profiles similar to women with polycystic ovary syndrome (PCOS). Based on these previous studies, we hypothesized that High A4 cows ($n = 6$) have altered endocrine and metabolic profiles with irregular reproductive cycles compared to Low A4 controls ($n = 5$). To test this hypothesis, cows were 1) synchronized to a more natural estrous cycle (one injection of Prostaglandin F 2 α (PG) and ablation of follicles greater than 7 mm (FA) on the same day) without ultrasound; 2) a more intensively manipulated estrous cycle (multiple injections of PG and FA); 3) stimulated with a low dose of FSH overtime and ovariectomized to measure endocrine, follicular, and lipid parameters during these three different cycles and at ovariectomy. Hormone data were analyzed using the MIXED procedure of SAS with day, group, and interaction as the fixed effects in a repeated measures model. Random Forest algorithm was used to select the top three lipids which were then compared between groups through unpaired *t* test. Plasma sex hormone binding globulin (SHBG) and nonesterified fatty acids (NEFA) concentrations were reduced in High A4 cows during the natural and manipulated cycle vs. Low A4 cows. Intensive manipulation of estrous cycles resulted in reduced SHBG in Low A4 cows compared to a natural cycle. Also, High A4 cows ovulated without behavioral estrus or displayed estrus without ovulation. Furthermore, at Day 10 serum LH and FSH concentrations ($P = 0.02$), ($P < 0.0001$) were reduced in High A4 cows. Lipidomic analysis identified reduced hydroperoxy, phosphatidylcholine, and lyso-phosphatidylethanolamine whereas phosphatidylglycerol was increased in blood plasma of High A4 compared to Low A4 cows. At ovariectomy after FSH stimulation there were fewer granulosa cells per mL of follicular fluid ($P = 0.007$), and dipalmitoylphosphatidylcholine (DPPC) was greater while monoacylglycerol was lower in High A4 vs. Low A4 cows. Phosphatidylethanolamine and sphingomyelin were both reduced in follicular fluid of High A4 cows. Thus, overall, High A4 cows had reduced gonadotropin secretion, NEFA, SHBG, and altered lipids during a non-FSH-stimulated cycle. High A4 cows had an impaired ability to respond to FSH stimulation resulting in reduced granulosa cell numbers and altered lipids. These altered metabolic factors may influence gonadotropin hormone secretion resulting in altered reproductive cycles and reduced calving rate in these High A4 cows. USDA is an equal opportunity provider and employer.

**Key Words:** sex hormone binding globulin, lipidomics, androgens
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**110 Changes in neonatal foal blood chemistry during the first 72 hours of life.**

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Limited research has been conducted to determine normal blood chemistry in equine neonates because the majority of data is derived from case studies of unhealthy foals. The objective of this study was to determine blood chemistry changes during the first 72 h of life in foals. Quarter horse foals ($n = 6$; 2 primiparous dams and 4 multiparous dams) were monitored closely at foaling. Time of parturition was recorded, and jugular blood samples were collected from foals pre-suckling (within 85 min of parturition) and at 6, 12, 24, 48, and 72 h from initial sampling.

Serum was used to determine blood chemistry within 48 h of sampling (Equine Maxi Chem Panel, MU Vet Med Diagnostic Laboratory). Data were analyzed using sampling hour as a fixed effect, and hour LS means were considered different when $P \leq 0.05$. There was an effect of hour ($P < 0.05$) on all blood chemistry measures except anion gap ($P = 0.06$), phosphorous ($P = 0.11$), and creatine kinase ($P = 0.35$). Glucose, total protein, and globulin increased from 0 to 12 h. Creatinine decreased from 0 to 6 h. Albumin decreased from 0 to 24 h. Blood urea nitrogen decreased from 12 to 72 h. Triglycerides increased from 12 to 48 h. Sodium decreased from 0 to 24 h and then from 24 to 48 h. Potassium decreased from 0 to 6 h and increased from 24 to 48 h. Chloride concentrations were greater at 0 and 48 h than 24 h. Bicarbonate was greater at 0 and 72 h than 6, 12, and 24 h. Calcium decreased from 6 to 24 h and increased from 24 to 48 h. Magnesium increased from 0 to 6 h but decreased from 24 to 72 h. Direct bilirubin increased from 0 to 6 h and decreased from 12 to 24 h. Total bilirubin increased from 0 to 6 h and 12 to 24 h and then decreased 24 to 48 h. Aspartate aminotransferase increased from 0 to 72 h, except from 12 to 24 h. Gamma-glutamyltransferase increased 0 to 6 h, decreased 12 to 24 h, and increased from 48 to 72 h. These data demonstrate that blood chemistry changes throughout the first 72 h of life in foals. Sampling time should therefore be taken into consideration when evaluating individual neonates.

**Key Words:** foal, metabolites, neonate
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**111 Effects of exogenous phytase supplementation and dietary phosphorus concentration on metabolism and digestibility of beef cattle.** C. J. Long*, H. H. Stein, T. L. Felix, *University of Illinois at Urbana-Champaign, Urbana.*

Objectives were to determine the interactions of phytase inclusion and dietary phosphorus concentration on metabolism of beef cattle fed a starch-based diet. Six ruminally fistulated steers (initial BW = 750 ± 61 kg) were allotted to a 6 × 6 Latin square design with a 3 × 2 factorial arrangement of treatments. Factors included phytase inclusion, at 0, 500, or 2000 phytase units (FTU)/kg of diet DM, and dietary P concentration, at 0.10% and 0.30% of total diet DM. Data were analyzed using the MIXED procedure of SAS with animal as the experimental unit. The CORR procedure was used to compare P concentrations between samples. There were no treatment interactions ($P \geq 0.30$) for any parameter measured. There were no main effects ($P \geq 0.45$) of phytase on DMI, total fecal output, apparent DM digestibility, water intake, or urinary output. Steers fed 0.10% P had decreased ($P < 0.01$) DMI and total fecal output but increased ($P < 0.01$) apparent DM digestibility compared with steers fed 0.30% P. Although N intake and retention were not affected by treatment, steers fed the 0.10% P diet tended ($P = 0.10$) to absorb more N and excrete more N in the urine ($P = 0.02$) and less N in the feces ($P < 0.01$) compared with steers fed 0.30% P. Steers fed 0.10% P also consumed 70.1% less ($P < 0.01$) total P each day and excreted 51.9% less P in the feces ($P < 0.01$) and 94.6% less P in the urine ($P < 0.01$) compared with steers fed 0.30% P. Water-soluble P in the feces was greater ($P < 0.01$) on a g/d basis in steers fed 0.30% P when compared with steers fed 0.10% P. However, the proportion of total fecal P excreted as water-soluble P increased by 23.0% in cattle fed 0.10% P compared with steers fed 0.30% P, regardless of phytase inclusion level. There was no effect of dietary phytase concentration on blood or urinary ($P \geq 0.27$) P concentrations. Blood P concentration was positively correlated ($r = 0.60$; $P < 0.01$) with urinary P concentration when steers were fed 0.10% P; however, when steers were fed 0.30% P, there was no correlation ($r = 0.36$; $P = 0.16$). Regardless of dietary P concentration, phytase supplementation did not increase P absorption or retention.

**Key Words:** phytase, phosphorus, beef cattle
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**112 Vaginal and uterine bacterial communities in postpartum lactating cows.** B. A. Clemmons[1,*], F. Guirado Dantas[1], G. A. Franco[1], S. T. Reese[1], O. I. Adeyosoye[2], T. P. Smith[3], P. R. Myer[1], K. G. Pohler[1], *[1]University of Tennessee, Knoxville, [2]Obafemi Awolowo University, Ile-Ife, Nigeria, [3]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The vaginal and uterine microbiome of cattle could provide important indicators of fertility pregnancy success; however, only recently has next-generation sequencing made it possible to deeply interrogate these microbial communities. The objective of this study was to determine the bacteriome of the vaginal and uterine environments in lactating Angus cows ($n = 30$) undergoing estrus synchronization prior to timed artificial insemination (TAI). On D-2 prior to TAI, uterine and vaginal flushes were performed. Vaginal flushes consisted of 60 mL of saline solution injected into the vaginal cavity, rectally massaged, and fluid collected using sterile 50 mL conical tubes. Uterine flushes were conducted using a Foley catheter, flushed with 180 mL of saline solution, and collected in sterile 50 mL conical tubes. After initial pregnancy check on Day 30 post TAI, 10 open cows were chosen based on successful flush, presence of corpus luteum on D-9, and ovarian activity throughout. DNA was extracted, and the V1-V3 hypervariable regions of the 16S rRNA gene were targeted and sequenced for bacterial community analysis. Sequences were cleaned and processed using QIIME-1.8.0 software package. Differences in bacterial community characteristics by normally distributed variables (Shannon index) were statistically analyzed by a one-way analysis of variance (ANOVA) for multiple independent groups. Differences for not normally distributed variables and all multiple-group comparisons (observed OTUs, Chao1, relative abundances of taxonomic profiles) were completed using the Kruskal-Wallis H test with Benjamini-Hochberg FDR multiple test correction. For all

analyses, the significance level was set at 0.05. The vagina contained a significantly greater number of operational taxonomic units (OTU; $p = 0.002$) than did the uterus, where 482 OTU were shared between the two. The vagina was significantly greater in phylogenetic diversity (Shannon diversity index; $P = 0.029$), and both environments were distinct in phylogenetic distribution utilizing UniFrac distance matrices ($P = 0.005$). The most abundant bacterial phyla in the uterus and vagina, respectively, were Firmicutes (31.3 ± 5.6%; 65.9 ± 4.1%), Protebacteria (22.9 ± 7.7%; 7.4 ± 3.8%), Actinobacteria (13.2 ± 6.7%; 2.3 ± 0.8%), and Bacteriodetes (8.5 ± 1.9%; 16.8 ± 2.7%). The vaginal and uterine bacteriome determined in this study provides the basis to evaluate potential roles microbiota may play in affecting reproductive outcomes.

**Key Words:** vaginal, uterine, bacterial
doi: 10.2527/asasmw.2017.112

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**113 The effects of supplementing EPA and DHA during late gestation on ewe metabolic profile and milk production.** D. N. Coleman*, A. Relling, P. A. Dieter, *Department of Animal Sciences, OSU, Wooster, OH.*

Fatty acids are involved in the regulation of many physiological pathways, including those involved in gene expression and energy metabolism. Therefore, our objective was to investigate the impact of supplementing ewes with the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahenaenoic acid (DHA) during late gestation on ewe performance, metabolic profile of ewes, and their milk production. Eighty-four gestating ewes were blocked by conception date into group pens with 3 animals per pen and randomly assigned to a diet enriched with monounsaturated fatty acids (MUFA using EnerG II as source) or the polyunsaturated fatty acids (PUFA, using Strata G113 as a source) EPA and DHA during the last 50 d of gestation. The dose of EPA and DHA supplemented was 18 mg per kg of metabolic body weight ($BW^{0.75}$), with total fat supplementation on MUFA and PUFA being fed at the same percent of the diet. After lambing, ewes and lambs were placed on pasture. The ewes were weighed and body condition scored on Days 0, 30, 80, and 120 (weaning) of the experiment. Blood samples were taken on Days 0, 30, 50 (lambing), 80, and 120, and plasma was analyzed for concentrations of glucose and non-esterified fatty acids (NEFA). Milk yield and composition were measured at 30 d postpartum. There was no difference ($P > 0.05$) in body weight or body condition score (BCS) between treatments. No significant differences ($P > 0.05$) were observed for plasma glucose and NEFA concentrations among ewes supplemented with MUFA or PUFA. Neither milk yield nor milk protein, fat, lactose, solids, somatic cell count (SCC), milk urea nitrogen (MUN), energy corrected milk (ECM), or net energy of lactation ($NE_L$) were different ($P > 0.05$) among treatments. These results suggest that supplementation of EPA and DHA during late gestation has no effect on ewe metabolic profile or milk production. Further laboratory analyses will determine if fatty acid composition of ewe plasma and milk were altered by feeding EPA and DHA. Future research should investigate the potential effects of supplementing higher doses of EPA and DHA on metabolism and milk production.

**Key Words:** fetal programming, essential fatty acids, metabolism
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**114 Improving sow productivity and nursery pig performance by injecting sows with D-α-tocopherol, retinyl palmitate, and cholecalciferol.** R. Becerra[1,*], E. van Heugten[1], R. L. Stuart[2], *[1]North Carolina State University, Raleigh, [2]Stuart Products Inc., Bedford, TX.*

Vitamins A, D, and E play important roles in preventing cell damage, enhancing immune function, and improving fertility. We hypothesized that highly productive sows require supplemental fat-soluble vitamins to maximize reproductive performance and the growth and health of their offspring. Fifty-four sows were allotted by parity to 3 treatments: 1) control (C; 5 mL i.m. saline injection on d 107 of gestation); 2) 2 injections (V2) of 5 mL i.m. of a multi-vitamin product containing 300, 200,000, and 100,000 I.U./mL of vitamin E, A, and D, respectively, on d 107 of gestation and d 4 of lactation; and 3) same as V2 plus a 5 mL i.m. injection of vitamins on d 14 of lactation (V3). Serum samples from sows were collected on d −7, 1, 7, and 17 relative to farrowing and from piglets on d 3, 7, 17, and 25 (4 d post-weaning). Serum retinol concentrations in sows and piglets increased over time ($P < 0.001$) but were not impacted by injection. Serum α-tocopherol in sows increased as lactation progressed ($P < 0.001$); V2 increased ($P < 0.05$) serum α-tocopherol on d 7 compared to control, and V3 tended ($P < 0.10$) to increase serum α-tocopherol on d 17 compared to control and V2. Piglet serum α-tocopherol decreased ($P < 0.001$) from d 3 to 25 (7.67 to 2.19 μg/mL) but was not affected by treatment. Vitamin injection increased ($P < 0.05$) serum $25(OH)D_3$ in sows on d 1, 7, and 17, and V3 increased ($P < 0.05$) serum $25(OH)D_3$ compared to V2 on d 17. In piglets, serum $25(OH)D_3$ increased ($P < 0.05$) on d 7 and 17 with V2 compared to control. Pigs from V3 sows had greater ($P < 0.05$) serum $25(OH)D_3$ on d 7, 17, and 25 than control (12.6, 26.7, 19.8, and 15.4 vs. 6.4, 7.2, 9.0, and 13.4 ng/mL for d 3, 7, 17, and 25, respectively) and had greater ($P < 0.05$) serum $25(OH)D_3$ on d 17 (32.2 vs. 19.8 ng/mL) and 25 (24.6 vs. 15.4 ng/mL) compared to V2. Piglet BW at birth and weaning was greater ($P < 0.05$) with V3 compared to V2, whereas BW after 14 d ($P = 0.06$; 8.76, 8.83, and 9.33 kg for control, V2, and V3, respectively) and 35 d in the nursery was improved with V3 compared to V2 and control ($P = 0.005$; 18.03, 18.31, and 19.73 kg for control, V2, and V3, respectively). In conclusion, injecting fat-soluble vitamins in sows improved piglet performance through the nursery, which may be related to improved vitamin status of pigs.

**Key Words:** fat-soluble vitamins, pigs, sows
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**115 Enhancing the nutritive values of corn DDGS via pretreatment and digestion.** C. A. Zangaro[1,*], R. Patterson[2], W. R. Gibbons[1], T. A. Woyengo[1], *[1]South Dakota State University, Brookings, [2]Canadian Biosystems, Calgary, AB, Canada.*

Dried distillers grains with solubles (DDGS) have high fiber content. Pretreatment of whole stillage (WS; slurry material that is dried into DDGS) with hot water (HW), diluted acids or alkalis, or multi-carbohydrases can potentially improve DDGS digestibility by pigs. Thus, effects of pretreating WS with HW or diluted citric acid (CA), sulfuric acid ($H_2SO_4$), or ammonia without or with multi-carbohydrases hydrolysis on porcine in vitro digestion and fermentation characteristics were determined. The WS was untreated or treated with HW, CA (10 g/L), $H_2SO_4$ (90 mM), or ammonia (1%) at 160°C for 20 min. Untreated WS and pretreated WS were hydrolyzed with multi-carbohydrase (9600 U of xylanase, 1200 U of glucanase, 4000 U of cellulase, 480 U of mannanase, 5600 U of invertase, 40,000 U of protease, and 96,000 U of amylase/kilogram of dried WS) for 24 h. The untreated and pretreated WS were dried and hydrolyzed in 2 steps using pepsin and pancreatin. Consequently, undigested residues were incubated in a buffer solution containing fresh pig feces as inoculum for 72 h. Gas production was measured for 72 h and modeled to estimate kinetics of gas production. Concentration of VFA per unit weight of residue incubated or feedstuff was measured in fermented solutions. On DM basis, untreated, HW-treated, CA-treated, $H_2SO_4$-treated, and ammonia-treated WS contained 25.43, 27.09, 27, 21.10, and 32.62% CP and 19.12, 10.03, 13.32, 15.03, and 17.78% total non-starch polysaccharides, respectively. In vitro digestibility of DM (IVDDM) of untreated WS was 73.9%. Treatment of WS with HW, CA, $H_2SO_4$ or ammonia increased ($P < 0.001$) IVDDM by an average of 14%. Multi-carbohydrase hydrolysis of HW-treated, CA-treated, $H_2SO_4$-treated, or ammonia-treated WS further increased ($P < 0.001$) IVDDM by an average of 14%. Multi-carbohydrase hydrolysis of untreated WS increased ($P < 0.001$) IVDDM by 22%. Treatment of WS with HW, $H_2SO_4$, or ammonia increased ($P < 0.001$) total gas production by an average of 42%. However, CA treatment did not affect total gas production. Treatment of WS with HW, CA, $H_2SO_4$ or ammonia increased ($P < 0.001$) total VFA production by an average of 65.36%. In conclusion, the digestibility and fermentability of WS was improved by the HW, CA, $H_2SO_4$, or ammonia pretreatment and multi-carbohydrase hydrolysis. Thus, HW pretreatment or multi-carbohydrase predigestion or both can be attractive methods of improving the digestibility of WS and hence DDGS because water is cheap and multi-carbohydrases are often added in swine diets.

**Key Words:** pig, DDGS, pretreatment
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**116 On the associations between linear body measurements, feeding behavior traits, and feed efficiency measures in finishing steers.** A. B. P. Fontoura[1,*], E. Knutson[1], F. E. Keomanivong[1], A. K. Ward[2], K. C. Swanson[1], *[1]North Dakota State University, Fargo, [2]Department of Animal Sciences, North Dakota State University, Fargo.*

Animal size and feeding behavior patterns may be associated with feed efficiency considering the energy metabolism linkage between these factors. However, these associations may differ partially according to the efficiency measure used. Thus, objectives were to evaluate the associations between linear body measurements, feeding behavior, and different measures of efficiency in finishing steers. A group of 61 steers (initial BW = 401 ± 54.20 kg) was tested over a 142-d period. Steers were fed a corn-based diet (with two different levels of vitamin A supplementation) allowing for ad libitum consumption. Feed intake was individually measured using the Insentec feeding system. Six productive performance traits were calculated: daily dry matter intake (DMI), daily DMI relative to BW (DMIp), average daily gain (ADG), residual feed intake (RFI), residual gain (RG), and gain to feed ratio (G:F). Body measurements of body length (BL), hip height (HH), hip width (HW), heart girth (HG), mid-girth (MG), and flank girth (FG) were performed on Days 1 and 142. Feeding behavior traits consisted of events per day (meals/day; visits/day), eating time (min/visit; min/meal; min/day), and eating rate (g of DM/visit; g of DM/meal; g of DM/day). The associations between body measurements, feeding behavior, and efficiency measures were measured through partial correlations, adjusted for dietary treatment, using the MANOVA/PRINTE statement within the GLM procedure of SAS. Among animal size traits, BL, HH, HG, MG, and FG were all negatively correlated with G:F (range: −0.25 to −0.55, $P \leq 0.05$), while no correlations were found when looking at RG and RFI. The HG was positively associated with ADG ($r = 0.36$, $P = 0.004$) and DMI ($r = 0.71$, $P = 0.0001$) and negatively associated with DMIp ($r = -0.23$, $P = 0.05$) and G:F ($r = -0.55$, $P = 0.0001$). Among feeding behavior traits, meals/day ($r = 0.34$), visits/day ($r = 0.35$), g of DM/day ($r = 0.52$) and g of DM/visit ($r = 0.33$) were all correlated with RFI ($P \leq 0.05$). Interestingly, the eating time (min/day) was negatively associated with G:F ($r = -0.25$, $P = 0.05$) and positively associated with RFI ($r = 0.52$, $P = 0.0001$). In general, our results reinforce that G:F ratio is highly dependent on animal linear body measurements (i.e., size), in contrast to the measures of RG and RFI. Additionally, feeding behavior traits and therefore animal activity may be important factors regulating efficiency of feed utilization. Thus, the selection criteria based on efficiency measures should take into account animals' stage of production and outputs of interest of the overall production system.

**Key Words:** residual feed intake, eating time, girth measurement
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## GRADUATE STUDENT POSTER COMPETITION: PH.D.

**117 Effects of floor cooling on late lactation sows under acute heat stress.** F. A. Cabezon[1,*], A. P. Schinckel[1], J. N. Marchant-Forde[2], J. S. Johnson[2], R. M. Stwalley[3], *[1]Department of Animal Sciences, Purdue University, West Lafayette, IN, [2]USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, [3]Department of Agricultural Biological Engineering, Purdue University, West Lafayette, IN.*

The objective was to evaluate the effects of floor cooling on late lactation sows under severe summer heat stress. Ten multiparous sows were provided with a cooling pad built with an aluminum plate surface, high-density polyethylene base, and copper pipes. Treatments were randomly allotted to sows to receive a constant cool water flow of 0.00 (CONTROL, $n = 4$), 0.25 (LOW, $n = 2$), 0.55 (MEDIUM, $n = 2$), or 0.85 (HIGH, $n = 2$) L/min for 100 min. The cooling was initiated 1 h after the room reached 35°C. Respiration rates (RR), vaginal temperature (VT), and skin temperature (ST, 15 cm posterior to the ear) were recorded before the trial, prior to cooling, and 5 times (every 20 min) after the cooling phase started. Rectal temperature (RT) was recorded before the trial, prior to cooling, and in the last 20 min of cooling. Water flow rates, inlet and outlet water temperatures were recorded 5 times (every 20 min) to calculate heat removal (watts) after the cooling initiation. The same procedure was repeated 8 times (2 times/day for 4 d). In each repetition treatments were switched randomly. Data were analyzed using the MIXED procedure in SAS. For the pre-trial and pre-cooling RR, VT, RT, and ST measurements, the model included treatment as fixed effect and repetition as a random block. During the cooling phase, RR, VT and ST, and heat removal were analyzed using repeated measures with sow as a repeated random effect. The model included treatment, cooling time, and their interactions as fixed effects. The mean room temperature and relative humidity during the trial were 35.1 ± 0.4°C and 68.4 ± 3.2%, respectively. The treatments impacted RR, VT, ST, and RT after 80 min of cooling, where the mean RR was 122, 76, 67, and 45 breaths/min for the CONTROL, LOW, MEDIUM, and HIGH treatments, respectively ($P < 0.001$). After 80 min of cooling the mean VT, RT, and ST were 40.1, 40.0, and 39.4°C for the CONTROL; 39.5, 39.5, and 39.0°C for the LOW; 39.4, 39.2, and 38.9°C for the MEDIUM; and 39.2, 39.0, and 38.6°C for the HIGH treatment, respectively ($P < 0.001$). Overall heat removal during the trial was 192.7, 320.7, and 364.8 W for the LOW, MEDIUM, and HIGH treatments, respectively ($P < 0.001$). Cooling pads with LOW, MEDIUM, and HIGH water flow rates reduced RR, RT, and VT in lactating sows.

**Key Words:** lactation, cooling pads, sow
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**118 Effects of dietary copper levels on growth performance and response to lipopolysaccharide challenge in nursery pigs from sows fed either high or low copper diets.** N. Lu*, M. D. Lindemann, *University of Kentucky, Lexington, KY.*

At weaning, a total of 32 piglets (half barrows and half gilts) were selected from multiparous sows fed diets supplemented with copper at either 20 or 120 ppm Cu throughout gestation and lactation. These piglets were blocked by BW and sex and then randomly allotted to 2 dietary treatments (supplemented with 20 or 220 ppm Cu from $CuSO_4$) as a split-plot design of sow diet (main plot) and nursery diet (subplot) with 4 pens/treatment and 2 pigs/pen. The diets were fed in two 2-wk phases, pigs and feeders were weighed weekly, and blood samples were collected on d 0, 14, and 28. Upon completion of the growth trial, one pig from each pen was moved to another pen to singly house the pigs, and all pigs were deprived of feed overnight. The next morning, the pigs from each original pen were injected with either lipopolysaccharide (LPS: 50 μg/kg of BW) or PBS solution, and then pigs were allowed to access the same diets as in the growth trial. Growth performance, respiratory rate, rectal temperature, and plasma cortisol level were measured right before injection and every 2 h until 12 h after injection. Piglets from sows that received the high Cu diet had greater ADG and ADFI during d 0 to 7, d 0 to 14, and overall period ($P < 0.05$) and higher G:F during d 0 to 14 ($P = 0.014$) than those from sows that received the low Cu diet. The piglets injected with LPS had lower BW gain from 2 to 6 h, lower feed intake, higher rectal temperature, and greater plasma cortisol levels from 2 to 12 h after injection ($P < 0.10$) when compared to piglets injected with PBS. The piglets from sows that received the high Cu diet had heavier BW from 0 to 12 h, greater BW gain from 6 to 10 h, higher rectal temperature from 0 to 12 h, and greater plasma cortisol levels at 2, 6, and 10 h after injection ($P < 0.10$) than those from sows that received the low Cu diet. The supplementation of Cu at 120 ppm to the sow diet improved growth performance of nursery pigs and resulted in different responses to LPS challenge. However, the Cu levels of the nursery diets did not affect the growth performance of piglets during the growth trial or response of piglets to LPS challenge.

**Key Words:** lipopolysaccharide, copper, nursery pigs
doi: 10.2527/asasmw.2017.118

## 119 Standardized total tract digestible phosphorus requirement of 11- to 25-kg pigs.

C. M. Vier[1,*], F. Wu[1], S. S. Dritz[1], M. D. Tokach[1], M. A. D. Goncalves[2], U. A. D. Orlando[2], J. C. Woodworth[1], R. D. Goodband[1], J. M. DeRouchey[1], *[1]Kansas State University, Manhattan, [2]Genus PIC, Hendersonville, TN.*

A total of 1080 barrows and gilts (PIC; 337 × Camborough, initially 11.4 ± 0.29 kg BW) were used in a 21-d trial to determine the standardized total tract digestible (STTD) P requirement of nursery pigs from 11 to 25 kg. Pigs were allotted to pens at weaning according to BW and gender. There were 6 replicate pens/treatment and 23 to 27 pigs/pen. Pens of pigs were randomly allotted to experimental diets based on average BW 21 or 24-d postweaning, in a randomized complete block design. The 7 dietary treatments consisted of 0.26, 0.30, 0.33, 0.38, 0.43, 0.48, and 0.53% STTD P. The NRC (2012) estimates a 0.33% STTD P requirement for nursery pigs from 11 to 25 kg. Two corn-soybean-meal-based diets were formulated to contain 0.26 and 0.53% STTD P by increasing the inclusion of calcium carbonate and monocalcium phosphate at the expense of corn, maintaining a constant 1.17:1 total Ca:P ratio, with no phytase added to the diets. Diets were blended using a robotic feeding system to achieve the intermediate STTD P levels. Experimental data was analyzed using generalized linear and nonlinear mixed models, fitting the data with heterogeneous residual variances when needed, and pen as the experimental unit. Competing models included linear (LM), quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ). Best-fitting models for each response were selected using the Bayesian information criterion. Increasing STTD P improved ADG, ADFI, and G:F (linear, $P < 0.05$). For ADG, the best-fitting models were LM and QP, estimating the maximum response at greater than 0.53% STTD P for both models. For G:F, best-fitting models were QP and BLL. The QP model estimated the maximum at 0.43% (95% CI: 0.36 to > 0.53%), with 99% of maximum G:F achieved at 0.36%. The BLL plateau was estimated at 0.34% (95% CI: 0.29 to 0.38%). In conclusion, the estimated STTD P requirement for nursery pigs from 11 to 25 kg ranged from 0.34 to at least 0.53% depending on the response criteria and statistical model.

**Key Words:** growth, phosphorus, nursery pigs
doi: 10.2527/asasmw.2017.119

## 120 After all, tomorrow is another day for the transition cow: Depending on liver and reproductive health, of course.

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Infertility in lactating dairy cows has been attributed to metabolic stress during the transition period. Potential metabolic alterations that dysregulate ovarian functions have not been completely cataloged. Our objective was to characterize metabolic parameters of dairy cows during the transition period. First, we examined the metabolic profiles in circulation to pinpoint time points of major changes. We collected weekly blood samples from Holstein cows ($N = 15$) from 3 wk before to 12 wk after calving. Glucose levels reduced during pre-calving weeks to reach a nadir at 3 wk post-calving ($P < 0.05$), and the first increase in glucose concentration occurred at 10 wk post-calving ($P < 0.05$). Also, β-hydroxybutyric acid levels increased from calving until week 3 of lactation ($P < 0.05$) and subsequently returned to baseline. Levels of triglycerides decreased during pre-calving weeks, while significant increase occurred at 5 wk post-calving ($P < 0.05$). Total cholesterol concentrations increased from the third to seventh week post-calving ($P < 0.05$). Oxidative stress indicator, glutathione, decreased to reach a nadir by 7 wk in lactation ($P < 0.05$). Thus, post-calving weeks 3 to 7 are associated with major alterations in metabolic indicators in circulation. In the second experiment, we evaluated changes in hepatic and granulosa cell (GC) mRNA levels and circulating metabolic indicators during the periods of major metabolic changes listed above. We collected blood and liver biopsies from Holstein cows at 3 wk pre-partum, during calving week, and 7 wk post-partum; this last liver sample accompanied collection of GCs from the dominant follicle by follicular aspiration. Cows were separated into two groups, where Group 1 ($N = 4$) consisted of cows that lost less than 0.75 body condition score (BCS) during the sampling trial and Group 2 ($N = 4$) consisted of cows that lost equal to or greater than 0.75 BCS. Lipid metabolism and oxidative stress were evaluated in hepatic tissue by qPCR. Transcript abundance revealed a decrease in *CYP7A1* ($P < 0.05$) and tendency for decrease of *LDLR* ($P < 0.1$) in cows from Group 2 at 3 wk pre-partum. Transcript abundance of

**Table 119.**

| | STTD P, % | | | | | | | Probability, $P <$ | |
|---|---|---|---|---|---|---|---|---|---|
| Item[1] | 0.26 | 0.30 | 0.33 | 0.38 | 0.43 | 0.48 | 0.53 | Linear | Quadratic |
| ADG, g | 513 | 510 | 533 | 532 | 566 | 563 | 573 | 0.001 | 0.718 |
| ADFI, g | 782 | 764 | 776 | 780 | 818 | 824 | 828 | 0.004 | 0.603 |
| G:F, g/kg | 656 | 667 | 687 | 682 | 692 | 684 | 693 | 0.001 | 0.067 |

[1]SEM for ADG, ADFI, and G:F were 11.57, 19.44, and 7.36, respectively.

*SRB1*, *ACAT1, PON1,* and *APOB100* remained unaltered between groups at all time points ($P > 0.05$). Assessing reproductive competence through mRNA abundance of genes required for growth and ovulation (*SRB1, FSHR,* and *LHR*) in GCs remained unchanged ($P > 0.05$). Taken together, transition period features increasing cholesterol, triglycerides and decreasing glucose and glutathione compared to pre-calving period. Further studies, including liver function assays, are required to thoroughly investigate the relationship between liver health, reproductive health, and alterations in circulating metabolic indicators.

**Key Words:** transition cow, liver, ovarian function
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**121 Impact of estrus expression and conceptus presence on plasma and uterine glucose concentrations up until maternal recognition of pregnancy in beef cattle.** E. J. Northrop[1,*], J. J. J. Rich[1], R. A. Cushman[2], G. A. Perry[1], *[1]Department of Animal Science, South Dakota State University, Brookings, [2]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Glucose is an essential component of uterine luminal fluid (ULF); it is a major energy source utilized by the conceptus for growth and development. Previously, we reported increased concentrations of glucose in the ULF of cows that exhibited estrus and observed differences in glucose transporter transcript abundance within the uterine endometrium. Our objective was to determine the relationship between plasma and uterine glucose concentrations throughout the estrous cycle and early stages of pregnancy. Beef cows/heifers were synchronized with the CO-Synch protocol and artificially inseminated (d0). Cows were classified by expression of estrus (estrus and no estrus). Blood was collected to determine glucose concentrations (d0, d5, d8, d10, d12, d16) using the Glucose Liquicolor assay. Uteri were flushed to collect d16 conceptuses nonsurgically (Rep 1; $n = 29$) or following slaughter (Rep 2; $n = 37$). Flush media were analyzed for glucose concentration. Data were analyzed using the MIXED procedure in SAS. There was an effect of replicate on glucose concentration ($P < 0.006$). There was no effect of time ($P = 0.79$) or conceptus ($P = 0.16$) on glucose concentration; however, there was a tendency for estrus cows to have lower glucose concentrations compared to no estrus cows ($P = 0.06$). There were no two-way interactions between time, conceptus, and estrus ($P > 0.24$). There was no correlation between uterine and plasma glucose concentrations in either replicate on d10, d12, and d16. In summary, there was no effect of time or conceptus on glucose concentration in beef cows, while estrus cows tended to have decreased glucose concentration. There was no correlation between uterine and plasma glucose concentration; therefore, the increased uterine glucose concentration among estrus cows on d16 is most likely due to changes in specific glucose transporter expression in the uterine endometrium. USDA is an equal opportunity provider and employer.

**Key Words:** maternal recognition of pregnancy, estrus, glucose
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## GROWTH, DEVELOPMENT, MUSCLE BIOLOGY AND MEAT SCIENCE SYMPOSIUM:

## IS BIGGER BETTER? A DISCUSSION ABOUT THE BENEFITS AND IMPLICATIONS OF PIGS BECOMING HEAVIER

**122 Heavy weight market pigs: Status of knowledge and future needs assessment.** F. Wu*, K. R. Vierck, J. M. DeRouchey, T. G. O'Quinn, M. D. Tokach, R. D. Goodband, S. S. Dritz, J. C. Woodworth, *Kansas State University, Manhattan.*

Marketing weight is an important economic variable that impacts the productivity and profitability of finishing pig production. Marketing weight has been increasing worldwide over the past decades driven by the dilution of fixed production cost and the improvement of genetic selection of lean-type pigs. A literature review was conducted based on studies reporting production of finishing pigs with marketing weight greater than 130 kg. Sensitivities of growth, carcass, and pork quality traits in response to increasing marketing weight by 10 kg increments were generated using simple linear regression. Average responses were calculated as the mean among studies. Increasing marketing weight affected overall pig growth; in particular, cumulative ADG over the finishing period decreased by 4.0 g/d, ADFI increased by 78.1 g/d, and G:F decreased by 0.011 for every 10 kg increase of marketing weight. Increasing marketing weight by 10 kg increased carcass yield by 0.41% units, backfat by 1.8 mm, LM area by 1.8 $cm^2$, carcass length by 2.2 cm, and belly yield by 0.32% units but decreased percentage of fat-free-lean by 0.78% units, loin, shoulder, and ham yields by 0.13, 0.16, and 0.17% units, respectively. Studies evaluating the effects of marketing weight on pork quality observed decreased pH by 0.02 and 0.01 at 45 min and 24 h postmortem, respectively, and an increased a* value by 0.28 per 10 kg marketing weight increase. Heavier pigs had increased concentrations of SFA and intramuscular fat. Conflicting results for L* and b* values, drip loss, Warner-Bratzler shear force, and sensory properties were reported. Also, there has been limited evaluation of nutrient requirement for pigs greater than 140 kg BW. Increased weight and size of heavy pigs require adjustments on barn and facility design; specifically, greater floor space (0.2 $m^2$), feeder space

(0.45 cm), drinker height (1 cm), truck space (1.4 $m^2$), and ventilation requirement are needed for every 5 kg increase in BW from 125 to 150 kg. Increasing marketing weight also creates challenges for processing facilities and equipment, but no published data are available to address the chilling rate requirement, pork safety, and consumer preference associated with heavier carcasses. In conclusion, increasing marketing weight creates both opportunities and challenges to current finishing pig production, and future research is needed to provide nutritional and management guidelines as well as understand how meat quality may be influenced.

**Key Words:** marketing weight, heavy pig, meat quality
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## GROWTH, DEVELOPMENT, MUSCLE BIOLOGY AND MEAT SCIENCE

### 123 Performance and docosahexaenoic acid (DHA) content in longissimus dorsi and backfat tissues of grow-finish pigs fed diets differing in heterotrophically grown algae content.

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Algae sources high in DHA provided in diets fed pigs can potentially produce a more nutritionally desirable pork product for consumers. The objective of this study was evaluation of performance and DHA content of longissimus dorsi (LD) and backfat of grow-finish pigs fed diets containing 0, 0.25, or 0.50% unextracted *Aurantiochytrium limacinum* CCAP 4087/2 algae (FORPLUS™, Alltech Inc). Diets were formulated not to exceed maximums permitted in Europe and contained no antibiotic growth promoters. The study involved 144 pigs (72 gilts and 72 barrows) of 27.9 ± 2.5 kg initial weight. The trial lasted 121 d (112 d and 9 d to slaughter of all pigs). Pigs remained on assigned test diets during the 9d between final weight measurement and slaughter. The study was divided into two growing periods (0□56 and 56□112 d, respectively) for calculation of average daily gain (ADG) and efficiency (feed:gain) on all animals. At trial end carcass characteristics from 72 animals were evaluated. Carcasses from only half the animals were evaluated owing to logistic and economic practicalities. The animals were selected based on live weight near treatment means within gender. DHA content of LD and backfat were sampled from each right side carcass at the 13th rib. Data were subjected to ANOVA with means separated using student's *t* test and Tukey test. ADG, feed:gain, feed, and water intake were unaffected by dietary treatment ($P > 0.05$). Carcass lean content revealed a treatment × gender interaction ($P < 0.05$): gilt backfat tended to increase with algae level with a trend toward lower LD thickness while the opposite was true for barrows. DHA content of LD differed with gender ($P < 0.05$), though differences are only apparent in higher values for barrows given 0.5% algae. In gilts, loin DHA content increased with dietary algae (3.3X control values at 0.25% algae, and 4.5X control values at 0.5%; 0.0054, 0.0178, and 0.243 g/100 g tissue, respectively, $P < 0.0001$). Corresponding values in barrows at 0, 0.25, and 0.5% dietary algae were 0.0059, 0.0178, 0.0297 g DHA/100 g tissue. Backfat DHA increased in response to algae level $P < 0.05$. Values were 0.047, 0.187, and 0.307 g/100 g fat for pigs given 0, 0.25, and 0.5% algae, respectively. It was concluded that DHA content of LD and backfat in pigs fed throughout the grow-finish period increased with dietary algae content. DHA increases in LD of 3.3X and 4.5X allow dosage to be calculated to meet target DHA values.

**Key Words:** algae, fatty acids, grow-finish
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### 124 Docosahexaenoic acid content in longissimus dorsi and backfat tissues of grow-finish pigs fed diets containing 0, 0.25 or 0.5% heterotrophically grown algae: Study 2.

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Higher DHA content of pork is of interest to consumers and could provide an added value product for producers and retailers. The study evaluated performance and some aspects of carcass characteristics and composition of grow-finish pigs fed diets containing 0, 0.25, or 0.50% unextracted *Aurantiochytrium limacinum* CCAP 4087/2 algae (FORPLUS™, Alltech Inc). A total of 144 pigs (72 gilts and 72 barrows) of 24.1 ± 2.6 kg live weight were fed for 117 d (112 d study plus 5 d to slaughter date). Pigs remained on assigned test diets from the final weight measurement at 112 d to slaughter at 117 d. Average daily gain (ADG), efficiency (feed:gain), and feed intake were measured at 112 d on all animals. Each dietary treatment was replicated in 8 pens (4 pens of gilts and 4 pens of barrows) of 6 animals. At trial end carcass characteristics from 72 animals (3 per pen, half barrows, half gilts) were evaluated. Carcasses from half the animals were used owing to logistical and economic practicalities. Animals were selected with live weights near treatment means within gender. Samples for DHA analysis of LD and backfat were obtained from each right carcass at the 13th rib. ADG, feed intake, and feed:gain were unaffected by algae addition ($P > 0.05$). Algae had no effect on backfat and LD thickness or lean meat content. DHA content (g/100 g of tissue) increased in LD and backfat of both genders ($P < 0.05$). LD DHA values were 0.0074, 0.0172, and 0.0252 g/100 g tissue for 0, 0.25, and 0.50% dietary algae, respectively. Total omega-3 FA and omega-3:omega-6 ratio were also increased in LD ($P < 0.05$). In backfat, total omega-3 FA and the omega-3:omega-6

ratio increased with dietary algae ($P < 0.001$). DHA increased (0.0723, 0.2210, and 0.3017 g/100 g fat tissue for 0, 0.25, and 0.50% diet algae, respectively; $P < 0.05$). Extent of treatment effects on DHA content of loin and fat varied with gender. DHA in loin tissue of gilts increased at 2.8 and 2.9X that of controls at 0.25 and 0.5% algae, respectively ($P < 0.05$). In barrows fed 0.25% algae, loin DHA was 2.7X controls $P < 0.05$). At 0.50% FORPLUS™ algae, DHA in loin tissue of barrows was 4X that of controls. Similar trends were noted in backfat DHA content. It was concluded that DHA content of LD and backfat increased with dietary algae level. This algae source can be useful in producing pork products to meet targeted DHA levels.

**Key Words:** fatty acids, algae, grow-finish
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**125 Changes in docosahexaenoic acid (DHA) content in longissimus dorsi and backfat tissue of finishing pigs given diets containing 1% heterotrophically grown algae during the last 28 days.** C. A. Moran[1], G. Fusconi[2], M. Morlacchini[2], K. A. Jacques[3,*], *[1]Alltech France, Vire, France, [2]CERZOO, Piacenza, Italy, [3]Alltech Inc., Nicholasville, KY.*

Consumer focus on nutritional value of pork and other animal products has driven industry interest in improving fatty acid (FA) profiles by providing dietary fat sources high in omega-3 long chain FA, particularly DHA. The objective of this study was an evaluation of tissue DHA content and performance of pigs fed either 0 or 1% algae (1.6 g DHA/kg feed) for 28 d before slaughter. A total of 144 pigs (PIC × Goland, 72 females and 72 castrates; average weight 117.1 ± 13.1 kg) were assigned by sex and weight to pens of 6 to provide 12 pens per treatment. Diets were pelleted and fed ad libitum. The test diet contained 1% unextracted *Aurantiochytrium limacinum* CCAP 4087/2 algae (FORPLUS™, Alltech Inc). Average daily gain (ADG) and feed efficiency (feed:gain) were calculated for Days 0–28 on all animals using pen as the experimental unit. At study end carcass characteristics and tissue DHA content of 72 animals (36 per treatment, half females and half males) were evaluated. Fatty acid profiles of longissimus dorsi muscle (LD) and backfat were sampled from each right carcass at the 13th rib. Daily gain, intake, and F:G were unaffected ($P > 0.05$). No differences due to treatment in backfat and LD thickness, lean meat content, and dressing % were noted ($P > 0.05$). DHA increased from 0.009 to 0.0312 g/100 g tissue in treated animals ($P < 0.001$), while backfat DHA increased 0.0616 to 0.1924 ($P < 0.001$). There were no trt × gender interactions in DHA values; however, values in females were numerically lower. It was concluded that 1% dietary FORPLUS™ algae fed during the last 28 d can increase DHA content by >3 times control values in LD and backfat of finishing pigs. This increase makes possible production of added value pork products.

**Key Words:** DHA, algae, fatty acids
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**126 Effects of dietary fat source and modified distillers grains on beef quality.** F. A. Ribeiro*, E. K. Kunze, K. Domenech-Perez, N. J. Herrera, H. R. Voegele, K. Hart, C. R. Calkins, *University of Nebraska-Lincoln, Lincoln.*

This research was conducted to evaluate the effects of feeding different fat sources with modified distillers grains plus solubles (MDGS) on beef tenderness, discoloration, lipid oxidation, and fatty acid profile. Steers ($n = 256$) were fed for 134 d on either a corn control, 40% full-fat modified distillers grains plus solubles (MDGS), 40% de-oiled MDGS, or 38% de-oiled MDGS plus 2% corn oil diet. Cattle were grouped 8 per pen for a total of 32 pens. Twenty-four low Choice carcasses (3 head/pen) were randomly selected within each treatment ($n = 96$) and strip loins (left and rights sides) were collected and aged for 2, 9, 16, or 23 d. Steaks were fabricated at each aging period and placed under retail display conditions for 0, 4, or 7 d. Tenderness (slice shear force and Warner-Bratzler shear force), discoloration, lipid oxidation, and fatty acid composition were determined. No differences among treatments were observed for slice shear force ($P = 0.7851$) and Warner-Bratzler shear force ($P = 0.4818$). A treatment-by-retail display interaction ($P = 0.0004$) was found for discoloration. Strip loins from steers fed de-oiled MDGS had greater discoloration rates in comparison to beef from the corn fed cattle at 7 d retail display (65.16%, and 49.82%, respectively). Samples from the full-fat and de-oiled MDGS plus oil groups were not different in discoloration from corn or de-oiled MDGS fed cattle (58.08% or 58.64%, respectively). There was a treatment-by-retail display interaction for lipid oxidation ($P = 0.0045$). Strip loins from steers fed de-oiled MDGS and de-oiled MDGS plus oil had numerically, but not statically ($P > 0.05$), greater TBARS values in comparison to corn as retail display progressed. Beef from the corn control cattle had the least amount of C18:2 ($P = 0.0007$) in comparison to all other dietary treatments (6.16% vs. 7.62% for the de-oiled MDGS plus oil, 8.02% for the full-fat MDGS, and 8.20% for the de-oiled MDGS groups). Similarly, beef from corn cattle had the least amount ($P = 0.0231$) of polyunsaturated fatty acids (PUFA, 8.86%) while beef from cattle fed de-oiled MDGS had the greatest amount of PUFA (10.87%). Samples from the full-fat MDGS and de-oiled MDGS plus oil groups were not different from corn or de-oiled MDGS fed cattle (10.66% or 9.95%, respectively).These results suggest that feeding de-oiled MDGS to cattle reduces color and lipid stability and increases PUFA and C18:2 content of the meat. Addition of corn oil to the de-oiled MDGS

had no effect on the results.

**Key Words:** distillers grains, fatty acid composition, quality
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**127 Effect of double stocking and nursery split-out age on wean-to-finish growth performance and economic parameters of growing pigs.**

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It is common practice in the swine industry to double stock wean-to-finish barns with nursery pigs until a desired weight or age has been reached, at which point half of the pigs are removed and transported to a feeder-to-finish barn for the remainder of the finishing period. However, it is uncertain what the optimal timing and duration of the double stocking strategy is to maximize growth and carcass characteristics. The objective of this study was to determine the effects of nursery split-out age in double-stocked wean-to-finish barns on subsequent growth performance, carcass characteristics, and economics. A total of 1260 (PIC TR4 × (Fast LW x PIC L02)) finishing pigs with an initial BW of 5.7 kg were used in a 155-d growth trial with 21 pigs per pen and 10 replications (pens) per treatment. Split-outs were performed at 4, 6, and 8 wk after nursery placement, at which time 50% of the pigs were loaded on a truck and transported to mimic the stress pigs would endure during split-outs and then returned to the barn and placed in separate pens at single stocking density. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. From Day 0–56 there was a linear decrease in ADFI and subsequently ADG and BW as nursery split-out age increased (Linear, $P < 0.003$). The differences in ADFI were not significant from Day 56–155; however, G:F and ADG improved as nursery split-out age increased (Linear, $P < 0.019$). Overall, there was an improvement in G:F as nursery split-out age increased (Linear, $P = 0.024$). There was no difference ($P > 0.16$) in live weight, HCW, or carcass yield; however, lean yield, loin depth, and back fat thickness tended to be decreased (Linear, $P \leq 0.09$) as split-out age increased. In terms of economics, fixed cost decreased as split-out age increased, reducing total cost per pig (Linear, $P < 0.001$). Cost per unit of gain improved as split-out age increased (Linear, $P = 0.026$). When taking into account the savings in facility cost by double stocking pigs in the nursery longer, nearly $1/hd of marginal revenue was gained when marketing to the packer. These data indicate that double stocking up to 8 wk does not result in impaired feeder-finish growth performance and can be utilized without a negative impact on overall economic parameters or final carcass characteristics.

**Key Words:** split-out, stocking density, wean-finish
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**128 Fatty acid profile of meat from Nellore and Angus young bulls fed a whole shelled corn diet.**

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Many fatty acids have beneficial and malefic actions to human health; thus, it is extremely important to analyze the effect of nutrition and genetic group on beef fatty acid profile. The objective was to evaluate the fatty acid profile of muscle of Nellore and Angus young bulls fed whole shelled corn (WSC) and a ground corn (GC) diet. Thirty-four bulls with average initial body weight of 381 ± 11.8 kg were used in a completely randomized design and arranged as a 2 × 2 factorial (2 breeds and 2 diets). The GC diet had 30% of corn silage and 70% of a concentrate based on flint corn and soybean meal. The WSC diet had 85% whole shelled flint corn and 15% of a pellet based on soybean meal and minerals. After harvested, samples were taken from the *longissimus dorsi* (LD) muscle between the 12th and 13th ribs for fatty acid analysis, using gas chromatography. The model included the fixed effects of breed, diet, and their interaction and animals as random effect and was analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). A greater ($P < 0.01$) concentration of palmitic acid (C16:0) was observed in the LD muscle of Angus bulls and a greater ($P < 0.01$) concentration of linoleic acid (C18:2 n6) was observed in Nellore bulls, regardless of diet. The concentration of myristic (C14:0) ($P < 0.01$) and stearic acid (C18:0) ($P = 0.04$) were greater in Angus bulls fed WSC. Nellore bulls fed WSC had a greater ($P = 0.02$) concentration of α-linolenic (C18:3 n3) and Nellore bulls fed GC had a greater ($P = 0.01$) concentration of myristoleic (C14:1). Regardless of breed LD muscle of bulls fed WSC had a greater ($P = 0.01$) concentration of CLA C18:2 t10, c12. In addition, feeding WSC tended to increase concentration of trans octadecenoic acid (C18:1) ($P = 0.09$) and CLA C18:2 c9, t11 ($P = 0.10$). LD muscle of bulls fed GC had a greater ($P < 0.01$) concentration of palmitic acid (C16:0). In conclusion, WSC diet change FA profiles and may reduce lipogenesis in the LD muscle because it is favorable to increase C18:2 t10, c12 content.

**Key Words:** beef, CLA, feedlot
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**129 The effects of instrumental color and extractible lipid content on sensory characteristics of pork chops cooked to a medium-rare degree-of-doneness.**
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The objective was to determine the effect of instrumental color and extractable lipid on sensory ratings of pork chops cooked to an internal temperature of 63°C. Approximately 300 boneless loins (NAMP #414) were selected from a group of pigs with the same genetic background, housing, and management, cut into 2.54 cm chops and aged 14-d postmortem. Instrumental L* color scores of the chops ranged from 43.11 to 57.60 and extractable lipid ranged from 0.80% to 5.52%. Chops were assigned a quality grade using the newly proposed National Pork Board (NPB) quality grade standards. Low ($n = 56$) quality included loins with color scores < 1.5 regardless of color or loins with color < 2.5 and marbling scores ≤ 2.0. Medium ($n = 180$) quality included color scores 2.0 through 3.5 with marbling ≥ 2.5 and color scores from 3.0–3.5 with marbling scores ≥ 2.0. High ($n = 50$) quality included color scores of > 4.0 with marbling scores ≥ 2.0. Chops were assigned to sensory panel sessions in an incomplete block arrangement, cooked to a medium-rare degree-of-doneness (63°C), and evaluated for tenderness, juiciness, and pork flavor by trained sensory panelists. Slice shear force (SSF) and cooking loss were also determined from each loin cooked to 63°C. Data were analyzed using the MIXED procedure in SAS as a one-way ANOVA where quality grade was considered a fixed effect and using the REG procedure in SAS. Extractable lipid content and instrumental chop color individually accounted for a maximum of 2% ($R^2 = 0.02$) of the variation of tenderness, juiciness, or pork flavor. Chops categorized as NPB high quality (SSF = 17.50 kg) were 6.5% more tender ($P = 0.04$) than chops categorized as medium (SSF = 18.56 kg) and 11.2% more tender ($P < 0.01$) than chops categorized as low quality (SSF = 19.60 kg) and medium quality chops were 5.6% more tender ($P = 0.04$) than low quality chops. However, trained sensory panelists did not discern sensory tenderness differences ($P = 0.13$) among NPB quality grades. Juiciness ($P = 0.48$) scores did not differ among NPB quality grades. Cook loss tended ($P = 0.06$) to decrease from 16.57% to 15.32% as quality grade increased. When color or marbling was used as a single trait, it was not predictive of sensory quality. However, using these traits in combination such as with the NPB quality grades may result in differences in sensory quality between pork loins.

**Key Words:** pork, sensory, tenderness
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**130 Effects of antibiotic program and floor space in the nursery and grow-finish periods on wean-to-finish growth performance of pigs under commercial conditions.**
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The effects of floor space and antibiotic program in both the nursery and grow-finish periods on wean-to-finish growth performance of pigs was evaluated using a RCBD with a 2 × 2 × 2 × 2 factorial arrangement of treatments: 1) Nursery floor space (0.31 vs. 0.65 $m^2$/pig); 2) Nursery antibiotic program (none vs. antibiotics); 3) Grow-finish floor space (0.56 vs. 0.65 $m^2$/pig); 4) Grow-finish antibiotic program (none vs. antibiotics). The antibiotic program included providing antibiotics in the feed (at growth promoting concentrations), in the water (to treat all animals on the specific study treatment for specific disease issues), and via injections (to treat individual animals for specific disease issues). The wean-to-finish study (from 6.4 ± 1.10 to 127.7 ± 2.28 kg BW) used a total of 3840 pigs housed in single-sex pens of 30 (8 replicates). Pigs were given ad libitum access to feed and water throughout the study. The pen of pigs was the experimental unit; data were analyzed using PROC MIXED of SAS with the model accounting for the 4 treatments and all interactions, block, and replicate. Results reported are for the wean-to-finish period. There were no interactions ($P > 0.05$) between the floor space and antibiotic program treatments for any measure. Increasing floor space from 0.31 to 0.65 $m^2$/pig in the nursery and from 0.56 to 0.65 $m^2$/pig in grow-finish increased ($P < 0.05$) ADG (1.2 and 1.8% in nursery and grow-finish, respectively) and G:F (1.7 and 1.4%, respectively) with no effect ($P > 0.05$) on ADFI, or morbidity and mortality. Compared to the control (no antibiotics) providing antibiotics in nursery and grow-finish resulted in increased ($P < 0.05$) ADG (1.8 and 1.8%, respectively), ADFI (in nursery only; 2.7%), and G:F (grow-finish only; 2.9%). Morbidity and mortality for the overall study period were significantly increased when antibiotics were removed during the nursery period (7.6 vs. 12.3% for antibiotic and no antibiotic treatments, respectively; $P < 0.001$) and grow-finish period (8.5 vs. 11.4%, respectively; $P < 0.01$). The results of this study suggest that, regardless of floor space, the use of antibiotics significantly increases ADG and G:F and reduces morbidity and mortality levels in wean-to-finish pigs.

**Key Words:** antibiotics, growth, pigs
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**131 Retail color and aerobic bacterial count of strip steaks from beef cattle fed endophyte-infected tall fescue seeds.** A. J. Holtcamp*, A. Theradiyil Sukumaran, R. L. Lemire, B. B. Karisch, D. D. Burnett, T. Dinh, *Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State.*

The objective of this study was to determine the effects of endophyte-infected tall fescue seeds on lean color and microbial growth of beef strip steaks during simulated retail display. Seeds of KY32 (E- or control) and KY31 (E+ or treatment; approximately 20 µg of ergovaline per kg of BW) were randomly assigned to twelve Angus steers ($n = 6$), blocked by initial BW. Steers were fed individually by using Calan® gates during a 70-d trial in the summer of 2015 followed by a 149-d withdrawal period and a 64-d trial in the winter of 2016. Steers were slaughtered after a 66-d finishing period at approximately 500 kg of BW. Strip loins were collected at 72 h post mortem and aged for 14 d. Loins were cut into 2.54-cm steaks, placed on black Styrofoam® trays, overwrapped with PVC film ($O_2$ permeability of 1.21 mL/cm$^2$/d and water vapor permeability of 0.022 g/cm$^2$/d; LINPAC Packaging-Filmco Inc., Aurora, OH), and placed under simulated retail display conditions for 7 d (2 to 4°C, 900-lux fluorescent light intensity, and 80% relative humidity). Objective color and reflectance attenuance were recorded by a reflectance spectrophotometer. Total aerobic plate count was determined by using 3M Petrifilm Aerobic Count Plates (3M, St. Paul, MN). Statistical analysis was performed by the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with treatment and retail day serving as fixed effects, and BW and slaughter day serving as random block effects. Steaks from treated steers had greater oxymyoglobin (1.04%) and less deoxymyoglobin (0.70%) proportions ($P = 0.012$ and 0.024, respectively). However, treatment did not influence other lean color attributes and total bacterial count ($P \geq 0.095$). As expected, lightness (L*), redness (a*), and oxymyoglobin percentage decreased from 45.39, 32.60, and 67.40% on d 0 to 39.37, 21.74, and 48.40% on d 7 of retail display ($P \leq 0.004$) regardless of treatment. Metmyoglobin and deoxymyoglobin increased ($P \leq 0.009$) from 31.87 and 0.67% on d 0 to 38.96 and 14.03% on d 7 of retail display, respectively. Retail display also increased aerobic bacteria by 0.5 log CFU/g ($P \leq 0.020$) for both treatment and control steaks. Feeding endophyte-infected tall fescue seeds followed by a long period of withdrawal had minimal effect on beef color and total bacterial count.

**Key Words:** beef quality, lean color, tall fescue
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**132 Effects of feeding stockpiled tall fescue versus tall fescue hay to late gestation beef cows on steer offspring carcass quality and yield.** A. M. Meyer*, K. N. Niederecker, A. R. Rathert, K. E. Shircliff, Z. D. Callahan, B. R. Wiegand, *Division of Animal Sciences, University of Missouri, Columbia.*

We hypothesized that cows grazing stockpiled tall fescue (STF) during late gestation would have greater nutrient intake than cows fed summer-baled hay, which would result in increased prenatal nutrient supply and ultimately improved fetal development and subsequent carcass quality and yield. Multiparous, spring-calving crossbred beef cows (yr 1: $n = 48$; yr 2: $n = 56$) either strip-grazed STF ($n = 4$ pastures/yr, 12.3% CP, 63.9% NDF; DM basis), or received ad libitum tall fescue hay (6.9% CP, 66.6% NDF; DM basis) fed in uncovered drylots ($n = 4$ pens/yr) from d 188 ± 2 (SEM) until calving. Treatments were terminated within a week post-calving, and all cow-calf pairs were managed as a single group until weaning in each year. Post-weaning, steer offspring (yr 1: $n = 17$; yr 2: $n = 25$) were placed under common management and fed growing and finishing diets in each year. Steers were slaughtered in groups (yr 1: 4 slaughter groups; yr 2 = 3 slaughter groups) based on degree of finish. At slaughter, samples were collected from the longissimus dorsi (LD) for determination of Warner Bratzler shear force, cooking loss, fat content, and moisture content. Data were analyzed with maternal forage system, year, and their interaction as fixed effects in the model. Dam pasture or pen was considered the experimental unit. It has been previously reported that birth weight was reduced in calves born to cows fed hay during late gestation (main effect of treatment only), suggesting impaired fetal growth due to low forage nutrient availability. Despite this, there was no effect ($P > 0.10$) of maternal forage system on final BW at slaughter, carcass weight, yield grade, marbling score, backfat thickness, ribeye area, KPH, or dressing percent. Additionally, Warner Bratzler shear force, cooking loss, percent moisture, and percent fat of LD were not impacted by maternal forage system ($P > 0.14$). In conclusion, maternal nutrition during late gestation did not impact steer offspring carcass quality or yield, nor did it affect tenderness or cooking loss of the LD, despite the differences observed in cow performance and calf birth weight. This suggests that late gestational forage systems used in the current study did not impair fetal muscle or adipose development enough to cause long-term negative impacts on product quality or yield.

**Key Words:** carcass, developmental programming, meat quality
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**133 Young scholar presentation: Metabolic modifiers in beef cattle: Current application and future considerations.** B. M. Bohrer[1,2,*], A. C. Dilger[1], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]University of Guelph, Guelph, ON, Canada.*

In the upcoming years, the expansion of global animal agriculture will be forced to keep pace with expected world population growth. Feeding the growing world will be accomplished by producing more food with fewer resources and improving efficiency in the methods in which food is currently being produced. This leaves great opportunity for the scientific community to improve efficiency in food and agricultural sciences. Metabolic modifiers can be used in livestock production to increase live efficiency and improve yields of animal-derived food products. Less is known about other benefits associated with the use of metabolic modifiers in beef cattle production. Multiple projects in our laboratory have focused on the use of metabolic modifier products in beef cattle, specifically ractopamine hydrochloride (RAC). Key outcomes of this research include production advantages in rate of gain, feed efficiency, and improvements in carcass yields in cattle fed RAC. The objectives of this research were to use commercially relevant approaches to answer applied research questions. Studies were conducted to analyze the effects of feeding cattle RAC with or without supplemental zinc and chromium and feeding cattle RAC with or without the ionophore monensin and the antibiotic tylosin phosphate. Rate of gain (9–16%), and feed efficiency (8–16%) during the finishing period were increased ($P < 0.01$) in cattle fed RAC compared with cattle not fed RAC. Carcass characteristics impacting quality and yield grade were minimally affected in cattle fed RAC compared with cattle not fed RAC. There were no differences ($P > 0.05$) in live animal performance or carcass traits with feeding supplemental zinc and chromium to cattle fed RAC. There were no differences ($P > 0.05$) in live animal performance or carcass traits when including or removing monensin and tylosin from the finishing diet of cattle fed RAC. In addition, research was dedicated to the effect of RAC on glucose and lipid metabolism parameters. Glucose and insulin were measured in non-fasted cattle. Glucose and insulin were measured after glucose-tolerance tests were conducted in cattle fed RAC (300 mg ractopamine·animal$^{-1}$·d$^{-1}$ for 21 d) in two studies. Only in one study were baseline and glucose-induced insulin levels reduced ($P < 0.01$) in cattle fed RAC compared with cattle not fed RAC. Overall, this research provided a brief sampling of strategies and possible considerations to be used with RAC in the beef cattle industry.

**Key Words:** beef cattle, metabolic modifier, ractopamine
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**134 Growth performance, carcass characteristics, and shelf-life of loin chops of finishing pigs fed peroxidized soybean oil.** M. F. Overholt[1,*], G. D. Kim[1,2], S. C. Lindblom[3], B. J. Kerr[4], D. D. Boler[1], A. C. Dilger[1], *[1]University of Illinois, Urbana, [2]Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, South Korea, [3]Iowa State University, Ames, [4]USDA-ARS, Ames, IA.*

Objectives were to determine the effects of feeding peroxidized soybean oil (SO) to finishing pigs on growth performance, carcass characteristics, and loin chop shelf-life. Individually housed pigs ($N = 56$; initial BW = 46.7 ± 5.1 kg) were randomly allotted to 1 of 4 diets containing 10% SO treated as follows: 1) unheated (CON), or heated at 2) 45°C for 288 h (45C), 3) 90°C for 72 h (90C) or 4) 180°C for 6 h (180C), each aeriated with 15 L air/min, and fed for 81-d. Data were analyzed as a one-way ANOVA with initial BW used as a covariate for growth performance and carcass characteristics. Feeding 90C reduced ($P \leq 0.03$) ADG compared with pigs fed 45C and 180C by 11.2 and 9.2%, respectively. There was no difference ($P = 0.81$) in ADFI, but G:F of pigs fed 90C was reduced ($P \leq 0.03$) compared with pigs fed 45C and 180C by 8.6 and 6.4%, respectively. Ending BW of pigs fed 90C diet were reduced ($P < 0.01$) compared with pigs fed 45C and 180C by 7.3 and 6.2%, respectively. For ADG, G:F, and ending BW, CON-fed pigs were similar to all other treatments ($P \geq 0.09$). Feeding pigs 90C reduced ($P \leq 0.03$) HCW by 6.3 to 9.0% compared to all other treatments. Livers of 90C-fed pigs were heavier as a proportion of ending BW ($P \leq 0.03$) than those from pigs fed 45C or 180C. Livers of CON-fed pigs were proportionally smaller than ($P \leq 0.01$) those from pigs fed 90C or 180C, but did not differ ($P = 0.15$) from those fed 45C. There was no effect ($P \geq 0.18$) of diet on BF depth or LMA. Clear plate iodine value of 90C-fed pigs was reduced ($P < 0.01$) by 15.1, 14.0, and 11.2 units compared with 45C, CON, and 180C, respectively. Iodine value of 180C-fed pigs was 4.1 units less ($P < 0.01$) than 45C but not different ($P = 0.07$) from CON. There were no diet × storage time interactions ($P \geq 0.44$). Loin chops from 45C-fed pigs had the greatest ($P \leq 0.03$) a*, b*, chroma, and 530/680, but were the most ($P < 0.01$) discolored after 10-d of simulated retail display. In conclusion, feeding SO heated at 180°C reduced growth performance and HCW; whereas, feeding SO heated at 45°C resulted in redder loin chops that discolored more rapidly during simulated retail display.

**Key Words:** growth performance, peroxidized oil, shelf-life
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**135 Effect of hot carcass weight on fresh loin, ham, and belly quality from pigs sourced from a commercial processing facility.** B. N. Harsh[1,*], E. K. Arkfeld[1], D. A. Mohrhauser[2], D. A. King[3], T. L. Wheeler[3], A. C. Dilger[1], S. D. Shackelford[3], D. D. Boler[1], *[1]University of Illinois, Urbana, [2]Smithfield Foods, Denison, IA, [3]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

The objective was to quantify the effect of HCW on pork primal quality of 7684 pigs with carcass weights ranging from 53.2 to 129.6 kg. Carcass composition, subjective loin quality, and ham face color were collected on all carcasses. In-plant instrumental loin color and belly quality analyses were conducted on 52.0% and 47.5% of carcasses, respectively. Over 10% of the loins ($n$ = 856) were selected for slice shear force (SSF) analysis. Coefficients of determination between traits were computed using the REG procedure of SAS and considered significant at $P \leq 0.05$. As HCW increased, boneless loins were both darker and redder, evidenced by lesser L* ($\beta_1$ = −0.72, $P < 0.001$) and greater a* values ($\beta_1$ = 1.48, $P < 0.001$); however, HCW only accounted for ≤ 0.80% of variability in loin L* and a* values. Similarly, loin subjective color score ($\beta_1$ = 1.45, $P < 0.001$) increased with carcass weight. Subjective marbling score was not affected by HCW ($\beta_1$ = −0.49, $P$ = 0.06). After 20 d aging, HCW only explained 0.98% of variability in loin L* values ($\beta_1$ = −0.75, $P < 0.01$). Heavier carcasses had lower SSF values ($\beta_1$ = −0.77, $P < 0.001$) of loin chops, although HCW only explained 4.46% of variability in SSF. Although heavier carcasses produced loins that exhibited lower ultimate pH values ($\beta_1$ = −15.41, $P < 0.001$), HCW only explained 1.23% of the variability in ultimate loin pH. Interestingly, cook loss decreased ($\beta_1$ = −2.36, $P <$ 0.001) as HCW increased, with HCW accounting for 5.60% of the variability in cook loss. Heavier carcasses resulted in darker ham face color, but HCW only accounted for 2.87% of variability in *gluteus profundus* L* values ($\beta_1$ = −0.97, $P <$ 0.001) and 0.47% of variability in *gluteus medius* L* values ($\beta_1$ = −0.42, $P < 0.001$). Heavier carcasses produced thicker and firmer bellies, with HCW accounting for 37.81% of variability in belly thickness ($\beta_1$ = 76.41, $P < 0.001$) and 20.35% of variability in subjective flop score ($\beta_1$ = 11.01, $P < 0.001$). Overall, the proportion of variability in loin and ham quality explained by HCW was poor ( ≤ 5.60%) suggesting HCW is a poor predictor of primal quality of pigs within this weight range. However, the proportion of accounted variability may need to be revisited as market weights continue to get heavier. Supported by National Pork Board Grant #14–221.

**Key Words:** hot carcass weight, pork, quality

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**136 Downregulated myostatin signaling does not enhance protein kinase B/Akt phosphorylation in skeletal muscle of low birthweight neonatal pigs.** Y. Chen*, S. R. McCauley, R. P. Rhoads, S. W. El-Kadi, *Virginia Tech, Blacksburg.*

Low birthweight (LBWT) neonatal pigs are at significant risk for morbidity and mortality, and experience restricted postnatal muscle growth. Myostatin (MSTN), a member of transforming growth factor-β (TGF-β) family, is expressed and secreted predominantly in skeletal muscle. MSTN negatively regulates skeletal muscle development and growth by inhibiting protein synthesis. Our previous data suggest that LBWT neonatal pigs have reduced protein synthesis but unaltered protein degradation rates, which result in lower protein deposition in skeletal muscle. We hypothesized that decreased protein synthesis in skeletal muscle of LBWT pigs is due to higher abundance of MSTN and upregulated MSTN signaling through protein kinase B/Akt dependent process. Twelve pairs of newborn male LBWT (816 ± 55 g) and normal birth weight (NBWT; 1642 ± 55 g) littermates were euthanized to collect *longissimus dorsi* (LD) muscle. Muscle mRNA expression was measured by real-time PCR, and protein abundance and phosphorylation were measured by western blot. mRNA and protein abundance of MSTN were lower ($P < 0.05$) in LD muscle of LBWT pigs compared with their NBWT littermates. There was no difference in mRNA expression of MSTN receptors in muscle between LBWT and NBWT pigs, including *activin A receptor type IIB* and *activin receptor-like kinase 4*. In addition, muscle mRNA expression of *follistatin*, a physiological inhibitor of MSTN, did not differ between two groups. However, mRNA expression of *dEcoRIn* was higher ($P < 0.05$) in muscle of LBWT than NBWT pigs, suggesting more MSTN could be sequestered thus lowering its inhibitory action on muscle growth. There was no difference in protein abundance of smad2 in LD muscle between LBWT and NBWT pigs. However, abundance and phosphorylation of smad3 were lower ($P < 0.05$) in LBWT pigs compared with their NBWT siblings. Despite this reduction, there was no difference in protein abundance and phosphorylation of protein kinase B/Akt. Our data suggest that although abundance of MSTN was lower and MSTN signaling was downregulated, these changes do not explain the diminished protein synthesis rates previously observed in skeletal muscle of LBWT pigs. Thus it is likely that downregulated MSTN signaling may be a compensatory mechanism rather than the cause for the impaired muscle growth in LBWT neonatal pigs.

**Key Words:** low birthweight, muscle growth, myostatin

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**137 Fresh belly characteristics and commercial bacon slicing yield in growing-finishing pigs fed an antibiotic-free diet or a diet supplemented with a natural antimicrobial.** J. E. Lowell*, B. M. Bohrer, K. B. Wilson, M. F. Overholt, B. N. Harsh, H. H. Stein, A. C. Dilger, D. D. Boler, *University of Illinois, Urbana.*

The removal of antibiotic growth promoters (AGP) from swine diets may change carcass composition and belly quality. Therefore, our objective was to compare belly quality and bacon processing characteristics of pigs fed diets containing AGP or a natural antimicrobial. Ninety-six barrows and 96 gilts (initial BW: 27.52 ± 3.98 kg) were used in a 2 × 3 factorial arrangement in a randomized complete block design. Pigs were placed in 2 equal blocks based on age and housed in 48 single-sex pens with 4 replications per treatment in each block. Pigs were allotted to pens based on initial BW. Pens were randomly assigned to 1 of 3 dietary treatments. Diets were identical except Diet 1 contained no additive (ABF), diet 2 (AGP) contained 0.045% of Tylan 40 premix, and diet 3 (ORG) contained 0.025% of oregano oil. Pigs were slaughtered at an average BW of 127.31 ± 10.18. Within each block, the 2 pens with the heaviest barrows and the 2 pens with the heaviest gilts were harvested a week earlier than pigs in the remaining pens to reduce the variation in slaughter weights among pigs as much as possible. Whole bellies were approximately 14.6% of chilled side weight, regardless of treatment. Bellies did not differ in length ($P = 0.43$), width ($P = 0.91$), thickness ($P = 0.11$), or flop ($P = 0.10$) among treatments. Iodine values were calculated, as an indication of fat quality. The iodine value of adipose tissue from pigs fed AGP was increased ($P = 0.04$) by approximately 3 units compared with pigs fed ABF or ORG diets. The PUFA:SFA of bellies from pigs fed AGP was approximately 0.05 units greater ($P < 0.01$) compared with bellies from pigs fed ABF or ORG diets. Bellies did not differ in pump uptake percentage ($P = 0.07$), cooked yield ($P = 0.10$), slice yield ($P = 0.35$), or slice count ($P = 0.50$) among treatments. Overall, feeding an AGP diet or a diet supplemented with a natural antimicrobial did not improve fresh belly characteristics, processing characteristics or commercial bacon slicing yields of growing-finishing pigs.

**Key Words:** antibiotic-free, bacon, fat quality
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**138 Young scholar presentation: Effects of feeding antioxidants to steers fed microalgae (*Aurantiochytrium limacinum* CCAP 4087/2) on color stability and palatability of longissimus lumborum steaks.** K. J. Phelps[*1], J. S. Drouillard[1], K. A. Jacques[2], T. G. O'Quinn[1], J. M. Gonzalez[1], *[1]Kansas State University, Manhattan, [2]Alltech Inc., Nicholasville, KY.*

Previous research reports feeding increasing levels of microalgae to beef heifers increased concentrations of 20:5n-3 and 22:6n-3 fatty acids, but steak color stability was reduced and sensory panelists detected more off-flavors (Phelps et al., 2016). A follow up study was conducted to evaluate effects of feeding antioxidants to steers fed microalgae (MA; *Aurantiochytrium limacinum* CCAP 4087/2, Alltech, Inc., Nicholasville, KY) on color stability and palatability of longissimus lumborum (LL) steaks. Steers ($n = 40$) were blocked by initial BW (638 ± 29 kg) and assigned to one of four treatments: 10% flaxseed diet (FLAX), FLAX diet plus 100 g·steer$^{-1}$·d$^{-1}$ MA (ALGAE), 100 g·steer$^{-1}$·d$^{-1}$ MA plus antioxidants (103 IU/d vitamin E and Sel-Plex; Alltech Inc.) fed throughout feeding (AOX), and 100 g·steer$^{-1}$·d$^{-1}$ MA plus antioxidants fed for the final 10 d of feeding (LATE). On d-45 steers were harvested, LL were removed after 48 h and aged 14 d. After aging, each LL was fabricated into steaks for simulated retail display and trained sensory panel analyses. Treatment did not affect steak juiciness, tenderness, or beef flavor ($P > 0.15$), but impacted ($P < 0.01$) off-flavor intensity of steaks. Steaks from FLAX steers had decreased off-flavor scores compared to steaks from ALGAE and AOX steers ($P < 0.03$), but did not differ ($P = 0.07$) from LATE steaks. Off-flavor scores of steaks from ALGAE steers were not different from steaks from AOX and LATE steers ($P > 0.10$), but steaks from AOX steers had greater ($P = 0.04$) off-flavor scores than steaks from LATE steers. There were treatment × day interactions for surface metmyoglobin and visual panel discoloration score ($P < 0.01$). From d 0–5, there were no treatment differences for surface metmyoglobin percentage or discoloration score ($P > 0.10$). On d-6, steaks from ALGAE steers had more metmyoglobin and a greater discoloration score than steaks from AOX and LATE steers ($P < 0.01$), but were similar to FLAX steaks ($P = 0.18$). From d 7–10, steaks from ALGAE steers had more metmyoglobin and a greater discoloration scores compared to steaks from the other treatments ($P < 0.03$). Also from d 7–9, metmyoglobin percentage and discoloration score of steaks from AOX steers were similar to steaks from LATE steers ($P > 0.06$), but AOX steaks had less metmyoglobin and reduced discoloration score compared to steaks from FLAX steers ($P < 0.04$). When antioxidants were supplemented in diets containing microalgae, color of LL steaks was improved, but antioxidants did not combat off-flavors.

**Key Words:** antioxidants, beef, omega-3
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## HARLAN RITCHIE SYMPOSIUM

**139 Beef cattle type and selection tools have evolved to meet consumer demands and maximize producer profitability.** D. W. Shike*, *University of Illinois at Urbana–Champaign, Urbana.*

Beef cattle type has evolved through selection and planned matings targeted at meeting consumer demands and maximizing producer profitability. In the 1800s cattle were used for draft and milk. They were large-framed, light-muscled, and late-maturing, often not going to market until 3–5 yr of age. In the late 1800s, cattle breeders began selecting for more moderate frame size as well as increased fleshing ability and muscle thickness. This trend continued through the mid-1900s. By the 1950s, cattle were extremely small-framed and early-maturing. These cattle could not reach acceptable market weights and Choice quality grade without being overfat. The USDA implemented the beef yield grade system in 1965. Industry leaders and breed associations held type conferences to discuss concerns and to give breeders direction. Cattle breeders began selecting for cattle that could be fed to heavier weights without being overfat. In the 1960s, European breeds began being utilized in the United States to increase frame size and lean growth. Selection for increased frame and lean growth continued through the late 1980s resulting in cattle with excessive birth weights, extreme frame size, and poor fleshing ability. Starting in the late 1980s, selection emphasis was again on moderation of frame, muscle thickness and fleshing ability. Breeders now also placed greater emphasis on reducing birth weights. In the 1980s, performance records, sire evaluations, and expected progeny differences (EPD) were being utilized in conjunction with visual appraisal for selection and breeding decisions. Early cattle evaluations focused on the economically relevant traits of birth weight, weaning weight, and yearling weight. Carcass traits were also included in cattle evaluations but there were very few records submitted to breed associations. The adoption of ultrasound technology for prediction of carcass traits became common in the 1990s and so did the selection for increased marbling and improved quality grades. Selection decisions became much more complex as the number of EPDs continued to increase. In the 2000's and 2010's breed associations introduced bioeconomic indexes allowing multiple traits to be combined into a single value. Breed associations also began implementing genomic enhanced EPDs. Genomic enhanced EPDs increase accuracy in young cattle and characterize genetics for traits that are difficult to measure the phenotype. The information and tools available to cattle breeders has dramatically increased and so has the complexity of breeding programs. Beef cattle type has evolved as selection decisions continue to focus on meeting consumer demands and maximizing producer profitability.

**Key Words:** beef cattle, cattle type, selection
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**140 Factors contributing to increased quality grade of U.S. fed cattle.** P. S. Dykstra, W. J. Sexten*, *Certified Angus Beef, LLC, Wooster, OH.*

The quality grade (QG) trend in the U.S. is marked by functional shifts in grading methods as well as economically driven cattle marketing and management enhancements. As recently as 2005, the beef industry faced concerns related to inadequate marbling with only 52.9% of carcasses grading choice. From 2007 to 2015 fed cattle QG steadily increased to 69.1% choice and 5.1% prime. While these data may seem low compared to 1970s and 1980s QG one must recognize only carcasses expected to grade choice or greater were presented for grading during that period. Today nearly all cattle are quality graded, suggesting significant QG improvement. Implementation of instrument grading has enhanced QG accuracy and consistency. The transition toward value-based marketing on a carcass basis began in 2005 when 40% of cattle were sold on cash and carcass basis, whereas today carcass formula agreements exceed 60% of trade while cash declined to 20% of transactions. As cattle feeders began capturing the value of carcass merit in addition to weight, QG improved due to increased days on feed, heavier carcass weights and favorable value and cost of gain relationships. Feeding cattle to heavier endpoints improved QG, supplemented low beef supplies and increased the percentage of yield grade 4 and 5 carcasses. The seedstock and commercial cow-calf segments recognized market signals communicating increasing value for cattle with greater genetic potential for QG. The genetic trend for marbling EPD of Angus, Red Angus, Hereford, Simmental, and Charolais increased from 2005 to 2015. Survey data suggest these breeds make up over 95% of service sires marketed, with Angus or Angus-influenced sires representing the majority. Breed improvement for marbling coupled with drought induced culling of older, less productive cows and their replacement with heifers bred to Angus bulls also contributed to QG improvement. As the beef cattle inventory declined, the percentage of fed cattle comprised of Holstein increased to nearly 20% by 2015, this increased percentage coupled with greater marbling potential than native beef cattle contributed to additional QG improvement. Technology's role in QG improvement likely occurred through expanded endpoint management options. Delayed-release growth implants and β-agonists provided cattle feeders opportunities to feed cattle to heavier weights while managing potential yield grade discounts. Quality grade is the highest in modern history and this supply has been met with growing demand for prime and premium choice beef. The challenge, to continue demand growth while expanding the goal beyond grading choice.

**Key Words:** beef, marbling, quality grade
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**141 Where are we going as cattle get bigger?**

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Some would say that the cattle industry is slow to change. However, if you look at the change that has occurred during the past 60 yr, one may need to ask the question, "Can we keep up with the change"? Quantity of beef produced per cow has increased by over 50% since 1982. In the last 30 yr carcass weights have increased over 20% with a peak of 422 kg in 2015. However, is the current trajectory sustainable? Can packing plants handle the extra carcass size? Can distribution channels handle heavier boxes? How do consumers accept large cuts of beef? More importantly, what happens to the efficiency of the beef production system? Several researchers have shown that HCW is the most important factor in determining profitability. Record carcass weights have been achieved by using later-maturing genetics, growth enhancement technologies, and improved nutritional management. Factors which contribute to feeders taking cattle to heavier weights are needed to dilute higher feeder cattle prices with greater pounds and the ability to distribute increasing fixed costs and lower costs of gain. Research has quantified that the biological changes associated with increasing days on feed and taking cattle to heavier weights are not the same changes we saw in cattle 50 yr ago. Physiological changes in feed intake and dressing percent contribute to this phenomenon. Efforts to quantify changes in efficiency within the feedlot and throughout the beef system are needed to better assess industry implications. There are consumer concerns with larger LMA and portion size. Current carcass weight trends are resulting in cutting steaks thinner to meet menu parameters. Boxed beef is surpassing acceptable weights. Excess fat is an increasing concern with percentage of YG 4 and 5 carcasses increasing from 5.7% in 1985 to 12.78% in 2015, reaching over 17% in the fall of 2015. Can award systems be identified that increase the efficiency of beef production systems? Identifying and matching a particular biological type to a production system and slaughter group is a viable tool which will increase fed cattle efficiency while decreasing excess fat.

**Key Words:** beef cattle, carcass weight, profitability
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**142 Beef yield grading: History, issues, and opportunities.**

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Beef grades, rooted in quality determination, have been used for almost 100 yr to assist in uniform marketing of cattle, carcasses, and boxed beef. Grade standards were amended in 1965 to assess carcass lean meat yield. One-hundred-sixty-two beef carcasses were used to develop a multiple-linear regression equation for estimating percentage boneless closely trimmed round-loin-rib-chuck (BCTRLRC) using 12th rib fat depth (FAT), percentage kidney-pelvic-heart fat (KPH), hot carcass weight (HCW) and ribeye area (REA). The calculated yield grade (YG), also a multiple-linear regression equation, was developed as a 1-through-5 index to estimate ranges of BCTRLRC. The YG was developed when small-framed Hereford cattle dominated the market; today the fed beef population is a kaleidoscope of genetic diversity that is medium and large in frame. Cattle feeding technology now includes growth promoting implants, β-adrenergic agonists, and genomic sorting to maximize growth and composition of gain; HCW increases by 5 to 6 pounds annually and the average carcass now weighs > 900 pounds. Since implementation of the YG, consumers have transitioned from accepting retail cuts with 1/2-inch of trim fat to demanding cuts with no trim fat. This change in market signal dictates the need to accurately estimate carcass lean yield. Camera grading technology, used by approximately 75% of beef processors, continues to use the original equation; research has demonstrated that other variables could be generated to improve predictability of red meat yield. Multiple scientists have reported highly variable and weak to moderate relationships of the 4 YG factors to boneless lean yield. The YG is a poor estimator of red meat yield for beef-type carcasses and is unable to estimate red meat yield of Holstein steers. Researchers from the Canadian government, which is considering adoption of our YG system have concluded the current YG equations require updating. Beef quality grading standards have been amended 12 times; in contrast, the YG has remained static since inception in June 1965. Our YG estimation system was developed from a small population of a cattle type that no longer exists to predict red meat yield of carcasses that are increasingly more variable in genetic type and management. We apply that estimate to carcasses that weigh beyond the inference of which it was designed and we have ignored the opportunity to develop new yield estimates afforded by camera grading. Leadership within the beef community must decide if the status quo is acceptable, or if improvement is warranted.

**Key Words:** beef, carcass, yield
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## NONRUMINANT NUTRITION SYMPOSIUM:

## PROGRAMMING OF THE IMMUNE SYSTEM

**143 What are the nutritional and metabolic costs of immune system activation in pigs?** N. K. Gabler[1,*], S. M. Curry[1], W. P. Schweer[1], S. M. Lonergan[1], K. Schwartz[1], E. R. Burrough[1], C. L. Loving[2], *[1]Iowa State University, Ames, [2]USDA National Animal Disease Center, Ames, IA.*

Optimal lean tissue production can be severely compromised by stress and health challenges in grower-finisher pig production systems. Commonly seen enteric and respiratory pathogen include Porcine Reproductive and Respiratory Syndrome (PRRS) virus, swine dysentery, Porcine Epidemic Diarrhea virus (PEDV), *Lawsonia intracellularis, Mycoplasma hyopneumoniae, Salmonella typhimurium*, and pathogenic *E. coli* antagonize pig health and performance. Infection with these agents can alter feed efficiency, intestinal function, and the economic return for pork producers. Significant advances in molecular and quantitative genetics, clinical diagnostics, microbiology, and virology have been made to improve the health in pathogen challenged commercial pigs, but we are still unsure on how to best feed and manage these animals. Collectively, blood metabolite and hormone analyses suggest that there is a major catabolic cost, particularly to skeletal muscle, to support the energetic and protein synthesis needs of immune system response. Additionally, innate and adaptive responses to intense, prolonged, or poorly-contained immunological stressors can lead to mitochondrial damage which may impair capacity to generate sufficient ATP for homeostasis, limit energy availability (exacerbated by reduced feed intake), and compromise cell survival and organ function. These changes in bioenergetics link metabolism with inflammation, immune function, cellular and tissue homeostasis, and protection. Specific metabolic pathways also affect immune cell differentiation and function, and accordingly have an impact on the overall immune response during health and disease. The metabolic state of immune cells or "immunometabolism" may provide a signature associated with a particular condition or challenge. Therefore, by understanding the metabolic demand of a response to health challenges in pig muscle, liver, immune cells, lungs, and intestinal epithelium, we can better develop interventions to modulate the immune system or preserve lean tissue. This paper will discuss the molecular and physiological impact of pathogenic stress challenges on lean tissue accretion, digestibility, and immunometabolism in grow-finisher pigs.

**Key Words:** immune activation, metabolic cost, swine
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**144 Pre-programming of the immune system to enhance immunological capacity of offspring.** N. A. Karrow*, S. Y. Oh, A. Lee, Z. Li, L. You, R. E. Fisher, C. F. M. de Lange, *Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada.*

Livestock experience different forms of immune system stimulation (ISS) during their production cycle including microbial infection, vaccination, and tissue trauma. The release of pro-inflammatory cytokines during ISS activates the hypothalamic-pituitary-adrenal (HPA) axis or "stress axis", which regulates metabolism and the immune response during ISS to restore physiological homeostasis. When ISS occurs during pregnancy, it can later cause programming of the immature fetal neuroendocrine-immune system. It is hypothesized that this plasticity in neuroendocrine-immune programming allows the fetus to adapt to its post-natal environment; however, risk of adulthood disease may also increase if the newborn is not appropriately matched to its novel environment. Bacterial lipopolysaccharide (LPS) endotoxin is an ISS that is commonly used by immunologists to simulate and study the host response to bacterial infection. When LPS was administered to sheep and pigs during late pregnancy, and the dams were consuming diets containing different n3 and n6 polyunsaturated fatty acid (PUFA) profiles, we observed long-term changes to various offspring health-related phenotypes. This presentation will highlight the immunological changes that were observed, and the health implications of these changes will be discussed.

**Key Words:** maternal LPS, offspring health, PUFA
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**145 Immune system stimulation increases nursery pig maintenance energy requirements.** N. F. Huntley[1,*], C. M. Nyachoti[2], J. F. Patience[1], *[1]Iowa State University, Ames, [2]University of Manitoba, Winnipeg, MB, Canada.*

Immune system activation can partition energy and nutrients away from growth, but clear relationships between immune responses and the direction and magnitude of energy partitioning responses have yet to be elucidated. The objective of this study was to determine how lipopolysaccharide (LPS) immune stimulation and b-mannanase supplementation affect nursery pig maintenance energy requirements ($ME_m$) through changes in immune parameters, digestibility, growth performance, nitrogen, and energy balance. In a randomized complete block design, 30 pigs (10.27 ± 0.15 kg) were assigned to either the control treatment (CON; basal corn, soybean meal, and soybean hulls diet), the enzyme treatment (ENZ; basal diet + 0.056% b-mannanase), or the immune system stimulation treatment (ISS; basal diet + 0.056% b-mannanase, challenged with repeated increasing doses of *Escherichia coli* LPS). The experiment consisted of a 10 d adaptation, 5 d digestibility and nitrogen balance measurement, 22 h of heat production

(HP) measurements following the final injection, and 12 h of fasting HP measurements in indirect calorimetry chambers. The immune challenge consisted of either LPS (ISS) or sterile saline (CON and ENZ) injections every 48 h, for a total of 4 injections on d 10, 12, 14, and 16. Blood was collected pre- and post-injection for complete blood counts with differential analysis, haptoglobin and mannan-binding lectin, 12 cytokines, and glucose and insulin concentrations. Data were analyzed using the MIXED procedure of SAS (9.4) with blood immune parameters and rectal temperature data analyzed as repeated measures. The ENZ treatment did not differ from CON in growth performance, digestibility, immune parameters, or HP variables (P $^{3}$ 0.10). The ISS treatment induced fever, elevated proinflammatory cytokines (TNFa, IL-6, IL-1b), and decreased leukocyte concentrations ($P < 0.05$). The ISS treatment did not impact nitrogen balance or nutrient digestibility ($P > 0.10$), but increased total HP (CON = 278.8 vs. ISS = 333.0 kcal·kg $BW^{-0.60}$·kg $DMI^{-1}$·$d^{-1}$; $P = 0.04$) and estimated $ME_m$ by 23.6% ($P = 0.045$). This resulted in decreased lipid deposition (CON = 76.2 vs. ISS = 55.5 g/d; $P = 0.047$) and ADG (CON = 447.1 vs. ISS = 330.7 g/d; $P = 0.01$). Immune stimulation increased energy partitioning to the immune system by 23% which limited energy available for lipid deposition and weight gain. Understanding energy and nutrient partitioning in immune stressed pigs may facilitate the development of more effective feeding strategies.

**Key Words:** heat production, lipopolysaccharide, nitrogen balance

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**146 Ingestion of soy isoflavones alters the immune response of pigs during a respiratory viral challenge.** B. N. Smith, A. Morris, M. L. Oelschlager, R. N. Dilger*, *University of Illinois, Urbana.*

Porcine reproductive and respiratory syndrome virus (PRRSV) is the most prevalent disease facing the swine industry globally. Infection of weanling pigs with PRRSV leads to a complex immune response resulting in impaired growth performance and economic losses. Building on recent evidence linking ingestion of soybean products and immunity, the objective of this experiment was to identify a mode of action for soy isoflavones to influence the immunological response of PRRSV-infected weanling pigs. Four dietary treatments differed by soy source [soy protein concentrate (SPC) vs. HP 300®, a value-added soy product; Hamlet Protein, Findlay, OH] and isoflavone supplementation (none vs. 1500 mg total isoflavones/kg diet from Novasoy 400®; ADM, Decatur, IL); the control diet (CON) contained SPC and no supplemental isoflavones. All diets were isonitrogenous, isocaloric, and contained identical standardized ileal digestible AA concentrations. Weanling pigs (60 barrows, 21 d of age, 5.71 ± 0.44 kg) were individually housed in disease containment chambers and provided ad libitum access to experimental diets for 7 d before receiving either a sham inoculation (sterile PBS) or a $9.28 \times 10^3$ 50% tissue culture infective dose of PRRSV at 0 d post-inoculation (DPI). A total of 5 experimental treatments included an uninfected group receiving the CON diet, plus four infected groups each receiving different diets. Growth performance and rectal temperature data were recorded weekly, and blood was collected at 0, 3, 6, 8, 12, and 14 DPI for immunological analyses. Data were analyzed as a 2-way ANOVA for all treatments involving PRRSV-infected pigs, and a *t* test was used to compare uninfected and infected groups receiving the CON diet. A successful infection was confirmed through reduced ($P < 0.05$) growth performance and increased ($P < 0.05$) serum PRRSV concentrations when comparing uninfected and infected pigs fed the CON diet. No dietary treatment effects were observed within infected groups for growth performance or rectal temperatures. However, serum PRRSV load was increased in pigs receiving the isoflavone-supplemented HP 300 diet at 3 and 6 DPI compared with all other groups (interaction, $P = 0.003$). In general, no change in T cell (TC) numbers was observed, but PRRSV infection increased ($P < 0.05$) the proportion of circulating cytotoxic TC. Moreover, isoflavone supplementation increased (main effect, $P = 0.01$) the proportion of helper TC by 30%, thereby suggesting a benefit to the adaptive immune response. In conclusion, ingestion of supplemental soy isoflavones may alter the immune response of PRRSV-infected weanling pigs.

**Key Words:** immunity, isoflavone, porcine reproductive and respiratory syndrome virus

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**147 Early changes in the human Microbiome alter immune function and immunologically mediated disorders.** J. Vanderhoof*, *Harvard Medical School, Boston, MA.*

Recent evidence from a number of studies suggest that early changes in the human Microbiome may play an important role in regulating immune function. As the human gastrointestinal tract is not dissimilar from that of many other nonruminants, such as pigs, human studies may well have some relevance to nonruminant animal nutrition. During the past hundred years, humans have seen a marked increase in the incidence of disorders of immune regulation including allergy, and autoimmune diseases such as inflammatory bowel disease, type I diabetes, rheumatoid arthritis, and celiac disease. In the case of allergy, it has been noted that there is an association between the end incidence of allergy and children raised in a clean urban environment relative to farm raised controls. Close exposure to farm animals appears to be a factor. The revised hygiene hypothesis proposes that early changes in microbial colonization might ultimately direct the immune system to react differently later in life affecting the incidence of these disorders. Early colonization with increased numbers of lactobacilli

and bifidobacterium appear to be advantageous. Studies have shown differences in certain microbial populations earlier in life with later development of allergy and type I diabetes. Dietary and environmental factors appear to have a major effect on the gut Microbiome. Administration of antibiotics to pregnant mothers or infants, or other factors which alter early colonization such cesarean section or breast-feeding appear to affect the incidence of disorders of immune regulation such as allergy or autoimmune disease. Recent studies utilizing probiotics given early in life to alter microbial colonization appear to influence not only the incidence of allergy to foods such as cow milk but also to stimulate the development of immune tolerance early in life. When taken as a whole, this body of data suggests efforts to optimize microbial colonization of the gut early in life might reward us with more effective immune function. In all likelihood, the same could well be true with other nonruminants species including pigs.

**Key Words:** early life, immune development, microbiome
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**148 Immune system stimulation (ISS) alters the protein deposition (PD) and increases dietary threonine requirements of growing pigs.** W. S. McGilvray[1], C. F. M. de Lange[2], A. R. Pendleton[3], A. Rakhshandeh[1,*], *[1]Texas Tech University, Lubbock, [2]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, [3]South Plains College, Lubbock, TX.*

In previous studies we have shown that systemic ISS decreased apparent ileal digestibility of dietary amino acids (AA). Furthermore, we have shown that ISS increased the expression of Thr rich mucin 2, a major component of intestinal endogenous AA loss (EAAL), at the transcriptional level. We also observed a 1.5 times increase in plasma Thr flux, a measure of Thr utilization, in ISS pigs, suggesting an increased metabolic demand for Thr during ISS. To our knowledge, the effect of ISS on the dietary requirements for Thr has not been evaluated. Therefore, the current study evaluated the impact of ISS on dietary Thr requirements in growing pigs. A total of 39 gilts (initial BW 32 ± 2.1 kg) of commercially relevant genetics were individually housed in metabolism crates, and fed a corn-SBM based diet in which Thr was the first limiting among other AA. After 4-d adaptation to the experimental diets, ISS was induced by two intramuscular injections of increasing amounts of *E.coli* lipopolysaccharide (ISS+; 25 and 35 µg/kg BW) given 48-h apart. Pigs in the ISS- group received sterile saline. Pigs within each ISS group were assigned to three diets containing 70, 90, and 110% of SID Thr levels that were estimated based on the potential of each group for PD using NRC Swine, 2012 model for estimation of nutrient requirements. Blood samples were collected 24-h post-ISS and assayed for blood chemistry. Body temperature (BT) was also monitored on a daily basis. N-balance was determined during a 3-d post-ISS period. Results were analyzed in SAS using a completely randomized design and mixed procedures. ISS increased BT (0.7°C SE 0.15), BUN (10mg/dl SE 3.6), and blood creatinine (0.7 mg/dl SE 0.08) indicating an effective ISS in pigs ($P < 0.05$). SID Thr intake increased PD in a linear fashion in both ISS groups ($P < 0.01$). Marginal efficiency of SID Thr utilization for PD, represented by the slope, was not affected by ISS; 1 g of additional SID Thr intake supported 28 and 20 SE 3.9 g/d PD in the ISS+ pigs and ISS- pigs, respectively. However, ISS substantially increased the extrapolated maintenance SID Thr requirements, represented by the intercept at zero PD (ISS- vs. ISS+, −11.2 vs. −56.3 SE 14.8; $P < 0.05$). These results suggest that ISS increases the dietary requirements for SID Thr due to an increase in maintenance requirements. The latter may be associated with increased intestinal EAAL during ISS.

**Key Words:** immune system stimulation, pig, threonine
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**149 Management of clinical or subclinical immune activation.** E. Merlot[1,*], A. Prunier[2], N. Le Floc'h[3], *[1]INRA, Saint-Gilles, France, [2]PEGASE, Agrocampus Ouest, INRA, Saint-Gilles, France, [3]INRA-UMR SENAH, Saint Gilles, France.*

Besides infectious diseases, environmental constraints and farm management practices can also be a cause of chronic stimulation of the immune system of farm animals. This stimulation can in turn worsen animal welfare and impair production performances. When not related to a pathogenic infection, suspected causes of immune activation include increased non-pathogenic microbial environmental pressure, animal flora dysbiosis, and transient immune system or endocrine alterations. In pigs, immune activation can be observed not only in animals housed in facilities with poor hygiene conditions, but also in animals housed in standard environmental farm conditions (when compared to animals housed in enriched environments), and in response to specific challenging events such as weaning. Depending on the study, various indicators like white blood cell counts, blood concentrations of acute phase inflammatory proteins, immunoglobulins, oxidative stress products, and anti-oxidant blood potential demonstrate this immune stimulation. Experimental studies show that amelioration of the housing environment (adequate environmental temperature or hygiene, welfare friendly housing) and mitigation of stress factors are the most direct ways to reduce this unspecific immune stimulation. Few data also suggest the possible positive influence of environmental housing factors such as outdoor housing, ambient temperature and stocking density on animal resistance to viral and bacterial infections (for instance *E. coli* or porcine circovirus infections). However, other strategies could also be considered. Immune activation is usually accompanied by an inflammatory response which, in growing

animals, impairs growth. Inflammation downregulates feed intake, and is simultaneously a nutrient liberating (skeletal muscle catabolism) and nutrient consuming (acute phase protein synthesis, fever) process. Upon chronic inflammation, some amino-acids display more severe and longer alterations, possibly related to their role either as an energetic substrate or as specific precursors/substrates for immune processes. Based on this knowledge, various strategies have been tested, with the aims of adequately supplying the metabolism of the immunologically challenged pig, limiting inflammation and minimizing growth deterioration. For example, among nutritional approaches, moderate feed restriction during inflammation produced mixed results, while tryptophan supplementation is more promising. Genetic selection for animals exhibiting lower inflammatory traits or lower metabolic alterations during inflammation is another approach that deserves to be explored. As an example, the differences in response to a moderate inflammatory challenge of two lines of pigs divergently selected for residual feed intake are presented.

**Key Words:** immune activation, management, pigs
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## NONRUMINANT NUTRITION

**150 Supplementation of NSP enzyme increased the nutritive value of diets fed to lactating sows.**

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The objective of the current study was to evaluate the effect of supplementing a non-starch polysaccharide (NSP) degrading enzyme in a standard lactation diet, on total tract digestibility of nutrients, milk yield, and weight loss in late lactation, where feed intake is highest. A total of 20 first parity sows and their litters were included in the experiment from d 28 to 38 of lactation, including an adaptation period of 3 d. On d 28 of lactation sows were allotted, to two dietary treatments, a control diet or a diet with NSP enzyme addition, and fed for 10 d. The sows continued with their own piglets from the first part of the lactation, 12.1 and 12.3 piglets per litter for control and enzyme fed sows, respectively, throughout the experimental period. Sows and their litter were allotted according to BW and back fat. The experimental period lasted from d 31 to 38 of lactation, where feed consumption was recorded daily. Sow BW and back fat were measured on d 31 and 38 in lactation. In addition, piglets were weighed on d 31 and 38 to estimate milk production and litter weight gain. Milk and blood samples were collected at d 35. The milk samples were analyzed for the content of DM, fat, protein, and lactose. The blood samples were analyzed for the concentration of glucose, lactate, triglycerides, NEFA, and urea in plasma. Additionally, a fecal sample was collected from the sows in the end of the experimental period to determine the digestibility of DM, GE, and protein, using chromic oxide as internal marker. Data were analyzed using a general linear model procedure in SAS (version 9.4). The average daily feed intake for sows was 7.36 kg and 7.51 kg for control and enzyme treatments, respectively. The apparent total tract digestibility of energy ($P < 0.01$), N ($P < 0.05$), and DM ($P < 0.01$) were all increased by approximately two percent units and amounted to 82.9%, 80.6%, 81.9%, respectively, when sows were supplemented with enzyme. However, sow milk yield ($P = 0.27$) and sow weight loss ($P = 0.49$) were not affected by the enzyme supplementation. Energy status, as evaluated by plasma metabolites, was not affected by enzyme supplementation. In conclusion, the NSP degrading enzyme increased the apparent total tract digestibility of studied nutrients.

**Key Words:** digestibility, milk production, nutrition
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**151 Influence of *Enterococcus faecium* and *Endo-1,4-xylanase* supplementation to corn and soybean meal based diet on growth performance, nutrient digestibility, meat quality, fecal microflora, and fecal gas emission in finishing pigs.**

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A total of 128 finishing pigs [(Yorkshire × Landrace) × Duroc] with an average body weight (BW) of 49.9 ± 2.80 kg were used in a 12-wk trial to investigate to determine the effect of dietary supplementation of *Enterococcus faecium* (EF) and *Endo-1,4-xylanase* (XY) on pigs. Pigs were randomly allotted to one of four dietary treatments in a 2 × 2 factorial design, with 2 levels of EF (0 or 0.1 g/kg of feed) and XY (0 or 0.1 g/kg of feed) according to their sex and BW (8 pens with 2 barrows and 2 gilts/pen). Individual pig BW and pen feed consumption were recorded at the end of the sixth, ninth, and 12th weeks to calculate the average daily gain (ADG), average feed intake (ADFI), and gain to feed ratio (G:F). Fresh fecal samples were collected at the sixth week and 12th week for calculation of DM, N, and energy digestibility by adding 0.2% chromium oxide before 1 wk. Fecal sample (1 g) from each pen was diluted with 9 mL of 10 g/L peptone broth to evaluate fecal microbiota. All data were subjected to the mixed procedure of SAS for a randomized complete block design with a 2 × 2 factorial arrangement. During 0–12 wk, pigs fed diets supplemented with

EF increased average daily gain (ADG) and gain to feed ratio (G:F) compared with treatments without EF supplementation ($P < 0.05$). The inclusion of XY led to greater G:F compared to those fed diets without XY supplementation ($P < 0.05$). At the sixth week, the results showed that the apparent total tract digestibility (ATTD) of dry matter (DM), nitrogen (N), and energy increased with pigs fed EF supplemented diet compared to diet without EF supplemented diet ($P < 0.05$). Administration of XY improved DM digestibility compared with treatments without XY supplementation ($P < 0.05$) at the sixth week. Pigs fed diets supplemented with EF or XY had higher ($P < 0.05$) *Lactobacillus* population than those fed with treatments without EF or XY supplementation at the sixth week. In addition, at the sixth and 12th weeks, the *E. coli* counts were decreased ($P < 0.05$) in pigs fed with EF and XY supplementation. In conclusion, these results suggest that providing finishing pigs with diets that contained EF and XY can improve growth performance, nutrient digestibility, *Lactobacillus* population and decreased *E. coli* counts in finishing pigs.

**Key Words:** digestibility, growth performance, probiotics and xylanase
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**152 Effects of addition of protease with or without fructo-oligosaccharide to low protein diet on growth performance, nutrient digestibility, and fecal ammonia emission in growing-finishing pigs.**

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This study was conducted to determine the effects of supplementing protease with or without fructo-oligosaccharide (FOS) to a low-protein diet on growth performance, nutrient digestibility, and fecal ammonia emission in growing-finishing pigs. A total of 160 pigs (Duroc × [Landrace × Yorkshire]) with an average initial body weight (BW) of 57.70 ± 1.16 kg were randomly allotted into 1 of 4 dietary treatments based on initial BW and sex (10 replicate pens per treatment, 2 barrows and 2 gilts per pen). Dietary treatments included: 1) PC: a positive control diet (15.97% CP); 2) NC: a negative control diet (12.94% CP); 3) PRO: NC supplemented with 0.05% protease; 4) PROFOS: NC supplemented with 0.05% protease and 0.1% FOS. Apparent total tract digestibility (ATTD) was determined by mixing chromic oxide (0.2%) as an indigestible marker in the diet during the last wk of the experiment. All experimental data were analyzed as a completely randomized block design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The pen was considered as the experimental unit. Differences among treatments were separated by Tukey□s range test. Pigs fed the NC (2961 g/d) diet had higher average daily feed intake (ADFI) than those fed PC (2838 g/d) and PRO (2815 g/d) diets during wk 5 to 9 ($P < 0.05$). Pigs fed the NC (0.293) diet had lower gain:feed ratio (G:F) compared to those the PC (0.321), PRO (0.312), and PROFOS (0.313) diets during wk 1 to 9 phase. Compared to the PC (74.30%), PRO (73.65%), and PROFOS (73.81%) groups, ATTD of CP was lower ($P < 0.05$) in pigs offered the NC (71.97%) diet. Ammonia emission was reduced ($P < 0.05$) in pigs fed NC (16.55 ppm) and PRO (16.14 ppm) diets compared with those fed the PC (18.50 ppm) diet, but no difference was observed between pigs fed the NC diet and those fed the PRO diet. Additionally, pigs fed PROFOS (14.98 ppm) diet had lower ($P < 0.05$) ammonia emission compared to pigs offered the NC and PRO diets. In conclusion, supplementation of protease to a low-CP diet improved growth performance and increased ATTD of protein. Dietary supplementation with protease and FOS in a low-CP diet improved growth performance, increased ATTD of CP, and decreased fecal ammonia emission in growing-finishing pigs.

**Key Words:** fructo-oligosaccharide, growth performance, protease
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**153 Impact of xylanase and an enzyme blend on gut barrier function and growth performance in nursery pigs.**

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The objective of this experiment was to evaluate the effects of dietary xylanase and an enzyme blend (EB: cellulase, β-glucanase, and xylanase) on nutrient digestibility, intestinal barrier function and integrity, and growth performance in weaned piglets fed a low energy diet (NE: 2.43 and 2.37 Mcal/kg for wk 1–2 and 3–4, respectively). A total of 460 pigs (6.43 ± 0.06 kg BW; F52 Gentaporc × 6.0 Gentaporc) were randomly blocked by weight and assigned to 4 treatments, in a 2 × 2 factorial arrangement. There were 12 blocks and 48 pens with 9 or 10 pigs/pen. The diets were based on corn, soybean meal, corn DDGS, and wheat middlings (5 and 10% each fiber ingredient for wk 1-2 and 3-4, respectively) with or without enzyme supplementation (Huvepharma Inc., St. Louis, MO), with 0.40% titanium dioxide as an indigestible marker. Body weight and feed intake were recorded weekly. Performance data were analyzed as repeated measurements using the PROC MIXED procedure of SAS (9.4) with pen as the experimental unit. Xylanase (0 or 0.01%), EB (0 or 0.01%), week and their interactions were considered fixed effects. The EB addition (12.45 vs. 12.08 kg; $P = 0.044$), but not xylanase (12.27 vs. 12.26 kg; $P > 0.05$), increased body weight. Neither enzyme treatment had an impact on ADFI or G:F ratio ($P > 0.05$). The EB treatment improved ADG (482 vs. 466 g; $P = 0.024$) from wk 1–4. There was no interaction between the two enzyme treatments for ATTD of DM, GE, and CP ($P > 0.05$). Xylanase supplementation tended to reduce ATTD of EE (61.05 vs. 62.82%; $P = 0.073$) and reduced the ATTD of NDF (46.10 vs. 48.95%), ADF (27.30 vs. 31.71%), and

hemicellulose (52.77 vs. 55.23%; $P < 0.01$). Supplementation of EB improved ATTD of ADF by 22% (32.45 vs. 26.57%; $P = 0.001$). There was an interaction between xylanase and EB in ileal secretory IgA (SIgA) concentrations ($P = 0.027$), as EB addition alone decreased SIgA compared to control (1.72 vs. 2.72 mg/kg protein), but not in combination with xylanase. The EB supplementation also reduced urinary lactulose: mannitol ratio (0.51 vs. 0.68; $P = 0.012$), indicating improved small intestinal barrier integrity. In conclusion, EB but not xylanase improved growth rate in nursery pigs fed a low energy diet, which may be due to the improved intestinal barrier function and integrity.

**Key Words:** enzymes, intestinal barrier function, swine
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**154 Dose–response trial of an umami sensory additive in pig transition diets.** G. Tedo[1,*], A. Mereu[1,2], F. Bargo[1], *[1]Innovation Division, Lucta S.A., Barcelona, Spain, [2]Yara International, Oslo, Norway.*

Umami taste helps to identify protein sources in swine diets. Data from our in vitro studies using a cell reporter system that expresses the porcine umami taste receptor showed that, besides certain amino acids, there are other candidates able to act as umami ligands. Results from in vivo studies with weanling piglets supported the above suggestion by showing that a specific formulation of a non-nutritive high intensity umami (HIU) sensory additive appeared to be more effective than monosodium glutamate in stimulating the umami taste in pigs. Data reported herein is from a dose–response trial aiming to investigate the impact of this selected HIU sensory additive, added in pig pre-starter (weaning to 14 d a.w.) and starter (from 15 to 28 d a.w.) diets, in animal performance. Two-hundred eighty-eight 21-d-old weaned pigs (*Landrace x Large White*) were distributed in 48 pens among 4 dietary doses (12 pens/dose): 0, 900, 1800, and 3600 ppm of the HIU sensory additive (ref.136, LUCTA SA), following a randomized complete design. Experimental diets were in mash form, medicated, and formulated to meet piglet's nutrient requirements (NRC, 2012). Performance data were recorded weekly and analyzed with linear, quadratic, and cubic contrasts using a mixed-effect model with repeated measures that included pen as random effect and dose, week and their interaction as fixed effects. Overall, Body weight (BW) showed better results at 900 and 1800 ppm compared to 3600 ppm ($P < 0.05$) and a better gain to feed (G:F) ratio at the dose of 1800 ppm ($P < 0.05$) vs. 0 and 3600 ppm. No differences were observed in intake among doses. BW and G:F ratio showed a quadratic response to dose (shown in Table 154). According to these results, we conclude that the HIU sensory additive may improve animal performance when used between 900 and 1800 ppm.

**Key Words:** dose–response, sensory additive, umami
doi: 10.2527/asasmw.2017.12.154

**155 Effect of a new montmorillonite-based feed additive on the production performance of newly weaned piglets.** M. S. Hasan[1,*], T. Wang[1], S. Ching[2], J. M. Feugang[1], M. A. Crenshaw[1], S. L. Johnston[2], F. Chi[2], S. F. Liao[1], *[1]Department of Animal and Dairy Sciences, Mississippi State University, Mississippi State, [2]Amlan International, Chicago, IL.*

Weaning is the most stressful time period in a pig's life. NeoPrime (NeoP), a new feed additive product, was formulated with Ca-montmorillonite, yeast, and amino acids by Amlan International (Chicago, IL) to protect weaned pigs against bacterial toxins in the intestine, strength their enterocyte development, and activate the gut-associated immune response. This study was conducted to determine if there are any beneficial or detrimental effects of dietary NeoP supplementation on the fecal consistency, health status, and growth performance of weaned pigs raised in a university research facility. Forty crossbred barrows (18 to 21 d of age) housed in 20 pens (2 pigs/pen) were randomly allotted to 2 dietary treatments (10 pens/treatment). A control (Ctrl) diet was prepared with a commercial base mix (i.e., Show Sector 1 Crumble) according to the manufacturer's instructions (Sunglo Feeds, Lewisburg, OH), whereas the NeoP diet was prepared by adding NeoP powder to the Ctrl diet at a ratio of 0.15%. During the 5 wk feeding trial, pigs had ad libitum access to their respective diets and fresh water. Pigs' BW and feed intake were measured weekly after the initiation of the trial, and ADG, ADFI, and G:F ratio were calculated for each week as well as the overall treatment period. The health status and fecal consistency of the pigs were measured daily according to our previously reported scale systems. For health, 1 = healthy (normal); 2 = rough hair coat, reduced activity, and decreased appetite; 3 = lethargic, not eating, indifferent to surroundings; 4 = extremely lethargic and recumbent; 5 = death. For fecal consistency, 1 = solid (normal); 2 = soft, pasty, and unformed; 3 = diarrheic; 4 = watery diarrheic. Data were analyzed using Student's *t* test. There were no differences in the BW, ADG, AFDI, fecal consistency, and health status of the pigs between the two treatment groups during Week 1, 2, 3, 4, 5, or the overall period ($P > 0.10$). Although not statistically different ($P = 0.14$), numerically the G:F ratios of the NeoP pigs were consistently higher than that of the Ctrl pigs every week after Week 1, with an overall 6.7% improvement (0.64 vs. 0.60) for the whole 5 wk period. In summary, the NeoP product used in

**Table 154.**

| | HIU sensory additive dose, ppm | | | | | P < | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 900 | 1800 | 3600 | SEM | Linear | Quadratic | Cubic |
| BW, kg | 9.4 | 9.8 | 9.8 | 9.2 | 0.16 | 0.21 | < 0.01 | 0.58 |
| ADG, g/d | 255 | 270 | 272 | 254 | 9.06 | 0.91 | 0.07 | 0.83 |
| ADFI, g/d | 330 | 344 | 335 | 328 | 0.03 | 0.69 | 0.19 | 0.59 |
| G/F ratio, g/g | 0.77 | 0.79 | 0.85 | 0.75 | 0.01 | 0.92 | < 0.05 | 0.06 |

this study exhibited no detrimental effects on the health status and growth performance of newly weaned piglets with no beneficial effects being observed.

**Key Words:** feed additive, feed efficiency, weaner pig
doi: 10.2527/asasmw.2017.12.155

**156 Effect of different phase level of medium chain triglycerides on growth performance, excreta microflora, and blood profiles in broilers.** J. Hu*, J. Y. Zhang, S. D. Upadhaya, I. H. Kim, *Department of Animal Resource and Science, Dankook University, Cheonan, South Korea.*

In the past several decades, antibiotics have been widely used in livestock and poultry, to significantly improve growth performance and animal health, and to protect animals from pathogenic microorganisms. This study was conducted to investigate the effect of different phase levels of MCT on growth performance, excreta microflora, and blood profiles in broilers for the possibility of alternative antibiotics. A total of 1125 ROSS 308 mixed-sex broilers with an average initial body weight (BW) 49 ± 0.79g (1 d of age) were used in this trial. They were randomly assigned to 3 treatments, with 15 birds of 25 replications in each treatment of the following: CON (Basal diet); MCT1 (Starter, Grower, Finisher: Basal diet+0.1%, 0.075%, 0.05% of MCT), MCT2 (Starter, Grower, Finisher: Basal diet+0.1%, 0.1%, 0.1% of MCT). The experiment was conducted in 3 phases consisting of starter phase (from d 1 to 7), grower phase (from d 7 to 21), and finisher phase (from d 21 to 28). All data were statistically analyzed using the General Linear Model(GLM) procedure of the SAS program (SAS Inst. Inc., Cary, NC). Orthogonal contrasts were used to test the effect of differences between of CON, MCT1, and MCT2 (CON vs. MCT1&2, MCT1 vs. MCT2). The pen was used as an experimental unit for the productivity, blood profile, and excreta microflora measurements. A criterion α level of $P < 0.05$ was used to determine statistical significance. Results indicate that BWG was improved by 2.4% (MCT1) and 1.5% (MCT2), and FCR was decreased by 3.1% (MCT1) and 2.2% (MCT2) in broiler fed MCT compared with CON in the overall experiment phase ($P = 0.070$, $P = 0.087$, respectively). There was no difference in the concentration of white blood cells, IgG, and lymphocyte, and excreta microflora having no effect was observed among treatments. Therefore, we suggested that MCT could be used in broiler dietary and supplementation at 0.1% feed which may be suitable in the diet of broilers during d 7-d 21.

**Key Words:** broilers, growth performance, medium-chain triglycerides
doi: 10.2527/asasmw.2017.12.156

**157 Effects of KemTRACE Cr level and feeding regimen on finishing pig growth performance and carcass characteristics.** J. T. Gebhardt*[1], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], J. M. DeRouchey[1], J. A. Loughmiller[2], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]Kemin Industries, Des Moines, IA.*

A study was conducted to determine the effects of increasing Cr (KemTRACE Chromium propionate, Kemin Industries Inc., Des Moines, IA) and feeding regimen on growth and carcass performance of finishing pigs housed in a commercial environment. A total of 1206 pigs (PIC 337 × 1050; initial BW = 28.67 kg) with 27 pigs/pen and 9 pens/treatment were used in a 125 d study. Pigs were split by gender on arrival at the facility, with 4 blocks of each gender and a final mixed gender block. Gender blocks were randomly allotted to groups of 5 pen locations within the barn. Block was included in the generalized linear mixed model (PROC GLIMMIX; SAS Inst. Inc., Cary, NC) as a random effect and accounted for gender, initial BW, and barn location. Diets were corn-soybean meal-dried distiller grains with solubles-based and were fed in 5 phases. All nutrient concentrations met or exceed NRC (2012) requirement estimates. Treatments were arranged as a 2 × 2+1 factorial with two levels of Cr supplementation (100 or 200 μg/kg) fed during two growth phases (grower = 63-139 kg; finisher = 63 to 139 kg) and a control diet containing no added Cr. There was no effect of changing Cr supplementation during the finishing period. Therefore, only linear and quadratic effects of increasing Cr within period were considered using all treatments, as well as linear and quadratic effects of increasing Cr for the full duration using the 3 treatments which maintained a constant Cr concentration throughout. Increasing Cr during the grower period reduced (quadratic, $P < 0.001$) ADG and G:F. During the finisher period, increasing Cr tended (quadratic, $P < 0.058$) to increase G:F with the best G:F observed in pigs fed 100 μg/kg Cr. Overall, increasing Cr had no impact on ADG or ADFI; however, G:F was maximized (quadratic, $P < 0.020$) when pigs were fed 100 μg/kg of Cr. Carcass characteristics were not influenced ($P > 0.10$) by added Cr or feeding regimen. In summary, increasing Cr supplementation up to 100 μg/kg elicited improvement in G:F with no impact on ADG, ADFI, or carcass characteristics.

**Key Words:** Chromium propionate, duration, pigs
doi: 10.2527/asasmw.2017.12.157

**Table 157.** Effect of added Cr on pig performance, d 0 to 125

| Grower added Cr, µg/kg: | 0 | 100 | 200 | 100 | 200 | | Probability, $P <$ | |
|---|---|---|---|---|---|---|---|---|
| Finisher added Cr, µg/kg: | 0 | 100 | 200 | 200 | 100 | SEM | Linear | Quadratic |
| ADG, kg | 0.89 | 0.90 | 0.89 | 0.90 | 0.89 | 0.009 | 0.796 | 0.136 |
| ADFI, kg | 2.23 | 2.21 | 2.21 | 2.23 | 2.23 | 0.037 | 0.472 | 0.651 |
| G:F | 0.400 | 0.408 | 0.402 | 0.404 | 0.402 | 0.004 | 0.463 | 0.020 |

## 158 Interactive effects of KemTRACE Cr and Micro-Aid on finishing pig growth performance and carcass characteristics.

J. T. Gebhardt[1,*], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], J. M. DeRouchey[1], J. A. Loughmiller[2], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]Kemin Industries, Des Moines, IA.*

A study was conducted to determine the interactive effects of Cr (KemTRACE Chromium propionate, Kemin Industries Inc., Des Moines, IA) and Micro-Aid (*Yucca schidigera*-based product supplied by Distributors Processing Inc., Porterville, CA) on growth carcass performance of finishing pigs housed in a commercial environment. There were 1188 pigs (PIC 337 × 1050; initial BW = 27.3 kg) with 27 pigs/pen and 11 pens/treatment. Pigs were split by gender on arrival at the facility, with 5 blocks of each gender and a final mixed gender block. Gender blocks were randomly allotted to groups of 4 pen locations within the barn. Block was included in the statistical model as a random effect and accounted for gender, initial BW, and barn location. Diets were corn-soybean meal-dried distillers grains with solubles-based and were fed in 5 phases. Diets were formulated to meet or exceed NRC (2012) requirement estimates. Treatments were arranged as a 2 × 2 factorial with main effects of Cr (0 or 200 µg/kg) or Micro-Aid (0 or 62.5 mg/kg). No Cr × Micro-Aid interactions were observed. Overall, ADG and G:F were not influenced by treatment. Adding Micro-Aid tended to increase ($P = 0.077$) and adding Cr increased ($P = 0.049$) ADFI. For carcass characteristics, HCW, loin depth, and carcass yield percentage were not influenced by treatment. Backfat depth tended to increase ($P = 0.055$) and lean percentage was decreased ($P = 0.014$) when Cr was included in the diets. In summary, no synergistic effects were observed from feeding Cr and Micro-Aid in diets fed to finishing pigs housed in a commercial environment. Only marginal differences in ADFI were observed from adding either Cr or Micro-Aid. Finally, diets containing Cr were associated with carcasses having more backfat and less lean.

**Key Words:** Chromium propionate, Micro-Aid, pigs
doi: 10.2527/asasmw.2017.12.158

**Table 158.** Interactive effects of Cr and Micro-Aid on finishing pig growth and carcass performance.

| Added Cr, µg/kg | 0 | 200 | 0 | 200 | Probability, $P <$ | |
|---|---|---|---|---|---|---|
| Micro-Aid, mg/kg | 0 | 0 | 62.5 | 62.5 | Cr | Micro-Aid |
| ADG, kg | 0.87 | 0.87 | 0.87 | 0.88 | 0.446 | 0.490 |
| ADFI, kg | 2.22 | 2.26 | 2.26 | 2.30 | 0.049 | 0.077 |
| G:F | 0.39 | 0.39 | 0.39 | 0.38 | 0.115 | 0.178 |
| BF, mm | 16.97 | 17.69 | 17.26 | 17.54 | 0.055 | 0.787 |
| Lean, % | 56.89 | 55.92 | 56.83 | 56.54 | 0.014 | 0.261 |
| Yield, % | 74.51 | 75.23 | 75.27 | 75.44 | 0.302 | 0.254 |

SEM = ADG (0.009), ADFI (0.047), G:F (0.006), BF (0.639), lean% (0.408), and yield% (0.456)

## 159 Supplemental effects of fermented rice bran extracts on growth performance, bone characteristics, and immune response of broiler chickens.

L. Zheng*, M. E. Duarte, I. Park, S. W. Kim, *North Carolina State University, Raleigh.*

The objective of this experiment was to evaluate the supplemental effects of fermented rice bran extract (FBE, Maxcell Co., Los Angeles, CA) on growth performance, bone characteristics, and immune response in broiler chickens. FBE was produced from a fermentation process using rice bran and sucrose sources as medium inoculated by a mixture of probiotics (*Lactobacillus plantarum*, *Bacillus subtilis*, and *Saccharomyces cerevisiae*) producing metabolites. A total of 270 1-d-old male broiler chickens were used in a completely randomized design with 3 dietary treatments and 9 replicate cages of 10 birds per cage for each treatment. Broilers were fed a basal diet supplemented with FBE at the level of 0, 2.5, or 5 g/kg, respectively for 42 d based on 3 dietary phases. Body weight and feed consumption were recorded weekly. Ileal mucosa samples were collected for analysis of immune response and left tibias were removed for measuring bone characteristics. Data were analyzed using the GLM procedure of SAS. Increasing levels of FBE improved feed conversion ratio (FCR) (1.88 to 1.75, linear, $P < 0.05$) from d 29 to 42. During the whole experimental period, increasing levels of FBE decreased feed intake (4448 to 4121 g/bird, quadratic, $P < 0.05$), and tended to improve FCR (1.81 to 1.70, linear, $P = 0.082$) without affecting body weight gain. Increasing levels of FBE tended to increase tibia breaking strength (18.0 to 23.7 N/g, linear, $P = 0.098$). Supplementation of FBE did not affect the concentrations of immunoglobulin A, immunoglobulin G, and tumor necrosis factor-α in the ileal mucosa. In conclusion, dietary supplementation of FBE may improve

growth efficiency of broiler chickens without affecting health status. Furthermore, it can potentially increase bone strength of broiler chickens.

**Key Words:** broiler chickens, fermented rice bran extracts, growth performance
doi: 10.2527/asasmw.2017.12.159

**160 Effects of energy restriction during gilt development on parity 1 progeny growth performance.** S. M. Barnett*, M. D. Trenhaile-Grannemann, T. E. Burkey, P. S. Miller, D. C. Ciobanu, *University of Nebraska-Lincoln, Lincoln.*

There are many factors (pre- and postnatal) that affect piglet health and growth performance including environmental, nutritional, and genetic effects. Ongoing sow reproductive longevity research at the University of Nebraska has generated data over 14 batches monitoring females up to parity 4. Gilts included in this work have been developed under different nutritional management strategies including energy restriction and it has been determined that energy restriction increases sow longevity. The objective of this work was to determine if nutritional management (e.g., energy restriction) during gilt development (120 to 240 d of age) effects parity 1 progeny growth performance (Batches 5 through 13; $n$ = 733 gilts). Gilts included in the analysis were fed either a control diet (balanced according to the NRC, 2008) or energy restricted diet (20% energy restricted accomplished via the addition of soy hulls). At 240 d of age gilts were bred and fed a common diet. At d 109 of gestation, sows were transferred to farrowing crates and backfat (BF) and BW were recorded. After farrowing, individual piglet birth weights and d 21 piglet weaning weights were recorded. Gilts fed a restricted energy diet tended ($P < 0.09$) to farrow piglets with greater birth weight (1.26 vs. 1.28 kg for control and restricted, respectively) and weaned heavier pigs ($P < 0.05$; 5.20 vs. 5.34 kg for control and restricted, respectively) compared to unrestricted control animals. This preliminary research indicates that energy restriction during gilt development may have a positive effect on progeny growth performance resulting in greater birth weights and weaning weights.

**Key Words:** energy restriction, sow, weaning
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**161 Feed intake of lactation diets by sows during extended lactation periods.** A. P. Schinckel*[1], F. A. Cabezon[1], L. Y. León[2], B. A. Craig[3], *[1]Department of Animal Sciences, Purdue University, West Lafayette, IN, [2]Department of Statistics, Universidad Nacional de Colombia, Bogotá, Colombia, [3]Department of Statistics, Purdue University, West Lafayette, IN.*

The objectives of this research were to quantify and model daily feed intakes (DFI) of lactation diets to 28 d of lactation in modern sows. A total of 4512 DFI records were collected for 156 Hypor sows from February 2015 to March 2016. The mean lactation length was 27.9 ± 2.0 d, overall mean = 7.31 kg/d). Data included 9 parity 1, 33 parity 2, and 114 parity 3+ sows. Data were collected using a computerized feeding system (Gestal Solo, JYGA Technologies, Quebec, Canada). The feeding system was used to set an upper limit to DFI for the first 7 d of lactation. Overall, the least-squares means of a model including the random effect of sow indicated that DFI's continued to slowly increase to 28 d of lactation. The DFI data were fitted to Generalized Michaelis-Menten (GMM) and polynomial functions of day of lactation (t). The GMM function [$DFI_{i,t}$ (kg/d) = $DFI_0 + (DFI_A - DFI_0)(t/K)^C/[1 + (t/K)^C]$] was fitted with 2 random effects for DFI ($dfi_{Ai}$) and intercept ($dfi_{0i}$) using the NLMIXED procedure in SAS®. The polynomial function $DFI_{i,t}$ (kg/d) = $[B_o + B_1\ t + B_2\ t^2 + B_3\ t^3 + B_4\ t^4]$ was fitted with three random effects for $B_o$, $B_1$, and $B_2$ using the MIXED procedure in SAS®. Fixed effects models of the two functions had similar Akaike Information Criteria (AIC) values and predicted DFI. The polynomial function with 3 random effects provided a better fit to the data based on $R^2$ (0.81 versus 0.79), AIC (14,709 versus 15,158), and RSD (1.204 versus 1.321) values than the GMM function with two random effects. The random effect for $B_2$ allowed for the fitting of the function to lactation records that had decreased DFI after 15 d of lactation. The random effects were used to sort the lactation records into three groups based on the derivative of the polynomial function at 21 d of lactation. Lactation records of the three groups had similar DFI the first 2 wk of lactation ($P > 0.40$). The three groups of sows had substantially different DFI after 21 d of lactation (10.7, 9.1 and 6.9 kg/d, $P < 0.001$). The differences in actual and predicted DFI between the three groups increased with each day of lactation to Day 28 ($P < 0.001$). Mixed model polynomial functions can be used to identify sows with different patterns of DFI after 15 d of lactation.

**Key Words:** feed intake, sow
doi: 10.2527/asasmw.2017.12.161

**162 Effects of feeding levels during wean-to-estrus interval and first week of gestation on reproductive performance of sows.** L. Almeida[1,*], M. A. D. Goncalves[2], U. A. D. Orlando[2], A. Maiorka[1], *[1]Universidade Federal do Paraná, Curitiba, Brazil, [2]Genus PIC, Hendersonville, TN.*

This experiment was conducted to evaluate the effects of feeding levels during wean-to-estrus (WEI) and first week of gestation (1WK) on reproductive performance of sows. A total of 543 females (PIC-Camborough) were used from weaning to farrowing. Treatments were distributed in a factorial design 2 × 2 with 2 feeding levels during the WEI (2.8 or 5.2 kg/d) and 2 feeding levels during first week of gestation (2 or 3 kg/d). Dietary treatments were: Low-WEI, Low-1WK (LL), High-WEI, Low-1WK (HL), Low-WEI, High-1WK

(LH) and High-WEI, High-1WK (HH). Females were individually housed, blocked by body condition score (1 = thin, 2 = ideal, 3 = fat), parity group (P1, P2 and P3+), and randomly assigned to dietary treatments. The average body condition was 2.1 ± 0.52 and average parity was 2.8 ± 1.46. Sows were fed corn-soybean meal based diets with 3.4 Mcal ME/kg and 1.3% SID lys during the WEI and 3.2 Mcal ME/kg and 0.78% SID lys during gestation. All sows were fed 2 kg/d of the gestation diet after the first week of gestation until farrowing. Data were analyzed using generalized linear mixed models with pen as the experimental unit and week as random effect. Born alive weight index was calculated as farrowing rate × total born × born alive rate × 100 × individual born alive birth weight. There was no parity or body condition score interaction with dietary treatments. There was an increase ($P = 0.05$) in farrowing rate (93.3 vs. 88.3%, SEM = 2.78%) when sows were fed high vs. low feeding levels during the WEI. There were no evidences for differences between dietary treatments ($P^3$0.24) in total piglet born or rate of mummified fetuses. There was a WEI × 1WK ($P = 0.04$) interaction for stillborns where increasing feeding levels at WEI and 1WK increased stillborn rate (HH: 7.6 vs. HL: 5.0%, SEM = 0.93%). Consequently, there was a marginally significant ($P = 0.06$) interaction for born alive, where HH had reduced born alive rate vs. HL (89.9 vs. 92.4%, SEM = 0.85%). There was an increase ($P = 0.03$) in born alive weight index when high feeding levels were fed during WEI compared to low. Furthermore, there was a marginally significant ($P < 0.10$) interaction for individual piglet birth weight of total born, born alive, and stillborns, where HH had lower birth weight compared to HL. In conclusion, feeding 5.2 kg/d during wean-to-estrus interval increased farrowing rate by 5% points; however, high feeding levels in the first week of gestation increased stillborn rate and reduced piglet birth weight.

**Key Words:** early gestation, feed intake, wean-to-estrus
doi: 10.2527/asasmw.2017.12.162

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**163 Predicting post-farrow maternal weight for primiparous and multiparous sows.**
L. L. Thomas*, S. S. Dritz, R. D. Goodband, M. D. Tokach, J. M. DeRouchey, J. C. Woodworth, *Kansas State University, Manhattan.*

Maternal weight at the end of gestation is needed to calculate maternal and fetal weight gains throughout gestation. However, maternal weight after farrowing is difficult to obtain in commercial farms. Therefore, equations were developed from an analysis of 150 females (Line 1050, PIC, Hendersonville, TN) to predict the weight of conceptus by difference of pre- and post-farrowing weight change in multi-parity sows. Females were individually weighed as they were moved into the farrowing house at d 110 to 112 of gestation and again at 12 to 24 h after farrowing. Sows were provided with ad libitum access to feed in the farrowing house. Data were divided into 4 parity groups: 1, 2, 3, and 4+. Three predictor variables were evaluated within each parity group: pre-farrow weight, total born, and difference in days between the pre- and post-farrow weights. Prediction equations were then developed using models with significant terms based on the Bayesian Information Criterion. The optimum equations to predict maternal BW were similar for all parities except for the intercept (b) and can be described as: Post-farrow maternal BW (kg) = b + (0.897 × pre-farrow BW, kg)- (0.508 × total born, n) + (3.123 × days pre to post-farrow, d); where the intercept (b) for parities 1, 2, 3, and 4+ were −2.70, 2.34, 5.41, and 14.69, respectively. The prediction equations were then used to estimate post-farrow maternal BW using 332 mixed parity sows (PIC 1050). Pre-farrow weights were taken on d 113 of gestation and maternal BW were taken within 24 h of farrowing. Feed intake was limited to 2.7 kg/d prior to farrowing. On average, the predicted post-farrow maternal BW was overestimated by 1.5 kg of the actual ($P = 0.002$). Although the difference between the actual and estimated post-farrow maternal BW was significant this difference is negligible when partitioning maternal and fetal weight gains throughout gestation. When applying this difference (1.5 kg) to sow gestation models, the impact on daily maintenance requirement is a difference of only 32 kcal. We hypothesize the difference in feed allowance in the farrowing house prior to farrowing may have contributed to the overestimation of post-farrow maternal BW. The post-farrow BW prediction equation is a tool that can be applied to sow gestation models for an understanding of the females' maternal and fetal weight gains throughout gestation.

**Key Words:** maternal weight, post-farrow, sows
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**164 Effects of different feeding levels during three short periods of gestation on gilt and litter performance, nutrient digestibility, and energy homeostasis.**
P. Ren[1,*], X. Yang[1], S. Cui[2,3], J. Kim[1], D. Menon[1], D. Pangeni[1], H. Manu[1], A. Tekeste[1], S. K. Baidoo[1], *[1]Southern Research and Outreach Center, University of Minnesota, Waseca, [2]West Central Research and Outreach Center, University of Minnesota, Morris, [3]Northeast Agricultural University, Harbin, China.*

The present study investigated the effects of different feeding levels during 3 short periods of gestation on gilt and litter performance, apparent total tract digestibility (ATTD) of energy and nutrients, and energy homeostasis. A total of 18 gilts were allotted to 1 of 3 dietary treatments using a completely randomized design. All gilts were fed one common corn-soybean meal-based diet with the amount being 1.0 × maintenance energy intake (100 × body weight (BW)$^{0.75}$ kcal ME/d) throughout gestation except 3 periods of 7 d when dietary treatments were imposed on d 27, 55, and 83 of gestation. During the 3 short periods, sows were fed 1 of 3 different feeding levels: 0.5, 1.0, and 2.0 × maintenance energy level (0.5M, 1.0M,

and 2.0M, respectively). Titanium dioxide at 0.3% inclusion rate in the diet was used as inert maker to measure the ATTD of energy and nutrients during the 3 short periods. GLIMMIX procedure was used to analyze all the data. Dietary treatment was considered as the fixed effect, while each animal was considered as the random effect. Results showed that gilts on 2.0M feeding level had higher ($P < 0.05$) BW gain from d 27 to 109 of gestation (37.05 vs. 15.34 kg). No differences ($P > 0.10$) for litter performance were observed among the 3 feeding levels in terms of number and weight of piglets born alive and at weaning. The slopes of BW change in response to feeding levels in period 1 were 4.32 kg/0.5M change from 0.5M to 1.0M feeding level and 3.72 kg/0.5M change from 1.0M to 2.0M feeding level, respectively. Additionally, there were quadratic ($P < 0.05$) effects of feeding levels on ATTD of dry matter (88.33, 89.03 and 85.90%; 86.16, 87.93 and 84.66%, respectively) and gross energy (88.03, 88.71 and 85.11%; 85.63, 87.57, and 83.69%, respectively) in periods 1 and 2 (d 55–62). Furthermore, fasting plasma concentrations of acyl ghrelin and non-esterified fatty acids (NEFA) in period 1 were greater ($P < 0.01$) in gilts on 0.5M feeding level than those on 2.0M feeding level. In conclusion, increasing feeding levels during 3 short periods of gestation increased primiparous sow BW gain during gestation but did not affect litter performance. ATTD of energy and nutrients, and BW change efficiency were maximized for gilts at 1.0 M feeding level. The data also indicated that sows on the lowest feeding level were exposed to negative energy balance.

**Key Words:** feeding levels, gilt, nutrient digestibility
doi: 10.2527/asasmw.2017.12.164

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**165 Effects of feeding level and physiological stage on digestibility of gross energy and nutrients and concentration of digestible and metabolizable energy in full fat rice bran and defatted rice bran fed to gestating sows and growing gilts.**

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The objective was to determine the apparent total tract digestibility (ATTD) of GE, DM, OM, and NDF in full fat rice bran (FFRB) and defatted rice bran (DFRB) fed to gestating sows at 2 levels of feed intake. The second objective was to compare the ATTD of GE and nutrients and the concentrations of DE and ME in FFRB and DFRB fed to growing gilts or gestating sows at 3.5 × the maintenance requirement for ME. Forty-eight gestating sows (35 ± 0.8 d of pregnancy; 239 ± 27 kg BW; parity 2 to 6), were randomly allotted to 2 levels of feed intake (1.5 or 3.5 × the maintenance energy requirement for ME) and 3 diets (corn-soybean meal basal diet or diets containing 60% basal diet and 40% FFRB or DFRB). Twenty-four growing gilts (51.53 ± 3.1 kg BW) were randomly allotted to the same 3 diets and fed at 3.5 the maintenance energy requirement. Diets were fed for 24 d with 18 d of adaptation and fecal collection for 5 d using the marker to marker approach. Data were analyzed as a randomized complete block design in a 2 × 3 factorial for diets and a 2 × 2 factorial for ingredients. Results indicated that there were no effects of level of feed intake of sows on ATTD of GE, DM, OM, or NDF or on the concentrations of DE and ME. However, the concentrations of DE and ME were greater ($P < 0.05$) in FFRB (4185 and 4062 kcal/kg DM) than in DFRB (3224 and 3158 kcal/kg DM) regardless of intake level. The ATTD of GE and the concentrations of ME of FFRB and DFRB were greater ($P < 0.05$) in gestating sows (4119 and 3228 kcal/kg DM) than in growing gilts (3871 and 2933 kcal/kg DM). In conclusion, the level of feed intake by gestating sows did not affect digestibility of GE and nutrients or the concentrations of DE and ME in diets or in FFRB or DFRB. The ATTD of GE and the concentration of DE and ME in diets and in FFRB and DFRB were greater in gestating sows than in growing gilts.

**Key Words:** digestibility, energy, sow
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**166 Effects of energy restriction during gilt development on milk nutrient profile and progeny biomarkers.**

S. M. Barnett*, M. D. Trenhaile-Grannemann, P. S. Miller, T. E. Burkey, D. M. van Sambeek, *University of Nebraska-Lincoln, Lincoln.*

Research at the University of Nebraska investigating the effects of energy restriction on gilt development (including 14 batches with data collected over 4 parities per batch) has lead to the observation that this approach increases sow longevity but may also provide beneficial effects to first parity progeny with respect to health and growth. Specifically, parity 1 progeny may have increased weaning weight compared to progeny derived from gilts fed an ad libitum control diet. Thus, our objective was to evaluate the effects of energy restriction during gilt development on milk nutrient profile and post-natal progeny biomarkers. During the development period, gilts ($n$ = 128, 8 gilts/pen) were fed three dietary treatments including: 1) Control diet formulated to NRC (2012) specifications (CTL); 2) Restricted (20% energy restriction via addition of 40% soy hulls; RES); and 3) Control diet plus addition of crystalline amino acids equivalent to the SID Lys:Met of the RES diet (CTL+). All diets were fed ad libitum and applied in a 3 phase feeding regimen during gilt development (d 120 to 240). Average daily feed intake was used to estimate daily ME intake (Mcal/d) during each phase (Phase 1: 10.13, 6.97, 9.95; Phase 2: 11.25, 8.05, 10.94; and Phase 3: 9.47, 7.95,11.07) for CTL, RES, and CTL+, respectively. At 240 d of age gilts were bred and fed a common diet. For this preliminary analysis, milk samples were collected from batch 14 gilts ($n$ = 7/treatment) on d 0 and 14 post-farrowing for analysis of N, CP, DM, GE and milk insulin, and piglet blood samples ($n$ = 6 piglets/sow) were obtained on d 1 and 15 for quantification

of glucagon-like peptide-2 (GLP-2) and insulin. No effects of diet were observed for milk N, CP, or insulin; however, N, CP, and insulin were increased ($P < 0.05$) on d 1 compared to d 14. When evaluating DM and GE, no diet or time effects were observed. For piglet GLP-2, a treatment by time interaction was observed ($P < 0.009$); specifically, GLP concentrations were greater ($P < 0.001$) in CTL+ compared to RES (6.73 vs. 1.21 ng/mL). For serum insulin, a treatment by time interaction was observed ($P < 0.01$); specifically, insulin in RES was greater ($P < 0.03$) than CTL on d 1. In conclusion, nutritional management of the developing gilt may impact piglet serum biomarkers during lactation.

**Key Words:** energy restriction, milk, sows
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**167 The impact of dietary SID Trp:Lys on growth performance of nursery pigs.** D. D. Koehler[1,*], J. F. Patience[2], K. J. Touchette[3], S. A. Gould[2], T. A. Kellner[2], L. M. Gesing[1], L. S. Courtney[1], *[1]Vita Plus Corporation, Madison, WI, [2]Iowa State University, Ames, [3]Ajinomoto Heartland, Inc., Chicago, IL.*

The current NRC recommended SID tryptophan-to-lysine ratio (Trp:Lys) for nursery pigs is 0.17 (NRC, 2012). However, studies in both high-health and health-challenged pigs have reported performance advantages with Trp:Lys from 0.20 to 0.26. Therefore, the objective of this experiment was to evaluate the impact of varying SID Trp:Lys on growth performance of nursery pigs. There were 5 dietary treatments with 9 pens (90 pigs) per treatment. Pigs were fed a common diet from d 0 to 7. The five dietary treatments with titrated SID Trp:Lys (0.150, 0.175, 0.200, 0.225, and 0.250) were fed from d 7 to 35 in two 2-wk dietary phases. Pigs were individually weighed, and feed remaining in feeders was weighed on d 0, 7, 14, 21, 28, and 35. Data were analyzed using PROC MIXED of SAS with block as a random effect. Pen was the experimental unit. Incremental body weight and the corresponding rate of gain and feed efficiency were analyzed as repeated measures. For each variable, normal distribution of residuals was tested using PROC UNIVARIATE. Determination of the optimal SID Trp:Lys of the 5 dietary treatment least squares means were analyzed using PROC REG for linear, quadratic, and broken line models. PROC NILN was utilized for exponential regression analysis. Over the entire experiment increasing Trp:Lys resulted in increased ADG ($P = 0.002$), decreased ADFI ($P = 0.023$), improved gain to feed ratio ($P = 0.008$), and increased BW exiting the nursery (d 35; $P = 0.007$). The relationship between Trp:Lys and overall G:F tended to be significant when fitted to an exponential curve (Fig. 3; $P = 0.061$), but not a linear, quadratic, or broken line curve ($P \geq 0.244$). These data indicate that there is no advantage in growth performance and feed efficiency to having a diet containing a SID Trp:Lys greater than 0.175 for nursery pigs. These data are supportive of the 0.17 Trp:Lys ratio specified by the NRC.

**Key Words:** lysine, nursery pigs, tryptophan
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**168 Effects of a gluco-oligosaccharide on growth performance of nursery pigs.** F. Wu*, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, J. C. Woodworth, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 3456 pigs (initially 5.63 ± 0.41 kg) were used in a 42-d study to determine the effects of gluco-oligosaccharide (Midori USA, Inc., Cambridge, MA) on growth performance. In each of 3 rooms, pens of pigs (27 pigs/pen) were blocked (6, 5, and 5 blocks in room 1, 2, and 3, respectively) by initial pen weight and allotted randomly to 1 of 8 dietary treatments in a 2-phase feeding program (d 0 to 14 and 14 to 42). Dietary treatments were arranged in a 2 × 4 factorial: with or without antibiotic (0 or 55 ppm, Carbadox, Phibro Animal Health Corp., Teaneck, NJ) and 4 gluco-oligosaccharide concentrations (0, 200, 400, and 600 mg/kg). Gluco-oligosaccharide product used in rooms 1 and 2 originated from a different batch than that used in room 3. No 3-way or antibiotic × gluco-oligosaccharide interactions were observed for any overall growth responses, but tendencies were observed ($P < 0.10$) for room × gluco-oligosaccharide interaction for final BW and ADG. In rooms 1 and 2, antibiotic treatment increased ($P < 0.05$) ADG and ADFI in both phases and overall and G:F from d 14 to 42. Increasing gluco-oligosaccharide increased (linear, $P < 0.05$) ADG from d 0 to 14, d 14 to 28, and overall, and increased (linear, $P < 0.01$) G:F from d 0 to 14 and overall. In room 3, a smaller response was observed for antibiotic inclusion with only increased ($P < 0.05$) G:F from d 14 to 28 and ADG and ADFI from d 28 to 42. Pigs fed increasing gluco-oligosaccharide tended (linear, $P < 0.10$) to have decreased ADG and ADFI from d 14 to 28; however, overall growth performance was not affected by antibiotic or gluco-oligosaccharide treatments. In conclusion, feeding gluco-oligosaccharide may improve growth performance in nursery pigs, and this effect is independent of antibiotic treatment and more prominent during the early nursery phase. However, further research is required to confirm the consistency of the responses to the gluco-oligosaccharide used in this study.

**Key Words:** antibiotic, gluco-oligosaccharide, nursery pig
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**Table 167.** Least squares means for SID Trp:Lys in nursery pigs

| | SID Trp:Lys | | | | | Pooled | |
|---|---|---|---|---|---|---|---|
| Item | 0.150 | 0.175 | 0.200 | 0.225 | 0.250 | SEM | *P* value |
| ADG, kg | 0.338 | 0.372 | 0.356 | 0.332 | 0.364 | 0.013 | 0.002 |
| ADFI, kg | 0.510 | 0.539 | 0.531 | 0.491 | 0.529 | 0.021 | 0.023 |
| Gain/Feed | 0.661 | 0.691 | 0.680 | 0.676 | 0.688 | 0.006 | 0.008 |

**169 Effects of dietary supplementation with a probiotic (*Enterococcus faecium*) on growth performance, nutrient digestibility, fecal microbiota, and fecal score in weanling pigs.** R. X. Lan*, J. K. Kim, Y. H. Liu, H. M. Yun, I. H. Kim, *Department of Animal Resource and Science, Dankook University, Cheonan, South Korea.*

This study was conducted to evaluate the effects of dietary supplementation with a probiotic (*Enterococcus faecium* DSM7134) on growth performance, nutrient digestibility, blood parameters, fecal microbiota, and fecal score in weaning pigs. A total of 140 crossed [(Landrace ×Yorkshire) ×Duroc] weanling pigs with an initial body weight (BW) of 7.45 ± 0.86 kg were used in a 42-d trial. Pigs were randomly allotted to 4 experimental diets according to initial BW and gender (7 replicates each with 2 gilts and 3 barrows). Dietary treatments were: (1) CON, basal diet, (2) T1, CON + 0.05% *E. faecium*, (3) T2, CON + 0.10% *E. faecium*, (4) T3, CON + 0.20% *E. faecium*. Pigs were weighed on d 1, 21, and 42 whereas feed consumption was recorded to calculate ADG, ADFI, and G:F. Fresh fecal samples were obtained on d 42 to determine the ATTD of DM, N, and GE using $Cr_2O_3$ as an indigestible marker. One gram of fecal sample was diluted with 9 mL of 1% peptone broth and then homogenized. Viable counts of bacteria were conducted by plating serial 10-fold dilutions onto agar plates. Fecal scores: 1 hard, dry pellet; 2 firm, formed stool; 3 soft, moist stool that retains shape; 4 soft, unformed stool that assumes shape of container; 5 watery liquid that can be poured. Orthogonal comparisons were conducted using polynomial regression to measure linear and quadratic effects of increasing dietary supplementation of *E. faecium* with $P < 0.05$ indicating a significance.

From d 22 to 42, and overall, there were linear increase ($P = 0.0099$ and $P = 0.0203$, respectively) in ADG and G:F with *E. faecium* supplementation, only linear increase ($P = 0.0395$) in ADG was observed from d 1 to 21. On d 42, there were linear increase ($P = 0.0315$, $P = 0.0108$, and $P = 0.0046$, respectively) in ATTD of N and GE, and fecal *Lactobacilli* counts. *E. faecium* supplementation linear reduced ($P = 0.0056$, $P = 0.0116$, and $P = 0.0002$, respectively) fecal *E. coli* counts and fecal scores in week 1 and 2. In conclusion, dietary supplementation with *E. faecium* improved growth performance, ATTD of N and GE, shifted microbiota by increasing fecal *Lactobacilli* and decreased *E. coli* counts, and decreased fecal score during the two week post-weaning in weanling pigs.

**Key Words:** *Enterococcus faecium*, growth performance, weanling pigs

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**170 Comparing the effects of butyric acid source and level on growth performance of nursery pigs.** K. M. Gourley*, J. C. Woodworth, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, S. S. Dritz, *Kansas State University, Manhattan.*

A total of 400 nursery pigs (PIC 19 × 1050 or PIC 3×C 29 initially 6.2 ± 0.01 kg) were used to compare the effects of increasing levels of two encapsulated butyric acid sources on growth performance of nursery pigs. Dietary treatments were arranged as a 2 × 2 + 1 factorial with main effects of butyric acid source (ButiPEARL vs. ButiPEARLZ; Kemin Industries, Des Moines, IA) and acid source level (low (0.05 or 0.07%) vs. high (0.10 or 0.14%), for ButiPEARL or ButiPEARLZ, respectively) plus a control diet without butyric acid. The addition of butyric acid was established such that the same amount of butyric acid was contributed from each source for the low or high levels, respectively. Experimental diets were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 42. Pens of pigs were balanced by initial BW and randomly allotted to treatments, with 8 pens/treatment. From d 0 to 7, a source × level interaction ($P < 0.05$) was observed for ADG, ADFI, and G:F with pigs fed diets containing ButiPEARL having improved performance at the low inclusion, with those fed the high level not different from the control. However, pigs fed ButiPEARLZ had similar performance to the control regardless of level. In Phase 2 (d 7 to 21), ADG and ADFI were not influenced by butyric acid source or level, but an interaction ($P = 0.002$) was observed for G:F as pigs fed ButiPEARL had poorer G:F as level increased; whereas pigs fed increasing ButiPEARLZ had improved G:F. For Phase 3 (d 21 to 42), increasing either butyric acid source tended ($P = 0.060$) to decrease ADG. Overall (d 0 to 42), butyric acid source or level did not affect ADG, ADFI or G: F. In conclusion, this study showed that pigs fed low ButiPEARL in Phase 1 (d 0 to 7) had improved growth performance compared to other treatments

**Table 168.**

| | Antibiotic, ppm | | | Gluco-oligosaccharide, ppm | | | | |
|---|---|---|---|---|---|---|---|---|
| Item | 0 | 55 | SEM | 0 | 200 | 400 | 600 | SEM |
| Room 1 and 2 (overall) | | | | | | | | |
| ADG, g | 419 | 439 | 3.6 | 418 | 430 | 430 | 437 | 4.7 |
| G:F | 0.683 | 0.687 | 0.0035 | 0.679 | 0.687 | 0.683 | 0.691 | 0.0040 |
| Room 3 (overall) | | | | | | | | |
| ADG, g | 400 | 408 | 5.4 | 410 | 399 | 410 | 399 | 7.1 |
| G:F | 0.667 | 0.672 | 0.0052 | 0.673 | 0.666 | 0.667 | 0.672 | 0.0059 |

with only minor treatment effects observed thereafter.

**Key Words:** butyric acid, growth, nursery pigs
doi: 10.2527/asasmw.2017.12.170

**171 Effects of encapsulated butyric acid and copper on nursery pig growth performance from d 0 to 42 after weaning.** J. A. Loughmiller*, D. Sanders, H. Feng, V. Mani, J. K. Rubach, A. L. P. De Souza, F. R. Valdez, M. J. Poss, *Kemin Industries, Des Moines, IA.*

A study was conducted evaluating the effects of propionic acid plus copper carbonate (KemTRACE Cu®, Kemin Industries, Des Moines, IA), encapsulated butyric acid (ButiPEARL, Kemin Industries, Des Moines, IA) and a novel encapsulated butyric acid plus copper carbonate (ButiPearl C, Kemin Industries, Des Moines, IA) on the growth performance of weanling pigs. A total of 350 pigs (PIC 280 × 1050; initial BW = 5.54kg) with 10 pigs/pen and 7 replicate pens/treatment were used in a 42 d study. Pigs were allocated in a randomized, complete block design based on initial BW. Diets were pelleted, corn-soybean meal based and similar within phase except for the additional copper and encapsulated butyric acid. All nutrient concentrations met or exceeded NRC (2012) estimates. Treatments were Control (N), 500 mg/kg ButiPEARL (B), 65 mg/kg Cu from KemTRACE Cu® (C), 500 mg/kg ButiPEARL + 65 mg/kg C from KemTRACE Cu® (BC); 500 mg/kg ButiPEARL C (BPC). Treatment differences were determined by LSMEANS comparisons. During d 0 to 7, no differences were observed for initial BW, ADG; ADFI ($P > 0.10$). Gain:feed was greatest for BC and BPC ($P < 0.05$). From d 7 to 21, ADG was greatest for BPC and BC ($P < 0.05$). Day 7 to 21 Gain:feed for C, BC; BPC was higher than N ($P < 0.05$). Day 21 to 42 ADG was greatest for BC ($P < 0.05$). Day 21 to 42 ADFI was greatest for BC and BPC ($P < 0.05$); gain:feed was greatest for BC ($P < 0.05$). From d 0 to 42, overall ADG and ADFI were greatest for BC and BPC, while N and B were lowest ($P < 0.05$). Overall gain:feed was greatest for BC ($P < 0.05$). Final BW was greatest for BC and BPC ($P < 0.05$). Adding BC or BPC showed the greatest growth performance improvement for pigs from d 0 to 42 after weaning.

**Key Words:** butyric acid, copper, nursery pigs
doi: 10.2527/asasmw.2017.12.171

**172 Effects of feeding probiotic or chlortetracycline or a combination on nursery pig growth performance.** H. E. Williams*, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey, R. G. Amachawadi, T. G. Nagaraja, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 300 nursery pigs (initial BW 5.9 ± 0.05 kg) were used to determine the effects of feeding chlortetracycline (CTC) with or without probiotics on nursery pig performance. Pigs were weaned at approximately 21-d of age and randomly allotted to pens based on initial BW. Pigs were fed a common pelleted starter diet for 4 d and then weighed, and pens were allotted, in a randomized complete block design based on BW, to 1 of 6 dietary treatments with 10 replications/treatment. The treatments were arranged in a 2 × 3 factorial with main effects of CTC (0 vs. 440 ppm from d 0 to 42) and probiotic (0, 0.05% Bioplus 2B [Chr. Hansen USA, Inc., Milwaukee, WI], or 0.05% Poultry Star [Biomin America, Inc., San Antonio, TX]). Experimental diets were fed in 2 phases (Phase 1: d 0 to 14 and Phase 2: d 14 to 42) and all diets were fed in meal form. Diets were corn-soybean meal based and were formulated to meet the pigs' nutrient requirements for each phase of this study. The Phase 1 diets contained specialty protein sources while Phase 2 diets did not. On d 15 and 29, CTC was removed from CTC diets and non-medicated feed was fed for 1 d. For overall performance, there were no interactions ($P > 0.05$) between probiotics and CTC. Pigs fed CTC had improved ($P < 0.001$) ADG, ADFI, and overall BW compared with those fed diets without CTC. Adding Poultry Star to the diet increased ($P < 0.05$) ADFI and BW from d 0 to 14. However, there was no difference in ADG or ADFI for the overall d 0 to 42 period. In conclusion, CTC improved nursery pig performance, but there were no consistent benefits of feeding either probiotic alone or in combination with CTC.

**Key Words:** growth performance, nursery pig, probiotic
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**Table 170.**

| | | ButiPEARL | | ButiPEARLZ | | | $P <$ | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | Control | Low | High | Low | High | SEM | Source × level | Source | Level |
| d 0 to 7[1] | | | | | | | | | |
| ADG, g | 108[b] | 139[a] | 107[b] | 89[b] | 109[b] | 7.68 | 0.002 | 0.003 | 0.413 |
| G:F, g/kg | 767[ab] | 833[a] | 729[b] | 687[b] | 766[ab] | 6.20 | 0.007 | 0.096 | 0.711 |
| d 0 to 42 | | | | | | | | | |
| ADG, g | 481 | 470 | 456 | 452 | 446 | 8.88 | 0.693 | 0.130 | 0.260 |
| G:F, g/kg | 719 | 712 | 709 | 717 | 707 | 5.90 | 0.633 | 0.796 | 0.267 |

[1]Source × level interaction ($P < 0.05$)

**Table 171.** Effect of encapsulated butyric acid and copper on weanling pig performance, d 0 to 42

| | N | B | C | BC | BPC | SEM |
|---|---|---|---|---|---|---|
| ADG, g | 360[b] | 354[b] | 378[ab] | 404[a] | 401[a] | 13 |
| ADFI, g | 511[b] | 503[b] | 527[ab] | 548[a] | 553[a] | 15 |
| G:F, g/kg | 703[a] | 705[a] | 718[ab] | 737[b] | 723[ab] | 22 |
| D 42 BW, kg | 20.5[b] | 20.5[b] | 21.5[ab] | 22.5[a] | 22.4[a] | 0.6 |

[ab]Means within row differ ($P < 0.05$)

**Table 172.**

| CTC | - | + | - | + | - | + | | |
|---|---|---|---|---|---|---|---|---|
| Bioplus 2B[1] | - | - | + | + | - | - | | Probability < $P$ |
| Poultry Star[1] | - | - | - | - | + | + | SEM | CTC |
| d 0 to 42 | | | | | | | | |
| ADG, g | 424 | 469 | 405 | 482 | 445 | 473 | 13.16 | 0.001 |
| ADFI, g | 644 | 726 | 625 | 727 | 687 | 728 | 16.22 | 0.001 |
| G:F | 0.658 | 0.645 | 0.645 | 0.664 | 0.648 | 0.650 | 0.0003 | 0.795 |
| BW, kg | | | | | | | | |
| d 42 | 24.2 | 25.6 | 23.6 | 26.1 | 24.8 | 25.8 | 0.052 | 0.001 |

[1]No significant interactive or main effects of BioPlus 2B or Poultry Star ($P > 0.05$).

**173 Evaluation of dose response effects of Butipearl C on nursery pig growth performance from d 0 to 42 after weaning.** J. A. Loughmiller*, A. L. P. De Souza, J. K. Rubach, H. Feng, D. Sanders, V. Mani, F. R. Valdez, M. J. Poss, *Kemin Industries, Des Moines, IA.*

A study was conducted to evaluate the effects of a novel encapsulated butyric acid plus copper carbonate product (ButiPearl C; Kemin Industries, Des Moines, IA) on weanling pig growth performance. A total of 350 pigs (PIC 280 × 1050; initial BW = 5.86 kg) with 10 pigs/pen and 7 replicate pens/treatment were used in a 42 d study. Pigs were housed in a commercial research nursery and allocated in a randomized, complete block design based on initial BW. Diets were pelleted, corn-soybean meal based and were similar within phase except for the addition of the BuitiPEARLC (BPC). All nutrient concentrations met or exceeded NRC (2012) requirement estimates. Treatments were arranged as a dose titration of BPC at 0, 250, 500, 750, and 1000 mg/kg of feed. Data were analyzed using a mixed model with orthogonal contrasts. During d 0-7 after weaning, ADG and G:F tended to increase as pigs were fed diets containing up to 500 and 750 mg/kg of BPC, respectively (quadratic, $P < 0.07$). During the same period, ADFI increased when diets containing up to 500 mg/kg of BPC were fed (quadratic, $P < 0.05$). From d 7 to 21, no linear or quadratic effects were observed for ADG, ADFI, or G:F ($P > 0.40$). During d 21 to 42, ADG and G:F increased as pigs were fed diets containing up to 1000 mg/kg BPC (quadratic, $P < 0.01$). During this same period, ADFI increased as pigs were fed diets containing BPC levels up to 1000 mg/kg (quadratic, $P < 0.05$). Overall results (d 0 to 42) showed improved ADG, G:F, and final BW for pigs fed diets with up to 750 mg/kg BPC (quadratic, $P < 0.05$). Overall ADFI increased in pigs fed diets containing up to 1000 mg/kg BPC (linear, $P < 0.04$). These results indicate that pig growth performance was optimized when they were fed diets containing up to 750 mg/kg BPC from d 0 to 42 after weaning.

**Key Words:** butryic acid, copper, nursery pigs
doi: 10.2527/asasmw.2017.12.173

**174 Effects of dietary lysine level and amino acid ratios on nursery pig performance.** A. B. Clark[1,*], M. D. Tokach[1], J. M. DeRouchey[1], S. S. Dritz[1], J. C. Woodworth[1], R. D. Goodband[1], K. J. Touchette[2], M. Allerson[3], *[1]Kansas State University, Manhattan, [2]Ajinomoto Heartland, Inc., Chicago, IL, [3]Holden Farms Inc., Northfield, MN.*

A total of 2268 pigs (PIC 327×L42, initially 7.3 kg BW) were used in a 28-d growth study with 54 pigs/feeder (experimental unit) and 6 replications/treatment. Pigs were randomly allotted to pens at weaning and fed a common starter diet for 8 d. Pens were then blocked by BW and allotted to 1 of 7 dietary treatments in a randomized complete block design. Treatments were arranged in a [2 × 3]+1 factorial with 2 levels of standardized ileal digestible (SID) Lys, low (1.25%) and high (1.35%), and 3 SID amino acid (AA) ratios relative to Lys (industry, 95% of maximum performance, and maximum performance), as well as a control (1.35% SID Lys). Industry ratios were 55% Met+Cys:Lys, 62% Thr:Lys, 18% Trp:Lys, 65% Val:Lys, and 52% Ile:Lys. Maximum diet ratios were 60% Met+Cys:Lys, 65% Thr:Lys, 21% Trp:Lys, 72% Val:Lys, and 52% Ile:Lys. The 95% ratios were formulated to target 95% of maximum performance and were 56% Met+Cys:Lys, 62% Thr:Lys, 19% Trp:Lys, 67% Val:Lys, and 52% Ile:Lys. Diets

**Table 173.** Effect of increasing BPC supplementation on pig performance, d 0 to 42 after weaning

| | Dietary ButiPEARL C, mg/kg | | | | | | Contrast ($P <$ ) | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 250 | 500 | 750 | 1000 | SEM | Linear | Quadratic |
| ADG, g | 389 | 397 | 408 | 414 | 417 | 9 | 0.01 | 0.01 |
| ADFI, g | 546 | 547 | 564 | 563 | 567 | 12 | 0.04 | 0.11 |
| G:F, g/kg | 710 | 725 | 721 | 737 | 735 | 15 | 0.01 | 0.01 |
| D 42 BW, kg | 22.1 | 22.5 | 23.0 | 23.3 | 23.4 | 0.4 | 0.01 | 0.01 |

**Table 174.**

| | | Low Lys | | | High Lys | | | | Probability, $P <$ |
|---|---|---|---|---|---|---|---|---|---|
| Item: | Control | Industry AA | 95% AA | Max AA | Industry AA | 95% AA | Max AA | SEM | Low vs. High Lys |
| d 0 to 14 | | | | | | | | | |
| ADG, g | 369$^{a,b}$ | 346$^{c}$ | 361$^{b,c}$ | 370$^{a,b}$ | 379$^{a}$ | 384$^{a}$ | 362$^{b}$ | 6.9 | 0.001 |
| ADFI, g | 451$^{b}$ | 451$^{b}$ | 467$^{a,b}$ | 465$^{a,b}$ | 461$^{a,b}$ | 472$^{a}$ | 456$^{a,b}$ | 9.2 | 0.692 |
| G:F | 0.819$^{a,b}$ | 0.769$^{c}$ | 0.774$^{c}$ | 0.797$^{a,b,c}$ | 0.823$^{a}$ | 0.814$^{a,b}$ | 0.794$^{b,c}$ | 0.0099 | 0.001 |

$^{a,b,c}$ Means within a row with differing superscripts differ $P < 0.05$.

were formulated to Ile requirement with feed-grade Lys, Met, Thr, Trp, and Val added. The control contained less feed-grade AA (0.39% L-Lys HCl vs. 0.50-0.55% in other diets) and 5% fermented soy protein to achieve similar soybean meal level to high SID Lys diets. Experimental diets were formulated using analyzed AA for corn, soybean meal, and dried distillers grains with solubles and fed for 14 d in meal form. Pens were weighed and feed disappearance was measured on d 0, 7, and 14. Data were analyzed using PROC GLIMMIX. From d 0 to 14, feeding high Lys diets increased *(P* < 0.001) ADG and G:F compared with low Lys diets with no evidence for differences in ADFI between Lys level. Furthermore, for ADG, maximum AA ratios improved ($P < 0.05$) performance compared to industry ratios at low Lys, but not at high Lys levels. In conclusion, higher AA ratios were more critical in diets formulated below the Lys requirement of the pig.

**Key Words:** AA ratios, lysine, nursery pigs
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## 175 Evaluation of dietary phytogenics on growth performance, carcass characteristics, and economics of grow-finish pigs housed under commercial conditions.

J. A. Soto*[1], M. D. Tokach[1], G. R. Murugesan[2], S. S. Dritz[1], J. C. Woodworth[1], J. M. DeRouchey[1], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]BIOMIN America Inc., San Antonio, TX.*

A total of 1245 pigs (PIC 327 × 1050, initially 22.1 kg) were used in a 125-d trial to determine the effects of 2 dietary essential oil mixtures on growth performance, carcass characteristics, and economics of finishing pigs. Pens of 27 or 28 pigs were randomly assigned to 1 of 5 dietary treatments with 9 replications/treatment with treatments fed in 6 phases. Treatment 1 was the control with no feed additives. Treatment 2 contained essential oil mixture 1 (EOM 1) in all phases. Treatment 3 contained EOM 1 fed from phase 3 to 6 and essential oil mixture 2 in all phases (EOM 1+2). Treatment 4 contained EOM 1 in all 6 phases. Treatment 5 contained Ractopamine HCl (RAC) in phase 6. Treatments 1–3 and 4–5 had 12% and 16% CP (0.66 and 0.90% Standardized ileal digestible Lys, respectively) in phase 6 diets, respectively. Overall (d 0 to 125), pigs fed diets with EOM 1+2 had increased ($P = 0.003$) ADFI compared with pigs fed the control diet. Pigs fed EOM 1 + 16% CP had increased ($P = 0.032$) ADFI compared with pigs fed RAC. Pigs fed RAC had increased ($P = 0.027$) G:F compared with pigs fed EOM 1 + 16% CP. Pigs fed EOM 1+2 had heavier ($P < 0.05$) HCW compared with pigs fed the control treatment or EOM 1 + 12% CP. Pigs fed RAC had reduced ($P = 0.001$) backfat thickness and increased ($P = 0.001$) percentage lean, and greater ($P < 0.030$) income over feed cost (IOFC) compared with pigs fed EOM 1 + 16% CP. In summary, while ADG was not affected in this study, pigs fed RAC had the greatest G:F and IOFC. The addition of EOM 1+2 increased HCW similar to those fed RAC with EOM 1 + 16% CP being intermediate. Additional research to confirm these responses to essential oil additions is warranted.

**Key Words:** essential oils, feed additives, phytogenics
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## 176 Effect of feeding varying levels of *Lactobacillus plantarum* on nursery pig performance.

A. M. Jones*, J. C. Woodworth, J. M. DeRouchey, S. S. Dritz, M. D. Tokach, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 360 pigs (PIC C-29 × 359, initial BW 5.95 ± 0.007 kg) were used in a 42-d trial evaluating the effects of feeding varying levels of *Lactobacillus plantarum* on nursery pig performance. Pigs were weaned at 18 to 20 d and allotted to pens based on initial BW and gender to 1 of 4 dietary treatments in a completely randomized design with 10 pigs

per pen and 9 replications per treatment. Experimental diets were fed in 3 phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21; and Phase 3, d 21 to 42). Treatment diets were formulated to include 0, 0.05, 0.10, or 0.20% *Lactobacillus plantarum* product (LP1; Nutraferma Inc., Sioux City, IA). All treatment diets within phase were formulated to similar nutrient levels with diets containing 15% and 7.5% lactose in Phases 1 and 2, respectively. Furthermore, all diets were fed in pellet form and did not include antibiotics. Data were analyzed using the PROC GLIMIX procedure in SAS with pen as the experimental unit. Dietary treatment served as the fixed effect in the model. Means were evaluated using preplanned linear and quadratic orthogonal contrasts. During Phase 1 and 2, there were no differences among dietary treatments. During Phase 3, ADG and ADFI were not influenced by treatment; however, increasing LP1 marginally improved G:F (0.716; 0.728; 0.728; 0.718 for the 0, 0.05, 0.10, and 0.20 LP1 additions, respectively; quadratic $P = 0.085$). Overall (d 0 to 42), no evidence for differences in growth performance were observed among dietary treatments. In conclusion, feeding increasing dietary levels of *Lactobacillus plantarum* had no evidence of an impact on nursery pig performance.

**Key Words:** growth performance, *Lactobacillus plantarum*, nursery pig
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**Table 175.**

| Phase 6 CP, % | | 12 | EOM | 16 | | |
|---|---|---|---|---|---|---|
| Feed additive | Control | EOM 1[1] | 1+2[2] | EOM 1 | RAC[3] | SEM |
| ADG, kg | 0.81 | 0.83 | 0.83 | 0.83 | 0.83 | 0.014 |
| ADFI, kg | 2.19$^{bc}$ | 2.23$^{ab}$ | 2.27$^{a}$ | 2.23$^{ab}$ | 2.17$^{c}$ | 0.046 |
| G:F | 0.373$^{ab}$ | 0.375$^{ab}$ | 0.368$^{b}$ | 0.372$^{b}$ | 0.383$^{a}$ | 0.026 |
| Final BW, kg | 122.7 | 124.6 | 124.6 | 123.8 | 123.9 | 2.37 |
| HCW, kg | 94.5$^{b}$ | 94.8$^{b}$ | 97.1$^{a}$ | 96.1$^{ab}$ | 97.3$^{a}$ | 1.34 |
| IOFC, $/pig | 65.99$^{ab}$ | 64.55$^{b}$ | 65.64$^{b}$ | 65.45$^{b}$ | 67.77$^{a}$ | 0.723 |

Means within a row without a common superscript differ $P < 0.050$.
[1]Contained caraway, garlic, thyme, and cinnamon as key ingredients.
[2]Contained oregano, citrus and anise oils as key ingredients.
[3]Ractopamine HCl.

## 177 The effect of feeding AmbitineFA on growth performance and carcass characteristics of finishing pigs.

R. L. Schmitt[1,*], M. Ellis[1], J. E. Estrada[1], A. M. Gaines[2], O. F. Mendoza[2], C. M. Shull[2], S. A. Crowder[3], T. P. Karnezos[4], *[1]University of Illinois at Urbana-Champaign, Urbana, [2]The Maschhoffs, LLC, Carlyle, IL, [3]Purina Animal Nutrition LLC, Shoreview, MN, [4]PMI Nutritional Additives, Shoreview, MN.*

Two studies were performed to determine the effect of feeding AmbitineFA (blend of plant extracts and acidifiers) on growth performance and carcass characteristics of finishing pigs. Both studies used a RCBD with 2 treatments: Control (no AmbitineFA); AmbitineFA (0.10% dietary inclusion). Studies 1 and 2 used 1610 (23 replicates) and 4682 (68 replicates) barrows and gilts, respectively, in single-sex groups of 35. AmbitineFA was included in the final or final 2 dietary phases in Studies 1 and 2, respectively. Experimental diets were fed for approximately 28 and 49 d between start and end BW of 103.1 ± 4.75 kg to 128.0 ± 2.59 kg and 89.4 ± 2.29 kg to 121.9 ± 4.16 kg for Studies 1 and 2, respectively. Diets were formulated to a constant standardized ileal digestible lysine:ME ratio within each dietary phase and to meet or exceed nutrient requirements of NRC (2012). Pigs had ad libitum access to feed and water. At the end of each study, pigs were sent to a commercial facility for harvest and collection of carcass measurements in 2 groups/pen. The heaviest 50% of pigs was sent at mean pen weights of 117.0 ± 2.5 kg and 108.0 ± 2.0 kg BW for Studies 1 and 2, respectively, and the remaining 50% of pigs was sent 14 d later. Ractopamine hydrochloride (7.4 ppm) was fed during the final 28 d of the study period to pigs on both treatments in both studies (14 d for the first group and 28 d for the second group). The pen of pigs was the experimental unit; data were analyzed using PROC MIXED of SAS; the model accounted for the effects of treatment, block, and replicate. Compared to Control, feeding the blend of plant extracts and acidifiers had no effect ($P > 0.05$) on ADFI in either study, increased ADG in Study 1 (1.12 vs. 1.17 kg; SEM 0.015; $P = 0.02$) but not Study 2 (0.76 vs. 0.77 kg; SEM 0.010; $P = 0.16$) and increased G:F in both studies (0.405 vs. 0.418 kg:kg; SEM 0.0047; $P = 0.02$ and 0.362 vs. 0.368 kg:kg; SEM 0.0028; $P = 0.02$ for Study 1 and Study 2, respectively). There was no effect ($P > 0.05$)

**Table 176.**

| | | LP1 | | | | Probability, $P <$ | |
|---|---|---|---|---|---|---|---|
| Diets | Control | 0.05% | 0.10% | 0.20% | SEM | Linear | Quadratic |
| Initial BW, kg | 5.95 | 5.94 | 5.94 | 5.95 | 0.007 | 0.689 | 0.483 |
| ADG, g | 418 | 411 | 410 | 410 | 7.0 | 0.508 | 0.567 |
| ADFI, g | 562 | 552 | 546 | 551 | 9.2 | 0.448 | 0.316 |
| G:F | 0.74 | 0.74 | 0.75 | 0.74 | 0.005 | 0.814 | 0.313 |
| Final BW, kg | 23.53 | 23.34 | 23.16 | 23.17 | 0.298 | 0.402 | 0.612 |

of feeding the blend on carcass measurements. The results of these studies suggest that feeding this blend of plant extracts and acidifiers during finishing improves feed efficiency and can improve growth rate.

**Key Words:** AmbitineFA, feed efficiency, pig
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**178 Effects of zinc oxide and microbial phytase on standardized total tract digestibility of calcium in maize-based diets fed to growing pigs.**

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It is common industry practice to use diets with pharmacological concentrations of zinc during the post-weaning period to prevent post-weaning diarrhea in pigs. However, Zn competes with Ca for absorption, and Ca and Zn may bind to phytate, which may also affect Ca absorption. Therefore, an experiment was conducted to test the hypothesis that inclusion of Zn at a therapeutic level in diets fed to pigs affects apparent total tract digestibility (ATTD) of Ca and P and standardized total tract digestibility (STTD) of Ca. The second hypothesis was that inclusion of microbial phytase increases the STTD of Ca regardless of the concentration of Zn in the diet. Fifty-six growing barrows (average BW: 15.4 ± 1.9 kg) were allotted to a randomized complete block design with 7 dietary treatments and 8 pigs per treatment. A basal diet containing corn, cornstarch, potato protein isolate, soybean oil, calcium carbonate, monosodium phosphate, vitamins, and minerals was formulated with either 0 or 2400 mg/kg Zn from ZnO and 0, 1000, or 3000 units of phytase (FTU) per kg. A Ca-free diet was used to determine basal endogenous losses of Ca. Feces were collected from the feed provided from d 6 to 11 using the marker-to-marker approach, and urine was also collected. Retention of Ca, ATTD of Ca, and STTD of Ca increased linearly ($P < 0.01$) as the concentration of phytase in the diet increased, but were less if ZnO was used than if no ZnO was added to the diet (interaction, $P < 0.01$). Retention of P and the ATTD of P increased linearly ($P < 0.01$) and quadratically ($P < 0.05$) as the concentration of phytase increased in the diet, but the increase was greater if ZnO was not added than if ZnO was added to the diet (interaction, $P < 0.05$). In conclusion, pharmacological levels of Zn reduced Ca and P digestibility and retention, but this effect was partly mitigated by the inclusion of high levels of phytase in the diets. Inclusion of microbial phytase increased the ATTD and STTD of Ca in diets and also the ATTD of P.

**Key Words:** minerals, phytase, pigs
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**179 Effects of increasing copper from either $CuSO_4$ or combinations of $CuSO_4$ and a Cu-amino acid complex on growth performance and carcass characteristics of finishing pigs.**

C. B. Carpenter[1,*], J. C. Woodworth[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], S. S. Dritz[1], Z. J. Rambo[2], *[1]Kansas State University, Manhattan, [2]Zinpro Corporation, Eden Prairie, MN.*

A total of 1089 pigs (PIC 280 × 1050; initially 37.3 kg) were used in a 105-d growth study to determine the effects of increasing added Cu from either $CuSO_4$ (Prince Agri-Products, Quincy, IL) alone or a 50/50 blend of $CuSO_4$ and Cu-AA complex (Availa®-Cu, Zinpro Corporation, Eden Prairie, MN) on growth performance and carcass characteristics of finishing pigs. Treatments were fed in 5 phases (27 to 45, 45 to 61, 61 to 77, 77 to 104, and 104 to 127 kg BW) and consisted of a control diet with 17 ppm Cu from $CuSO_4$ from the trace mineral premix or the control plus added $CuSO_4$ to provide 70 and 130 ppm total Cu or a 50/50 blend of $CuSO_4$ and Cu-AA to provide 70, 100, and 130 ppm total Cu. There were 25 or 26 pigs/pen and 7 replicates/treatment. Overall, added Cu above 17 ppm did not influence ADG; however, pigs fed 70 and 130 ppm added Cu from the 50/50 blend of $CuSO_4$ and Cu-AA had decreased ($P = 0.045$) ADFI but G:F tended ($P = 0.051$) to be improved compared with those fed 70 and 130 ppm of added Cu from $CuSO_4$ only. Similar to the G:F response, pigs fed diets that contained $CuSO_4$ alone had poorer ($P = 0.033$) carcass G:F than those fed added Cu from the 50/50 blend of $CuSO_4$ and Cu-AA. Carcass characteristics were not influenced. In conclusion, these data suggest pigs fed diets that contained added Cu from $CuSO_4$ alone consume more feed but have poorer G:F on a live and carcass basis compared to those fed a 50/50 blend of $CuSO_4$and Cu-AA. Increasing Cu did not affect growth performance in this study.

**Key Words:** copper source, finishing pig, growth
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**180 Phytate hydrolysis, intestinal microbiota, microbial metabolites, and innate immune cell numbers are changed in growing pigs fed diets with varying calcium-phosphorus levels and fermentable substrates.**

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Effects of dietary calcium-phosphorus (CaP) on the swine immune system and intestinal microbiota are not fully elucidated. The present study assesses effects of diets containing varying

CaP levels and fermentable substrates on intestinal CaP net absorption, phytate (*myo*-inositol hexakisphosphate, $InsP_6$) hydrolysis, intestinal microbiota, microbial metabolites, and innate immune cell numbers using 32 crossbred pigs (initial BW 54.7 kg). In a 2 × 2 factorial arrangement, pigs were fed either a corn-soybean meal (SBM) or corn-field pea diet with either low (4.4 g Ca/kg; 4.2 g total P/kg) or high (8.3 g Ca/kg; 7.5 g total P/kg; supplemented with monocalcium phosphate) CaP content. Digesta and feces samples were examined for P, Ca, inositol phosphate isomers, and $TiO_2$. After 3 wk of diet adaptation, feces were collected by rectal stimulation to determine 16S rRNA gene copy numbers by qPCR and bacterial metabolite analyses. Blood was analyzed for immune cell numbers. Jejunal (−9.6 vs. 18.3%), cecal (−1.8 vs. 26.3%), and total tract P (3.6 vs. 22.1%) net absorption were lower ($P < 0.01$) for the low than high CaP diets. Diet did not affect $InsP_6$ hydrolysis in digesta. The jejunal $InsP_6$ concentration was lower ($P < 0.05$; 21.5 vs. 31.5 µmol/g DM) for the low than high CaP diets. Jejunal (1.6 vs. 1.2 µmol/g DM) and cecal (2.2 vs. 1.8 µmol/g DM) concentration of Ins(1,2,4,5,6)$P_5$ tended to be greater ($P < 0.10$) for the SBM than field pea diets. Gene copy numbers of *Bacteroides-Prevotella-Porphyromonas* were lower ($P < 0.05$) for pigs fed the high than low CaP diets. The *Clostridium* cluster IV tended to be greater ($P < 0.10$) and fecal acetate and propionate concentrations were lower ($P < 0.05$) for the field pea than SBM diets. Blood granulocyte, neutrophil, and monocyte numbers were lower ($P < 0.05$) for pigs fed the low CaP diet combined with SBM 3 wk after diet adaptation compared to the other diets. Diets low in CaP increased the abundance of proteolytic *Bacteroides-Prevotella-Porphyromonas* and in combination with SBM might impair the first line of defense and limited the activation of cellular adaptive immune response, thereby possibly increasing the risk for intestinal disturbances. For the corn-field pea diets, the greater SCFA concentration may indicate increased saccharolytic fermentation activity, which may be favorable for gut health, whereas the abundance of *Clostridium* cluster IV in feces, that is known to be less healthy, was greater for field pea.

**Key Words:** immune system, intestinal microbiota, phosphorus

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**181 Effects of increasing copper from Tri-basic copper chloride or a Cu-amino acid complex on growth performance of nursery pigs.** C. B. Carpenter[1,*], J. C. Woodworth[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], S. S. Dritz[1], J. L. Usry[2], *[1]Kansas State University, Manhattan, [2]Micronutrients, Indianapolis, IN.*

Many U.S. swine nutritionists supplement swine diets with added Cu to promote growth of weanling pigs. However, there is little research comparing different organic and hydroxyl Cu sources for their growth promoting benefits. Thus, the objective of this study was to compare the effects of increasing added Cu from Tri-basic CuCl (TBCC, IntelliBond-C; Micronutrients, Indianapolis, IN) or Cu-AA (Mintrex-Cu; Novus, St. Charles, MO) on growth performance of nursery pigs. A total of 665 pigs [Group 1; 350 barrows (DNA 200 × 400; initially 6.4 kg)] and [Group 2; 315 barrows and gilts (DNA 241 × 600; initially 5.2 kg)] were used. There were 5 pigs/pen and 10 replications/treatment in group 1 and 5 pigs/pen and 9 replications/treatment in group 2. Pens of pigs were allotted by BW to 1 of 7 dietary treatments arranged as a 2 × 3 factorial plus a control diet, with main effects of Cu source (TBCC or Cu-AA) and level (75, 150, or 225 ppm). Data were analyzed as a randomized complete block design using PROC GLIMMIX (SAS Inst. Inc., Cary, NC) with pen as the experimental unit and dietary treatment as the fixed effect. Random effects of group and block within group were included in the model. All diets, including the control, contained a trace mineral premix formulated to contribute 17 ppm of Cu from $CuSO_4$ in the complete diet. Experimental diets were fed in two phases from d 0 to 14 and d 14 to 35. Overall, there were no Cu source × level interactions observed. Increasing Cu increased ADG (linear, $P = 0.048$) and final BW (linear, $P = 0.019$) with no effect on ADFI. This resulted in a tendency for improved G:F (linear, $P = 0.052$) with increasing dietary Cu. In summary, Cu source did not affect growth performance and because the growth benefits were linear, it is unknown from our study if increasing added Cu beyond 225 ppm would further improve growth.

**Key Words:** copper source, growth, nursery pig

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**Table 179.**

| | Total Cu, ppm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Control** | $CuSO_4$ | | $CuSO_4$/Cu-AA | | | | Probability, $P <$ |
| Item[1] | 17 | 70 | 130 | 70 | 100 | 130 | SEM | Cu Source |
| ADG, kg | 0.87 | 0.88 | 0.89 | 0.89 | 0.89 | 0.87 | 0.010 | 0.573 |
| ADFI, kg | 2.43 | 2.46 | 2.47 | 2.44 | 2.46 | 2.38 | 0.029 | 0.045 |
| G:F | 0.358 | 0.359 | 0.360 | 0.363 | 0.362 | 0.368 | 0.0030 | 0.051 |
| HCW, kg | 93.04 | 93.84 | 93.89 | 93.72 | 94.73 | 92.92 | 1.353 | 0.547 |
| Carcass G:F | 0.259 | 0.260 | 0.259 | 0.264 | 0.263 | 0.266 | 0.0025 | 0.033 |

[1]**No effect of Cu level**: linear $P > 0.125$ and quadratic $P > 0.205$

**182 True total-tract digestibility of calcium in limestone and dicalcium phosphate for twenty-kilogram pigs are additive in a semi-purified diet.** F. Zhang[1,*], O. Adeola[2], [1]*Purdue University, West Lafayette, IN,* [2]*Department of Animal Sciences, Purdue University, West Lafayette, IN.*

The objective of this study was to test the additivity of true total tract digestibility (TTTD) for calcium (Ca) in limestone and dicalcium phosphate for 20-kg pigs. Seventy-two barrows with an average initial BW of 20.8 ± 1.3 kg were blocked by weight and randomly assigned to 9 dietary treatments in a 3 × 3 factorial arrangement of three Ca sources included limestone, dicalcium phosphate, and their mixture at a ratio of 1:1; and dietary Ca concentration at 4.0, 5.0, and 6.0 g/kg. Potassium phosphate was added to adjust the dietary phosphorus level and maintain a 1.0:1 total Ca: total P ratio. Diets were fed for a 5-d adjustment period followed by a total collection period of 5 d with chromium oxide and ferric oxide as a markers to determine the initiation and termination of fecal collection, respectively. Data were analyzed using GLM procedure of SAS as a randomized complete block design in a 3 × 3 factorial arrangement. The results showed the increased Ca concentration linearly increased ($P < 0.001$) Ca intake, fecal Ca output, and Ca absorbed, but no effect on apparent total tract digestibility of Ca within each Ca sources. The average apparent total tract digestibility was 66.46, 70.34, and 69.32% for limestone, dicalcium phosphate, and their mixture, respectively. By regressing daily digested Ca against daily Ca intake, the TTTD of Ca was determined at 70.06, 76.42, and 73.72% for limestone, dicalcium phosphate, and their mixture, respectively. And no difference was observed using confidence intervals derived from standard errors of respective regression coefficients. The calculated TTTD for Ca in limestone and dicalcium phosphate mixture was calculated to be 72.67% based on the Ca contribution coefficient calculated to be 0.590 for limestone and 0.410 for dicalcium phosphate. The calculated Ca TTTD (72.67%) in the mixture was not statistically different from the determined Ca TTTD (73.72%). In conclusion, the TTTD for Ca in limestone and dicalcium phosphate are additive in the semi-purified diet for pigs.

**Key Words:** additivity, pigs, true total tract digestibility of calcium

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**183 To determine the effect of superdosing phytase on nursery pig performance, zinc, and copper blood serum levels when fed varying levels of copper supplementation.** G. Cordero*, C. L. Bradley, P. Wilcock, *AB Vista, Marlborough, United Kingdom.*

Dietary phytate is an anti-nutrient, and phytase hydrolyzes phytate improving mineral, energy, and amino acid utilization. The objective of this trial was to determine the effect of copper sulfate supplementation on nursery pig performance, serum copper, and zinc levels with or without superdosing phytase. A total of 720 weaned pigs (7 kg BW; D21) were randomly assigned to one of 8 dietary treatments (2 × 4 factorial) with 4 levels of supplementary copper; 15, 62.5, 125, and 250 ppm at 2 levels of phytase (Quantum Blue); 0 and 2000 FTU/kg. Each treatment consisted of 9 pen replicates with 10 pigs per pen (mixed sex) and were fed a 3 phase feeding program P1 (W-D7), P2 (D7-D21), and P3 (D21-D42). In P1 and P2 all diets were formulated to meet the pigs' nutrient requirements (NRC, 2012) including adequate phosphorus. In P3, with phytase addition, diets were formulated at 0.15% and 0.16% below requirement for available P and calcium, respectively. At D21 and D42 pigs were weighed and one pig per pen was selected for blood sampling. At D21 there was a linear ADG response ($P < 0.05$) to copper addition and an ADG improvement ($P < 0.001$) with phytase and no phytase x copper interaction in ADG was observed. In contrast, FCR showed an interaction with phytase superdosing improving performance at 15 and 125 ppm copper ($P < 0.05$) with a numerical improvement at 62.5 ppm copper. At D21 there was no effect of copper on blood mineral levels; however, with phytase addition there was a reduction ($P < 0.02$) of copper and an increase ($P < 0.01$) in zinc serum levels. At D42 there was no interaction between copper and phytase. Phytase superdosing improved liveweight (24.29 v 25.88; $P < 0.05$) and FCR (1.41 v 1.30; $P < 0.05$) at D42 irrespective of copper dose with copper addition resulting

**Table 181.**

| | | Added Cu, ppm | | | | | | | Probability, $P <$ |
|---|---|---|---|---|---|---|---|---|---|
| | **Control** | TBCC | | | Cu-AA | | | | Cu level |
| Item[1] | 0 | 75 | 150 | 225 | 75 | 150 | 225 | SEM | Linear |
| BW, kg | | | | | | | | | |
| d 0 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 0.60 | 0.974 |
| d 35 | 21.1 | 21.0 | 21.7 | 22.0 | 21.6 | 22.2 | 21.8 | 2.77 | 0.019 |
| d 0 to 35 | | | | | | | | | |
| ADG, g | 436 | 430 | 452 | 459 | 441 | 459 | 451 | 66.4 | 0.048 |
| ADFI, g | 637 | 629 | 651 | 660 | 647 | 654 | 637 | 83.7 | 0.305 |
| G:F | 0.681 | 0.683 | 0.692 | 0.694 | 0.677 | 0.700 | 0.701 | 0.0168 | 0.052 |

[1]No effect of copper source $P > 0.315$.

in a linear improvement in ADG ($P < 0.05$) and FCR ($P < 0.02$). At D42 copper did not affect zinc serum levels but did result in higher ($P < 0.05$) copper serum levels for 250 ppm compared to all other treatments. In summary, at D42 phytase improved ADG and FCR at all levels of copper supplementation while increasing copper to 250 ppm resulted in an improved nursery performance. Furthermore, performance was similar between pigs fed 250 ppm copper and pigs fed 62.5 ppm copper with phytase at 2000 FTU/kg

**Key Words:** copper, phytase, superdose
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**184 Alleged predisposing factors in diets fail to increase the incidence of osteochondrosis lesions in growing pigs at 12 and 24 weeks of age.** J. Baker[1], M. Grez[1,*], J. A. Shutter[1], M. E. Wilson[2], T. D. Crenshaw[1], *[1]University of Wisconsin-Madison, Madison, [2]Zinpro Corp., Eden Prairie, MN.*

Early lesions of osteochondrosis (OC) are exhibited by regions of cartilage retention along the growth plate. Progression of OC lesions may lead to fractures and impaired locomotion. Little is known about the disease etiology, but diet is commonly implicated as a predisposing factor. In this study nutrient concentrations and physical form of diets were altered in an attempt to induce the formation of OC lesions under controlled conditions. At 6 wk of age 96 crossbred (1/4-Landrace X 1/4-Large White X 1/2-PIC Line 19) gilts (initial BW = 17.4 + 0.36 kg) were randomly assigned to 1 of 4 corn-SBM based dietary treatments (4 pens/diet, 6 pigs/pen) to assess effects of diet on number and volume of OC lesions. Diets included a standard meal diet (Ctl); Ctl plus 20% glucose (Glc); a meal diet formulated to supply 120% of requirements for lysine, Ca, and P (+CaP); and the +CaP diet pelleted (PEL). Pigs were killed at either 12 or 24 wk of age and femurs were collected. Based on mixed model analysis with pen as the experimental unit, treatments did not affect final BW (129.3 + 3.8 kg) or ADG (1.00 + 0.03 kg/d). As expected, pigs fed PEL and Glc diets were more efficient ($P < 0.05$) in feed conversion compared with Ctl and +CaP. Using femur as the experimental unit, at 12 wk, bone mineral content, determined by dual-energy X-ray absorptiometry scans, was greater ($P < 0.05$) in pigs fed +CaP and PEL diets than Ctl or Glc, but only +CaP group differed ($P < 0.05$) at 24 wk. Computed tomography scans of the femurs were analyzed by multiple observers using Mimics (Materialize software 17.0) to detect incidence and volume of lesions in distal growth plates. At 12 wk, pigs fed Ctl had fewer lesions ($P < 0.05$), but no differences were detected in total lesion volume across the entire growth plate. Pigs had fewer lesions at 24 than 12 wk, but differences were not detected among treatments. However, at 24 wk pigs fed Ctl diet had the greatest lesion volume among diets. In conclusion, none of the pigs exhibited symptoms of lameness regardless of dietary treatment or OC lesion traits.

**Key Words:** computed tomography, osteochondrosis, pelleted diets
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**185 Effects of chromium methionine and zinc source on performance, carcass traits, and meat quality of growing-finishing pigs.** X. Xu[1], Z. C. Li[1], H. L. Wang[1], L. Pan[1], X. K. Ma[1], Y. T. Xu[1], X. S. Piao[1], T. L. Ward[2], F. Ji[3,*], *[1]China Agricultural University, Beijing, China, [2]Zinpro Corporation, Eden Prairie, MN, [3]Zinpro (Wuxi) Additives Bio-Technology Co., LTD, Shanghai, China.*

The objectives of this study were to evaluate the effects of chromium methionine complex (CrMet) fed with $ZnSO_4$ (ZnS) or Zn amino acid complex (ZnAA) on performance and carcass quality of growing-finishing pigs. One hundred eighty crossbred pigs (Duroc x Landrace x Yorkshire; 32.0 ± 1.71 kg BW) were used in a completely randomized design with 3 treatments: 1) Control (CON): 100 mg/kg Zn from $ZnSO_4$; 2) CrMet-ZnS: CON + 0.2 mg/kg Cr from CrMet; or 3) CrMet-ZnAA: 50 mg/kg Zn from $ZnSO_4$ + 50 mg/kg Zn from ZnAA + 0.2 mg/kg Cr from CrMet. Each treatment had 10 replicates (5 pens each of barrows or gilts; 6 pigs/pen). Pigs were fed corn-soybean meal diets based on NRC (1998) requirements. The experiment lasted 105 d with 3 stages: Phase 1 (30 to 50 kg BW, 28 d), Phase 2 (50 to 80 kg BW, 42 d), and Phase 3 (80 to 110 kg BW, 35 d). At the end of the experiment, one pig from each pen with BW nearest the mean of the pen was selected for harvest. Average daily gain was similar ($P > 0.05$) among the 3 treatments in all 3 phases and for the entire experiment (overall average 0.74 kg/d). Average daily feed intake by pigs fed CrMet-ZnAA was lower ($P < 0.05$) compared to pigs fed CON for the entire experiment (2.30 vs. 2.42 kg/d). Gain:feed was improved ($P < 0.05$) in Phases 2 and 3 in pigs fed CrMet-ZnS or CrMet-ZnAA compared to pigs fed CON (0.324, 0.332, and 0.312, respectively, for Phase 2 and 0.282, 0.293, 0.266, respectively, for Phase 3) and for the entire experiment by pigs fed CrMet-ZnAA compared to pigs fed CON (0.326 vs. 0.301). Pigs fed CrMet-ZnAA had greater ($P < 0.05$) HCW, dressing percentage and LM area than pigs fed CON (83.2 vs. 80.5 kg, 76.0 vs. 73.5%, and 64.26 vs. 62.03 $cm^2$). Pigs fed CON and CrMet-ZnS had similar ($P > 0.05$) HCW, dressing percentage, and LM area. Color and drip loss of LM did not differ ($P > 0.05$) among treatments. The $pH_{24h}$ of

**Table 184.**

| | | Treatment | | | | |
|---|---|---|---|---|---|---|
| Lesion Traits | Week | Ctl | Glc | +CaP | PEL | SEM |
| Number | 12 | $4.06^{A}$ | $6.94^{B}$ | $7.00^{B}$ | $6.88^{B}$ | 0.89 |
| | 24 | $2.97^{A}$ | $1.78^{A}$ | $2.56^{A}$ | $3.16^{A}$ | 0.63 |
| Total Volume, $mm^3$ | 12 | $30.16^{A}$ | $66.89^{A}$ | $55.16^{A}$ | $54.36^{A}$ | 13.39 |
| | 24 | $7.05^{A}$ | $2.33^{B}$ | $3.75^{AB}$ | $4.21^{AB}$ | 1.92 |

LM from pigs fed CrMet-ZnS and CrMet-ZnAA was greater ($P < 0.05$) compared to pigs fed CON (5.73 and 5.71 vs. 5.45). Results suggest that Cr from CrMet improved performance and carcass characteristics of growing-finishing pigs and Zn from ZnAA further enhanced the effects.

**Key Words:** chromium methionine, pigs, zinc
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**186 Effect of organic Cu supplementation on growth performance, apparent total tract digestibility (ATTD), and tissue mineral composition in nursery pigs.**

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A 28-d feeding trial was conducted to evaluate the effect of organic Cu supplementation on growth performance, ATTD, and tissue mineral concentrations for nursery pigs. A total of 160 crossbred weanling pigs (initial BW = 5.98 ± 0.53 kg) were blocked by BW and gender and then randomly allotted to 4 dietary treatments with 5 pigs/pen for 8 replicates. Dietary treatments were: 1) Control: corn-SBM based basal diet without Cu supplementation, 2) 80 ppm of Cu supplementation from organic Cu (MINTREX; Novus International, Saint Charles, MO), 3) 150 ppm of Cu supplementation from organic Cu, and 4) 150 ppm of Cu supplementation from $CuSO_4$. Two diet phases were used for d 0–14 (Phase 1) and d 14–28 (Phase 2). Pigs were slaughtered (1 pig/pen) at d 28 postweaning to collect bile, liver and duodenal mucosa. In Phase 2, the 150 ppm Cu groups had lower ADG than the control and 80 ppm of organic Cu groups ($P < 0.05$) regardless of Cu sources. In the results of ATTD, the 80 ppm of organic Cu group had the highest ATTD of ether extract ($P = 0.10$) but the lowest ATTD of Ca ($P < 0.05$) and ash ($P = 0.07$) with quadratic responses as organic Cu supplementation levels increased. The Cu concentrations in bile ($P < 0.01$, linear; 28.3, 28.9, and 52.1 mg/kg for 0, 80, and 150 ppm of organic Cu levels) and liver ($P < 0.01$, quadratic; 14.7, 17.4, and 63.9 mg/kg) at d 28 postweaning increased with increasing organic Cu supplementation levels in which the 150 ppm of organic Cu group had greater liver Cu concentrations compared with the 150 ppm of $CuSO_4$ group ($P < 0.05$; 63.9 vs. 39.9 mg/kg). Duodenum mucosal lipase activity tended to increase ($P = 0.109$, linear; 1718, 1928, and 2250 U/kg for 0, 80, and 150 ppm of organic Cu levels) with increasing organic Cu supplementation levels. In conclusion, Cu supplementation had no benefits on growth performance, tended to increase ether extract ATTD and lipase activity, but reduced Ca and ash ATTD. Copper deposition in bile and liver increased with Cu supplementation; Cu deposition in liver at d 28 postweaning was greater in the organic Cu group compared to the $CuSO_4$ group at the same supplementation level indicating that organic Cu had greater bioavailability relative to $CuSO_4$ in Cu deposition.

**Key Words:** bioavailability, copper, nursery pigs
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**187 Chemical composition and physicochemical characteristics of feed ingredients and effects on in vitro ileal and total tract digestibility of dry matter.**

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It is necessary to have a complete account of all measurable components of a feed ingredient or diet to accurately predict a pig's response to high fiber diets. Therefore, an experiment was conducted to quantify and characterize fiber fractions of feed ingredients that vary in concentrations of soluble and insoluble dietary fiber (IDF) and to determine in vitro DM digestibility. The ingredients used were corn, wheat, soybean meal, canola meal, corn distillers dried grains with solubles (DDGS), corn germ meal, copra expellers, and sugar beet pulp. Cellulose (SF) and pectin were also included to represent purified synthetic sources of insoluble and soluble fiber, respectively. The in vitro apparent total tract digestibility (IVATTD) was determined using a 3-step procedure modified from Boisen and Fernández (1997). For in vitro apparent ileal digestibility (IVAID), the same procedure was used, but the process was discontinued after the second step. Analyses were performed in triplicates with the exception of viscosity which was performed in quadruplicates. Correlation coefficients between the physicochemical characteristics of the feed ingredients and the IVAID and IVATTD of DM were determined to identify relationships between measurable components of feed ingredients and DM digestibility. Results indicated that the analyzed nutrient composition of all ingredients added to 100% or greater, except for SF, which added to only 96.09%. However, the difference between the calculated GE of the analyzed components and the analyzed GE of the ingredients ranged from −0.97 MJ/kg in DDGS to 1.74 MJ/kg in pectin. Bulk density was negatively correlated ($P < 0.05$) with NDF ($r = -0.78$) and ADF ($r = -0.69$). Soluble dietary fiber was positively correlated ($P < 0.05$) with viscosity ($r = 1.00$) and swelling ($r = 0.64$). Swelling was also positively correlated ($P < 0.01$) with water binding capacity ($r = 0.89$). Concentration of total dietary fiber (TDF) was negatively correlated ($P < 0.05$) with IVAID ($r = -0.65$) and IVATTD ($r = -0.76$) of DM. Concentration of IDF was also negatively correlated ($P < 0.01$) with IVAID ($r = -0.87$) and IVATTD ($r = -0.92$) of DM. The stronger correlation between IDF and TDF with in vitro DM digestibility indicates that these methods of measuring fiber are more appropriate in evaluating digestibility compared with NDF and ADF. Physical characteristics of the feed ingredients were not correlated with in vitro DM digestibility, which indicates that these parameters do not influence

digestibility of feed ingredients in vitro.

**Key Words:** dietary fiber, in vitro digestibility, physicochemical characteristics
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**188 Effects of physicochemical characteristics of feed ingredients on total tract digestibility of dry matter, energy, fiber, and protein by growing pigs.**

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An experiment was conducted to determine the effects of physicochemical characteristics of feed ingredients on the concentration of DE and ME and apparent total tract digestibility (ATTD) of DM and nutrients in corn, wheat, soybean meal (SBM), canola meal, distillers dried grains with solubles (DDGS), corn germ meal, copra expellers, sugar beet pulp, solka floc, and pectin fed to growing pigs. Correlation among the physical characteristics, concentration of DE and ME, and ATTD of energy and nutrients in feed ingredients, and apparent total tract digestibility (IVATTD) of DM from an in vitro experiment using the same ingredients was determined. Results indicated that ATTD of GE was greater ($P < 0.05$) in wheat than in canola meal, DDGS, corn germ meal, copra expellers, sugar beet pulp and solka floc, but not different from corn, SBM, and pectin. The concentration of DE and ME (DM basis) were greater ($P < 0.05$) in wheat than in canola meal, DDGS, corn germ meal, sugar beet pulp, solka floc, and pectin, but not different from corn and copra expellers. Soybean meal had the greatest ($P < 0.05$) concentration of DE and ME (DM basis) among all ingredients. Swelling was positively correlated ($P < 0.05$) with ATTD of NDF ($r = 0.75$), ADF ($r = 0.80$), IDF ($r = 0.89$), and TDF ($r = 0.84$). Viscosity was also positively correlated ($P < 0.01$) with ATTD of NDF ($r = 0.92$), ADF ($r = 0.86$), and IDF ($r = 0.79$). Water binding capacity was also positively correlated ($P < 0.05$) with ATTD of IDF ($r = 0.67$) and TDF ($r = 0.68$). The concentration of TDF, but not the concentrations of ADF and NDF, was negatively correlated ($P < 0.01$) with ATTD of GE ($r = -0.80$) and the concentration of DE ($r = -0.86$) and ME ($r = -0.85$), which indicates that TDF is a better estimate of DE and ME than NDF and ADF. The IVATTD of DM was positively correlated ($P < 0.05$) with ATTD of DM ($r = 0.79$) and the concentration of DE ($r = 0.74$) and ME ($r = 0.72$), indicating that the in vitro procedure may be used to estimate digestibility of DM and energy. However, physical characteristics of feed ingredients were not correlated with the concentration of DE and ME, which indicates that these parameters may influence fiber digestibility but not energy digestibility in feed ingredients in vivo.

**Key Words:** dietary fiber, energy, physicochemical characteristics
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**189 Does chemical composition alter the digestibility of energy of fat sources fed to 10 Kg and 50 Kg pigs?**

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Our objective was to determine if the apparent total tract digestibility (ATTD) of dietary fat sources is altered by chemical composition. A total of 120 Genetiporc 6.0 × Genetiporc F25 (PIC Inc., Hendersonville, TN) individually housed barrows with an initial BW of 9.9 ± 0.6 kg were randomly allotted to 1 of 15 dietary treatments. Each dietary treatment included 95% of a corn-soybean meal basal diet and 5% of either corn starch (CNTR), animal-vegetable blend (AV), canola oil (CANO), choice white grease source A (CWGA), choice white grease source B (CWGB), coconut oil (COCO), corn oil source A (CORA), corn oil source B (CORB), fish oil (FISH), flaxseed oil (FLAX), palm oil (PALM), poultry fat (POUF), soybean oil source A (SOYA), soybean oil source B (SOYB), or tallow (TAL). Pigs were fed these experimental diets from d 0 to 10 and d 46 to 56, and fed a common diet from d 10 to 46. Fecal samples were collected from d 7 to 10 and from d 53 to 56. Titanium dioxide was included as indigestible marker at 0.40%. Data were analyzed using PROC MIXED with dietary treatment as a fixed effect, replicate (2 cohorts of 60 barrows each; $n = 8$ pigs/trt) as a random effect, and pig as the experimental unit. From d 7 to 10, diets containing the unsaturated dietary fat sources CANO (90.7%) or FISH (91.0%) had greater ATTD of acid hydrolyzed ether extract (AEE) than the diets with the saturated fat sources PALM (87.6%) or TAL (87.7%; $P < 0.001$); the ATTD of AEE of other sources (CORA = 88.1%, FLAX = 88.2%, CORB = 88.3%, AV = 89.0%, SOYB = 89.3%, SOYA = 89.4%, COCO = 89.6%, POUF = 89.6%, CWGB = 90.0%, CWGA = 90.2%) was intermediate between the two. The ATTD of AEE was lowest in the CNTR (74.0%; $P < 0.001$). From d 53 to 56, ATTD of AEE was greater in unsaturated based diets than saturated fat based diets, though the high free fatty acid unsaturated source CORA (87.5%) had the least digestible AEE of the fat based diets ($P < 0.001$). All fat based diets had greater ATTD of AEE than CNTR (73.5%; $P < 0.001$). In conclusion, fat sources that are unsaturated and have a low concentration of free fatty acids were more highly digested.

**Key Words:** dietary fat, digestibility, swine
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**190 Comparative starch, fiber, and energy digestibility and characterization of undigested starch using confocal laser scanning of pulse and cereal grains in growing-finishing pigs.** F. P. Tan[1,*], L. F. Wang[2], J. Gao[1], E. Beltranena[2,3], T. Vasanthan[1], R. T. Zijlstra[1], *[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, [2]University of Alberta, Edmonton, AB, Canada, [3]Alberta Agriculture and Forestry, Edmonton, AB, Canada.*

Starch content is included in the equation to predict NE value of feedstuffs (NRC, 2012), but NE value may vary depending on apparent ileal digestibility (AID) vs. apparent total tract digestibility (ATTD) of starch. The botanical origin of starch determines starch structure and, thus, may affect the AID of starch. The objective was to determine digestibility of starch, fiber, and energy, and to characterize undigested starch of grains in growing pigs. Seven ileal-cannulated barrows (initial BW 30 kg) were fed 6 diets containing 96% of 1 of 6 feedstuffs (pulse: faba bean, field pea, chick pea; cereal: barley, wheat, corn) or a N-free diet in a 7 × 7 Latin square at 2.8 × maintenance DE to collect feces and digesta. Apparent hindgut fermentation (AHF) was calculated as ATTD−AID. Starch structure of feedstuffs and digesta was analyzed using confocal laser scanning microscopy (CLSM) and scanning electron microscopy (SCEM). The model included diet as fixed effect, and pig and period as random effects. Cereals contained more starch than pulses (57–68% vs. 41–45%), but pulses contained more total dietary fiber (TDF) than cereals (23–27% vs. 14–21%). The AID of starch was lowest ($P < 0.05$) in faba bean (85.3%) followed by field pea and chick pea (87–90%), and cereals (93–96%). The ATTD of starch was almost complete ( > 99%) among grains; therefore, AHF of starch was greatest ($P < 0.05$) for faba bean and field pea (12–15%). The AID and ATTD of TDF was greatest ($P < 0.05$) in field pea and chick pea and lowest in corn. The AHF of TDF was greatest ($P < 0.05$) for corn (42.0%) and lowest for wheat (23.8%). The AID of energy was greatest ($P < 0.05$) in field pea and wheat; and AHF of energy was greater ($P < 0.05$) in pulses than cereals (17–20% vs. 8–11%). The CLSM revealed that larger pulse starch granules were embedded in protein matrixes; hence, more starch granules remained intact in digesta. In SCEM images, the greater surface area of small corn starch granules may contribute to its 97% AID. Smooth and cracked surfaces of starch granules in digesta among sources indicated different stages of digestion. In conclusion, AID of starch is greater in cereals than pulses; however, ATTD of starch was complete among grains. Hindgut fermentation of starch and TDF of pulses will contribute to their energy value. Defining the digestible fraction of starch and fermentable fractions of starch and fiber may enhance accuracy of equations to predict NE value of feedstuffs.

**Key Words:** digestibility, energy, starch
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**191 Nutrient digestibility of mash, steam pelleted, and extruded barley and faba bean in growing pigs.** U. S. Ruiz[1,2,*], G. C. Luna[1,3], L. F. Wang[1], E. Beltranena[1,4], R. T. Zijlstra[1], *[1]University of Alberta, Edmonton, AB, Canada, [2]University of São Paulo, Piracicaba, SP, Brazil, [3]Universidad Autónoma de Baja California, Mexicali, Mexico, [4]Alberta Agriculture and Forestry, Edmonton, AB, Canada.*

Steam pelleting and extrusion are heat processing technologies that can increase the nutritional value of feedstuffs for pigs. Thus, the nutritional quality of barley and faba bean in mash, steam pelleted, and extruded forms was evaluated in a 2 × 3 factorial arrangement in growing pigs. The apparent ileal digestibility (AID) of GE, starch, CP, and AA, the standardized ileal digestibility (SID) of AA and CP, and the apparent total tract digestibility (ATTD) of GE were measured. The 2 feedstuffs were either fed as mash (2.8-mm hammer mill screen), steam pelleted (California Pellet Mill, Crawfordsville, IN), or extruded (X115, Wenger, Sabetha, KS). Seven crossbred ileal-cannulated barrows (54.3 ± 3.9 kg) were fed diets containing 96.5% of each of the 6 test feedstuffs and a N-free diet, in a 7 × 7 Latin square. Pigs were fed at 2.8 × maintenance DE for seven 9-d periods (sequentially 5 d adaptation and 2 d collections of feces and digesta). Data were analyzed by ANOVA using the mixed procedure. The 3 faba bean and 3 barley samples contained (DM basis) 28.2–29.7% and 12.0–12.3% CP, 8.62–9.90% and 4.66–5.73% ADF, and 4.37–4.39 and 4.44–4.46 Mcal/kg GE, respectively. Feedstuffs and processing interacted ($P < 0.05$) for AID and SID of CP, AA, AID of starch, ATTD of GE, DE value, and predicted NE value. Steam pelleting faba bean increased ($P < 0.05$) the AID of CP, Ile, Leu, Met, Val, and starch by 3–12%, the SID of these AA and Phe by 3–9% and of CP (84.9% vs. 89.2%), and the predicted NE value (4%), and tended to increase ($P = 0.06$) the AID of GE (68.8% vs. 73.0%), compared to mash. Extruding faba bean increased ($P < 0.05$) the AID of Ile, Leu, Met, Phe, Thr, Val, and starch by 3–10%, and the SID of these AA by 3–9%, and tended to increase ($P = 0.06$) the AID of GE (68.8% vs. 72.8%), compared to mash. Steam pelleting barley increased ($P < 0.05$) the ATTD of GE (80.4% vs. 82.9%), DE value, and predicted NE value compared to mash. Extruding barley increased ($P < 0.05$) the ATTD of GE (80.4% vs. 83.1%), DE value, and predicted NE value compared to mash. The greater efficacy of heat processing for faba bean than barley indicates that the protein and starch matrix is more resistant to digestion in ground faba bean than in ground barley.

**Key Words:** cereal grain, feed processing, pulse grain
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**192 Determination of optimal pelleting parameters to maximize pellet durability of reduced-fat DDGS.**

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Reduced-fat distiller's dried grain with solubles (DDGS) is commonly pelleted and fed as a dairy supplement, but pelleting 100% DDGS is not common. The objective of this 3 phase experiment was to determine pellet mill manufacturing parameters to optimize pellet quality of a commercially-available reduced-fat (6.11% crude fat) DDGS source (Dakota Gold, POET Nutrition, Sioux Falls, SD) pelleted on a 3000 series pellet mill (3016-4 California Pellet Mill Co., Crawfordsville, IN). The three phases were 1.) 3 × 2 factorial with three conditioning temperatures (49°C, 66°C, 82°C), and two retention times (30s vs. 60s), 2.) Two die-diameter sizes with varying Length/Diameter (L/D) ratios (5.5 and 10.0). A larger L/D ratio indicates a higher degree of friction on the feed flowing through the die-hole. 3.) 3 × 2 factorial with three production rates (1360 kg/h., 2270 kg/h., 3175 kg/h.), and two die RPM (166 vs. 254). Pellet samples were collected, cooled, and analyzed for Pellet Durability Index (PDI) according to the Holmen NHP100 (TekPro Ltd., Norfolk, United Kingdom). For PDI analysis, 100 g of pellets, sifted on a U.S. sieve screen, are placed in the machine's perforated mesh hopper; pellets are blown by air to create friction for 60 s, while the fines filter through a chamber. The percentage pellets remaining is used to calculate PDI. Data were analyzed using the GLIMMIX procedure of SAS v. 9.4 (Cary, NC). Phase 1 results indicate, the interaction ($P = 0.235$), retention time ($P = 0.601$), or temperature ($P = 0.052$) did not impact PDI. The remaining phases were processed at 66°C with a 30s retention time. Phase 2 having a varying L/D Ratio impacted ($P = 0.011$) PDI (87.10 vs. 93.27 for L/D ratio 5.5 and 10.0, respectively). A die with an L/D ratio of 10.0 was used in Phase 3 due to a 6.17% point improvement compared to a. 5.5 L/D ratio die. Phase 3 results indicate neither the interaction ($P = 0.642$) nor production rate ($P = 0.558$) impacted PDI, the faster die RPM improved ($P = 0.0334$) PDI (95.89 vs. 94.46 for die-RPM 1800 and 1200, respectively). These results suggest that of the parameters tested, reduced-fat DDGS have optimal pellet durability when pelleting on a die size of 10.0 L/D Ratio with a die rotating at 254 RPM. Temperature, retention time, and production rate evaluated in this study did not impact PDI when performing analysis by the Holmen NHP100.

**Key Words:** DDGS, pellet, Pellet Durability Index
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**193 Impact of PRRSV on digestibility and endogenous losses in pigs fed high or low soybean meal diets.**

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Porcine reproductive and respiratory syndrome virus (PRRSV) is a significant pathogen that antagonizes pig performance. Increasing dietary soybean meal during disease challenges may improve performance. Our objectives were to determine the impact of soybean meal level on apparent total tract (ATTD) and apparent ileal digestibility (AID) during PRRSV infection and to determine ileal and total tract basal endogenous losses during PRRSV infection. Forty PRRSV naïve pigs (~40 kg BW) were surgically fitted with a T-cannula in the distal ileum. Treatments were arranged as a 2 x 2 factorial (HSBM, 29% vs. LSBM, 10%) with and without PRRSV ($n = 6$/treatment group). The remaining 16 pigs ($n = 8$/PRRSV status) were fed a nitrogen-free diet. Chromic oxide was used as an indigestible marker. On days post-inoculation (dpi) 0, 20 pigs were inoculated with live PRRSV (strain 1–3-4); control pigs were sham inoculated. Infection was confirmed by serum PCR and seroconversion in all inoculated pigs. Feces were collected at dpi 5–6 and 16–17 and ileal digesta were collected at dpi 7–8 and 18–19. Feed, feces, and digesta were analyzed for DM, OM, N, and energy. Digesta and feed were also analyzed for amino acids. Data were analyzed in a 2 x 2 design to determine diet and PRRSV main effects and interactions. Control pigs remained PRRSV negative throughout the study. There was no main effect of PRRSV or diet by PRRSV interaction for AID values at either time point. There was no diet by PRRSV interaction for ileal amino acid digestibility. The HSBM diet decreased DM AID at dpi 7–8 (72.52 vs. 77.87%, $P < 0.01$) and tended to decrease DM AID at 18–19 dpi (70.16 vs. 77.56%, $P = 0.09$). There was an interaction for energy ATTD at dpi 16–17 ($P = 0.04$), where PRRSV decreased energy ATTD in HSBM (86.42 vs. 83.82%), while energy ATTD remained unchanged in LSBM (84.95 vs. 84.97%) due to PRRSV. Similar results were observed for N ATTD; however, this was only a tendency ($P = 0.06$). There was an effect of PRRSV to reduce DM ATTD ($P = 0.04$) at dpi 16–17 regardless of diet. Interestingly, total tract endogenous loss of crude protein (Nx6.25) was increased due to PRRSV at dpi 5–6 (10.91 vs. 4.90 g CP/kg DMI) and 16–17 (17.58 vs. 10.78 g CP/kg DMI) in pigs fed a nitrogen-free diet. In summary, energy and DM ATTD were influenced differently by diet during PRRSV challenge, while AID remained unaffected. Endogenous loss of total tract N was increased due to PRRSV.

**Key Words:** digestibility, PRRSV, soybean meal
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**194 Chemical composition and amino acid digestibility of soybean meal produced in the United States, China, Argentina, Brazil, or India.** L. V. Lagos*, H. H. Stein, *University of Illinois at Urbana-Champaign, Urbana.*

An experiment was conducted to compare chemical composition and standardized ileal digestibility (SID) of AA in soybean meal (SBM) from 5 countries when fed to growing pigs. Five sources of SBM from China, Argentina, Brazil, and the U.S., and 4 sources from India were included in diets where SBM was the sole source of AA. An N-free diet was also used. Twenty-five barrows (initial BW: 30.53 ± 1.73 kg) were fitted with a T-cannula in the distal ileum and allotted to a 25 × 8 Youden square design with 25 diets and 8 periods. Data were analyzed using Proc Mixed in SAS. The model to compare chemical composition of SBM included country as fixed effect and source within country as random effect and the model to analyze SID of AA included country as the fixed effect, and pig and period as random effects. Results indicate that the concentration of CP was greater ($P < 0.05$) in SBM from Brazil and India (49.3 and 49.5%) than in SBM from China, Argentina, or the U.S. (45.1, 46.7, and 47.3%), but SBM from the U.S. contained more ($P < 0.05$) indispensable AA than SBM from China or Argentina. Indian SBM contained more ($P < 0.05$) trypsin inhibitor units than SBM from other countries. A greater ($P < 0.05$) SID of most AA was observed in SBM from the U.S. compared with SBM from Brazil, Argentina, and India (Table 194). There was less ($P < 0.05$) variability in SID values for AA among sources of SBM from the U.S. or Brazil than among sources from Argentina, China, or India. In conclusion, the SID of AA in SBM is dependent on the country where the SBM is produced.

**Key Words:** amino acid digestibility, pigs, soybean meal

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**195 Estimation of the productive energy content of corn germ meal based on a growth assay in wean-to-finish pigs.** J. E. Estrada[1,*], M. Ellis[1], O. F. Mendoza[2], A. M. Gaines[2], *[1]University of Illinois at Urbana-Champaign, Urbana, [2]The Maschhoffs, LLC, Carlyle, IL.*

Two wean-to-finish growth studies were performed to determine the productive energy (PE) of CGM by correcting ME estimates for caloric efficiency relative to a control (reference diet). Both studies used a RCBD and evaluated CGM inclusion level (0, 12.5, and 25% in Study 1; 0, 10, 20, 30, and 40% in Study 2). The CGM was from a single source; the chemical composition averaged across both studies was: DM, 88.4%; CP, 23.8%; Crude Fat, 2.4%; NDF, 37.1%; ADF, 11.6%; Ash, 2.7. A total of 1020 (10 replicates) and 2380 (14 replicates) barrows and gilts were used in Studies 1 and 2, respectively, housed in groups of 34 (Study 1 single-sex; Study 2 mixed-sex). Start and end BW were from 6.6 ± 0.54 and 6.4 ± 0.56 to 127.1 ± 1.71 and 133.3 ± 1.62 kg, for Studies 1 and 2, respectively. An 8-phase dietary program was used with diets formulated to be isocaloric (by using supplemental fat), to a constant standard ileal digestible lysine to energy ratio within phase, and meet or exceed nutrient requirements proposed by NRC (2012). The corn-soybean meal-based control diet (0% CGM) was used as the reference diet to compare with the CGM diets to estimate PE. Caloric efficiency (calories consumed per unit of weight gain) was calculated for each treatment using the feed:gain ratio. For Study 1, the CGM ME value used to formulate diets, based on published values and previous unpublished research, was 3037 kcal/kg. The pen of pigs was the experimental unit; data were analyzed using PROC MIXED of SAS; the model accounted for the effects of CGM level and block. Increasing CGM level increased feed-gain linearly ($P < 0.05$; 2.34, 2.38, and 2.42 kg/kg for 0, 12.5, and 25.0% CGM diets, respectively; SEM 0.023) which gave an estimate of productive ME for CGM of 2604 kcal/kg. For Study 2, CGM diets were formulated using this ME value (adjusted for the chemical composition of the batch of CGM used). Increasing CGM inclusion level increased feed:gain linearly ($P < 0.05$; 2.46, 2.49, 2.49, 2.51, and 2.55 kg/kg for 0, 10, 20, 30, and 40% CGM diets, respectively; SEM 0.018) and this resulted in an estimate productive ME of CGM of 2462 kcal/kg. These results suggest considerable variation in CGM PE estimated from growth studies. Further research is needed to define appropriate methodology to determine PE and validate the energy content of CGM.

**Key Words:** corn germ meal, pig, productive energy

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**Table 194.** Standardized ileal digestibility of AA in soybean meal from different countries

| Item | China | Argentina | Brazil | U.S. | India | SEM | *P*-value |
|---|---|---|---|---|---|---|---|
| Arg | 96.8$^{ab}$ | 95.6$^{c}$ | 95.6$^{c}$ | 96.9$^{a}$ | 95.9$^{bc}$ | 0.49 | 0.003 |
| His | 93.5$^{a}$ | 92.1$^{b}$ | 92.1$^{b}$ | 93.8$^{a}$ | 92.3$^{b}$ | 0.61 | 0.002 |
| Ile | 92.6$^{ab}$ | 91.6$^{b}$ | 91.7$^{b}$ | 93.4$^{a}$ | 91.5$^{b}$ | 0.59 | 0.004 |
| Leu | 92.3$^{ab}$ | 91.0$^{c}$ | 91.2$^{bc}$ | 92.9$^{a}$ | 90.9$^{c}$ | 0.61 | 0.001 |
| Lys | 92.1$^{ab}$ | 90.0$^{c}$ | 90.6$^{bc}$ | 92.9$^{a}$ | 90.8$^{bc}$ | 0.79 | 0.002 |
| Met | 94.4$^{ab}$ | 93.5$^{bc}$ | 93.6$^{abc}$ | 94.7$^{a}$ | 92.7$^{c}$ | 0.54 | 0.007 |
| Phe | 92.5$^{ab}$ | 90.9$^{c}$ | 91.6$^{bc}$ | 93.0$^{a}$ | 91.4$^{bc}$ | 0.59 | 0.001 |
| Thr | 90.2$^{a}$ | 88.5$^{b}$ | 88.4$^{b}$ | 90.8$^{a}$ | 88.2$^{b}$ | 0.82 | 0.004 |
| Trp | 93.7$^{ab}$ | 93.0$^{b}$ | 92.6$^{bc}$ | 94.3$^{a}$ | 91.7$^{c}$ | 0.56 | < 0.001 |
| Val | 90.6$^{ab}$ | 89.3$^{bc}$ | 89.0$^{c}$ | 91.4$^{a}$ | 88.9$^{c}$ | 0.74 | 0.002 |

[a-c]Means within a row lacking a common superscript letter are different ($P < 0.05$).

**196 Assessing the effects of medium chain fatty acids and fat sources on PEDV RNA stability and infectivity.** R. A. Cochrane[1,*], S. S. Dritz[1], J. C. Woodworth[1], A. R. Huss[1], C. R. Stark[1], M. Saensukjaroenphon[1], J. M. DeRouchey[1], M. D. Tokach[1], R. D. Goodband[1], J. F. Bai[1], Q. Chen[2], J. Zhang[2], P. C. Gauger[2], R. J. Derscheid[2], R. G. Main[2], C. K. Jones[1], *[1]Kansas State University, Manhattan, [2]Iowa State University, Ames.*

Research has confirmed that chemical treatments, such as combinations of medium chain fatty acids (MCFA) and commercial formaldehyde, can be effective to reduce the risk of porcine epidemic diarrhea virus (PEDV) cross-contamination in feed. However, the efficacy of individual MCFA levels is unknown. The objective of this study was to compare the efficacy of commercially-available sources of MCFA and other fat sources versus a synthetic custom blend of MCFA to minimize the risk of PEDV cross-contamination as measured by qRT-PCR and bioassay. Treatments were arranged in a 17 × 4 plus 1 factorial with 17 treatments: 1) Positive control with PEDV and no chemical treatment, 2) 0.3% commercial formaldehyde (Sal CURB, Kemin Industries, Des Moines, IA), 3) 1% MCFA blend [caproic, caprylic, and capric acids; 1:1:1] (aerosolized), 4) 1% MCFA blend [caproic, caprylic, and capric acids; 1:1:1] (non-aerosolized), 5) 0.66% caproic acid, 6) 0.66% caprylic acid, 7) 0.66% capric acid, 8) 0.66% lauric acid, 9) 1% capric and lauric acid (1:1 ratio), 10) 0.3% FRA C12 (Framelco, Raamsdonksveer, Netherlands), 11-15) 1% choice white grease, soy oil, canola oil, palm kernel oil, and coconut oil, and 16-17) 2% palm kernel oil and coconut oil-; 4 analysis days: 0, 1, 3, and 7 post-inoculation; and 1 treatment of PEDV negative, untreated feed. Feed was first treated, then inoculated with PEDV, and stored at room temperature until analyzed by qRT-PCR and swine bioassay. The bioassay was performed by administering Day 1 aliquots of treatments by oral gavage to 10 d old pigs, and collecting fecal swabs every 2 d. The values represent threshold cycle (CT), where a higher CT represents less detectable RNA. All main effects and interactions were significant ($P < 0.002$). The interaction of treatment × day indicated that over time the MCFA treatments, either as a mixture (aerosolized 39.0 CT, and non-aerosolized 40.0 CT), or as individual fatty acids (caproic 37.0 CT, caprylic 37.3 CT, and capric 35.3 CT), and Sal CURB (37.3 CT), had less detectable PEDV RNA compared to the control (32.7 CT). These treatments also resulted in negative bioassays. Day also had a significant impact as CT increased from 29.5 to 34.6 from Day 0 to 7, respectively. In summary, time, Sal CURB, 1% MCFA, 0.66% caproic, 0.66% caprylic, and 0.66% capric acids all enhance the RNA degradation of PEDV in swine feed.

**Key Words:** medium chain fatty acids, PEDV, swine
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**197 Estimation of energy and nutrient composition of food waste from different sources as potential use in swine diets.** L. Fung[1,*], G. C. Shurson[1], P. E. Urriola[1], L. Baker[2], *[1]Department of Animal Science, University of Minnesota, St. Paul, [2]Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul.*

In the United States, approximately 40% of the food produced is wasted annually, representing about 60 million t, and valued at $165 billion dollars. The objective of this study was to investigate nutrient and energy variability in food waste sources collected in the Minneapolis-St. Paul, MN metropolitan area, and their potential for use in swine diets. A total of 3 food waste sources were selected and included a supermarket (SM; retail to consumer), university residential dining hall (RH; consumer to post-consumer), and a waste recycling and transfer station (TS; post-consumer to municipal waste disposal). Samples were collected directly from each site during 12 visits throughout 2015. After collection, samples were oven dried for 72 h at 60°C and ground. Samples were analyzed for inputs to NRC (2012) DE, ME, and NE equations (GE, DM, CP, ether extract, starch, ADF, NDF, and ash). Samples were also analyzed for fatty acid profile and thiobarbituric reactive substances (TBARS). Reference values were obtained from NRC (2012). Data were analyzed using 1-way ANOVA with waste sources as fixed effect. Samples of SM contained the highest ($P < 0.05$) amount of calculated DE (5016 kcal/kg), ME (4832 kcal/kg), and NE (3740 kcal/kg) among the three sources. Samples from SM and RH, but not TS, had greater DE, ME, and NE than corn and soybean meal. Samples of SM contained the most Lys (1.82%) and Met (0.53%) among the sources ($P < 0.05$), but less than soybean meal (Lys 2.79%, Met 0.60%). Samples of TS contained the highest amount of linoleic acid (7.05% DM) among the three sources ($P < 0.05$) and all three sources were greater than corn and soybean meal. Likewise, samples of SM contained greater ($P < 0.05$) iodine value product (211) compared with RH (95) and TS (71). All samples contained low TBARS (SM: 0.17; RH: 0.16; and TS: 0.18 mg MDA eq/g oil). Although the concentrations of nutrients and calculated energy values of SM, RH, and TS were comparatively high compared with corn and soybean meal, their composition was highly variable (SD > 300 kcal/kg for GE, DE, ME and NE; SD > 3% for CP, ether extract, NDF and ADF). Pre-consumer food waste (SM) appears to have greater nutritional value than post-consumer food waste (RH and TS), but all sources are suitable for use in commercial swine diets provided that iodine value product and TBARS are properly managed.

**Key Words:** food waste, nutrient variability, swine
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**198 Growth and performance of finishing pigs fed oat screenings.** P. J. Lammers[1,*], M. S. Honeyman[2], [1]*University of Wisconsin-Platteville, Platteville,* [2]*Iowa State University, Ames.*

Forty-five crossbred barrows (initial BW 73.1 ± 2.3 kg) were used to evaluate effects of feeding diets containing 20% oat screenings or 20% wheat middlings. Oat screenings are a high-fiber by-product of cleaning oats. Pigs were allotted to 15 partially-slatted pens (3.34 $m^2$) and dietary treatments were randomly assigned to pens. Pigs were fed three dietary treatments in two phases for 8 wk total. Dietary treatments were corn-soybean meal control, corn-soybean meal diet containing 20% wheat middlings, and corn-soybean meal diet containing 20% oat screenings. The control and 20% wheat middlings diets were formulated to be isocaloric and oat screenings replaced wheat middlings in the 20% oat screening diet. Pigs were weighed every 14 d and feed disappearance was recorded. At trial end, all pigs were scanned using digital ultrasound to measure back fat and loin muscle area. Data were analyzed as a completely randomized design with 5 replicates per treatment. Pens were considered the experimental units. Significance was declared at $P \leq 0.05$. When differences were observed, means were compared using the Tukey-Kramer method (SAS Inst. Inc., Cary, NC). Growth and performance of pigs fed 20% wheat middlings was not different from pigs fed control diets ($P > 0.10$). Pigs fed diets containing 20% oat screenings had decreased ADG as compared to pigs fed the control or 20% wheat middlings diets (0.94 vs. 1.13 vs. 1.04 g/d; SEM 0.02; $P < 0.01$). Pigs fed the control or 20% wheat middlings diets had increased G:F as compared to pigs fed diets containing 20% oat screenings diets grew less efficiently (0.32 vs. 0.30 vs. 0.27 g/g; SEM = 0.01; $P < 0.01$). Average daily feed intake and back fat thickness was not different across treatments ($P > 0.10$) but loin muscle area of pigs fed 20% oat screenings diets were smaller than pigs fed the control or 20% wheat middlings diets (20.57 vs. 23.07 vs. 22.70 $cm^2$; SEM = 0.42; $P < 0.01$). Estimated fat free lean, lean gain, and lean gain efficiency were not different across dietary treatments ($P > 0.10$). Based on diet composition and calculated analysis, the 20% oat screenings diets contained 4–5% less ME and 11–12% less SID Lysine compared to control or 20% wheat middlings diets. Because oat screenings contain 25% ADF compared to 6% ADF in wheat middlings the difference in NE of the two diets may be greater than estimated.

**Key Words:** by-products, oat screening, pigs
doi: 10.2527/asasmw.2017.12.198

**199 Effect of tail-end dehulling of canola meal on apparent and standardized total tract digestibility of phosphorus when fed to growing pigs.** G. A. Mejicanos*, J. W. Kim, C. M. Nyachoti, *University of Manitoba, Winnipeg, MB, Canada.*

Tail-end dehulling of canola meal (CM) has been identified as a means to reduce dietary fiber and increase crude protein content in the dehulled meal. This procedure also increases the total and non-phytate phosphorus (P) content in the dehulled meal. However, it is unclear if dehulling affects P digestibility in the different fractions (i.e., the dehulled meal and the coarse fraction) and if it differs when fed to growing pigs at 2 different body weights (BW). Therefore, 2 experiments were conducted to determine the effect of tail-end dehulling of CM on apparent (ATTD) and standardized (STTD) total tract digestibility of P in growing pigs. Diets containing non-dehulled (RCM), dehulled (DCM), and coarse (CCM) solvent extracted CM from *Brassica napus* black as the only source of P were fed to growing pigs at 2 different BW. A total of 48 pigs were used for the two experiments. In Exp. 1, 24 barrows [(Yorkshire-Landrace) x Duroc] of 24.5 + 1.68 kg BW were individually housed in metabolism crates and fed the experimental diets for 10 d for total fecal collection. In Exp. 2, 24 barrows with an average initial BW of 73.8 + 4.93 kg were used; experimental diets and fecal collection procedures were the same as Exp. 1. Each experiment used 6 replicate pens per treatment. A P free diet was used to determine basal endogenous losses of P. Data were analyzed as a completely randomized design using the MIXED procedure of SAS. In Exp. 1, the ATTD and STTD of P were greater ($P < 0.05$) for DCM (42.4 and 46.1%) than for the RCM (32.0 and 35.7%) and CCM (24.5 and 28.4%) diets. In Exp. 2, the same trend continued, the ATTD and STTD of P were greater ($P < 0.05$) for DCM (38.7 and 42.8%) than for the CCM diet (22.6 and 26.8%), whereas the values for RCM diet were intermediate (31.0 and 35.0%) and not statistically different from the DCM and CCM. In conclusion, dehulling canola meal increased apparent and standardized total tract digestibility of P in growing pigs of different BW.

**Key Words:** canola meal, dehulling, phosphorus digestibility
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**200 A novel simultaneous determination of native and isotopically-labeled plasma amino acids in pigs by gas chromatography mass spectrometry.** W. S. McGilvray, D. M. Klein, A. Rakhshandeh*, *Texas Tech University, Lubbock.*

The ultimate goal of the study was to develop a method that allows simultaneous quantification of both native and isotopically-labeled AA in plasma and other physiological fluids in pigs. The stable isotope infusion technique is commonly used in humans and animals to study various aspects of protein and

AA metabolism in vivo (e.g., plasma AA kinetics). Simultaneous quantification of these bio-compounds in physiological fluids is difficult, because native and labeled AA elute at the same time during gas chromatography; and quantification is usually achieved using separate chromatographic runs. The latter can potentially increase the intra-assay variation, and the time required for analysis. Quantification of derivatized (Phenomenex EZ:faast free AA analysis Kit) native and labeled AA in standard and plasma samples was achieved using GC–MS (Agilent 6890 GC coupled with an Agilent 5973 mass selective detector). The method was developed employing selective ion monitoring (SIM) to identify and quantify multiple native and labeled AA simultaneously. The validation of the method was related to linearity, sensitivity, accuracy, and repeatability. In the validated method linearity was achieved within concentration range 0.93 to 58.62 ng/μL for the labeled AA ($R^2 = 0.93$), and 3.52 to 12.36 ng/μL for native AA ($R^2 = 0.92$). The limits of detection for Lys, Met, Thr, Trp, Ile, Leu, Val, Phe, and Gln were, 0.03, 0.03, 0.02, 0.02, 0.03, 0.01, 0.02, 0.03, and 1.46 ng/μL, respectively. Coefficient of variation for the inter-day and the intra-day analysis, which is a precision and accuracy parameter, did not exceed 15%. The practical application of this method was supported by determining the isotopic enrichments of nine AA in plasma of pigs following a bolus infusion of [U-$^{13}$C, U-$^{15}$N] AA mixture. The isotopic enrichment mean was 0, 0.29 ± 0.060, 0.17 ± 0.035, 0.12 ± 0.025, 0.09 ± 0.020, 0.07 ± 0.015, 0.05 ± 0.012, 0.03 ± 0.009, and 0.02 ± 0.007 at 0, 2.5, 5, 7.5, 10, 15, 20, 30, and 45 min post-infusion, respectively. The method utilizes differences in mass between labeled and unlabeled AA. This method provides a fast and easy to use alternative for an accurate measurement of native and isotopically-labeled AA in plasma and other physiological fluids in pigs. Supported by NPB # 13–082.

**Key Words:** amino acids, plasma, stable isotope
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**201 Effect of different milk by-product types and levels on growth performance, blood profiles, immune response, and diarrhea incidence in weaning pigs.**

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This experiment was conducted to evaluate the different milk by-product types and supplementation levels in weaning pig diet on growth performance, blood profiles, immune response, incidence of diarrhea, and economic analysis on weaning pigs. A total of 200 weaning pigs ([Yorkshire × Landrace] × Duroc), average 6.93 ± 1.173kg body weight (BW), were allotted to one of four treatments in a 2 × 2 factorial arrangement in 5 replicates with 10 pigs per pen by BW and sex in a randomized complete block design. Pigs were fed experimental diet with different content and ratio of milk by-product (factor 1: milk by-product content 18-9%, 12-6%; factor 2: whey powder and lactose ratio 2:1, 1:2) for 6 wk (phaseI: 0-3 wk, phaseII: 4-6 wk). There was significant difference in ADG at phase 2 where the ratio of whey powder was high ($P < 0.01$, $P < 0.03$). However, there was no significant difference in BW, ADFI, and G:F ratio in the whole experimental period. In blood profiles, no difference in serum BUN and IGF-1 was observed among treatments. Serum IgG and IgA had no significant difference among treatments. Also, the incidence of diarrhea had no significant difference by dietary treatments. As a result of economic analysis, there was no significant difference among treatments. Considering feed cost per weight gain in piglet period, treatments which contained high ratio of lactose were lower than treatments where high ratio of whey powder was included. Consequently, different content and ratio of milk by-products brought no significant difference on growth performance, blood profiles, immune response, incidence of diarrhea, and economic analysis

**Key Words:** growth performance, milk by-product, weaning pig
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**202 Various levels of milk by-products in weaning pig diet on growth performance, blood profiles, intestinal morphology, muscle fiber diameter, and diarrhea incidence in weaning pigs.**

T. W. Goh*, B. O. Kim, S. H. Do, H. S. Kim, D. H. Yoo, Y. Y. Kim, *Seoul National University, Seoul, South Korea.*

This experiment was conducted to evaluate various levels of milk by-products in weaning pig diet on growth performance, blood profiles, intestinal morphology, muscle fiber diameter, and diarrhea incidence on weaning pigs. A total of 160 weaning pigs ([Yorkshire × Landrace] × Duroc), average 5.97 ± 1.53 kg body weight (BW), were allotted to one of four treatments with five replicates with eight pigs per pen by BW and sex in a randomized complete block (RCB) design. Pigs were fed each treatment diet with various levels of milk by-product (phase1: 30, 20, 10 or 5%; phase2: 15, 10, 5 or 0%) for 5 wk (phase1: 0-2 wk and phase2: 3-5 wk, respectively). Growth performance was decreased linearly as milk by-product level decreased during phase 2 and whole experimental period (0-5 wk) (linear response, $P < 0.05$). Average daily gain, ADFI, and G:F ratio were also decreased linearly as milk by-product level decreased during phase 2 and whole experimental period (0-5 wk) (linear response, $P < 0.05$). However, pigs fed milk by-product 10%-5% diet had similar growth performance rather than pigs fed milk by-product 30%-15%. In blood profiles, supplementation of milk by-products by different levels was not affect in BUN, creatinine, IgA, and IgG among treatments during whole experimental period (0-5 wk). However, IGF-1 concentration was significantly lower than other treatments when pigs were fed a diet containing 10%-5% of milk

by-product (quadratic response, $P < 0.05$). The villus height and crypt depth of small intestine (proximal, mid, and distal) had no significant difference among dietary treatments. In addition, muscle fiber diameter was not affected by dietary milk by-product levels. The incidence of diarrhea had no significant difference by dietary treatments. These results demonstrated that inclusion of milk by-product 10%-5% had no negative influence on growth performance and other measurements compared with inclusion of milk by-product 30%-15%.

**Key Words:** growing performance, milk by-product, weaning pig
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**203 Effect of different supplementation levels of palm kernel meal with β-mannanase on growth performance, blood profiles, pork quality, and economic analysis in growing-finishing pigs.**

J. H. Lee*, H. B. Yoo, S. H. Do, J. S. Hong, Y. Y. Kim, *Seoul National University, Seoul, South Korea.*

This experiment was conducted to evaluate different levels of palm kernel meal supplementation with β-mannanase on growth performance, blood profiles, pork quality, and economic analysis in growing-finishing pigs. A total of 120 growing pigs ([Yorkshire × Landrace] × Duroc), average 30.50 ± 3.039 kg body weight (BW), were used in feeding trial. Pigs were allotted to one of five treatments in 4 replicates with 6 pigs per pen by body weight and sex in a randomized complete block design. Pigs were fed experimental diet with different levels of palm kernel meal (0, 4, 8, 12, or 16%) for 12 wk (growingI: 0–3 wk, growingII: 4–6 wk, finishingI: 7–9 wk, finishingII: 10–12 wk). In feeding trial, there was no significant difference in BW and ADG among the treatments. However, ADFI was increased (linear, $P < 0.05$) when pigs were fed diet with high level of PKM supplementation during the whole experimental period (0–12 wk). In serum BUN concentration, no difference was observed among treatments. The pork pH after slaughter and proximate analysis of longissimus muscle were not affected by dietary PKM level. In meat color, a* and b* values, there was no significant difference among dietary treatments but in L* value, there was significant difference at 3, 12 h after slaughter. As dietary PKM supplementation level increased, L* value was increased at 3, 12h after slaughter (linear, $P < 0.05$). In addition, significant difference was not observed on shear force and water holding capacity by dietary PKM level. Cooking loss was increased linearly when dietary PKM level increased (linear, $P < 0.05$). Interestingly, TBARS value tended to decrease when pigs were fed diet with high level of PKM supplementation (linear, $P < 0.05$). When pigs were fed diets containing PKM with β-mannanase, days to market weight reached earlier compared to PKM 0% treatment and the cost of total feed was also decreased as dietary PKM level increased. PKM supplementation improved the economical profit by days to market weight and total feed cost with no detrimental effect on growth performance, so that PKM can be supplemented up to 16% in growing-finishing pig diet.

**Key Words:** growing-finishing pig, β-mannanase, palm kernal meal
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**204 Effect of rapeseed meal supplementation on nutrient digestibility in gestating sows.**

J. H. Lee*, W. L. Chung, S. O. Nam, Y. Y. Kim, *Seoul National University, Seoul, South Korea.*

This experiment was conducted to evaluate the effect of rapeseed meal (RSM) supplementation on nutrient digestibility in gestating sows. A total of 16 multiparous sows (Yorkshire × Landrace) with an initial body weight of 236.9 ± 1.24kg were used in a digestibility trial. Sows were allotted to one of four treatments with four replicates with one sow per metabolic crate in a completely randomized design by their body weight, backfat thickness, and their parity. Gestating sows were moved into individual farrowing crates (2.5m × 1.8m) for the digestibility trial and housed until the end of the digestibility trial. After 5 d of adaptation period (50–55d gestation), sows were fed the experimental diet to each treatment during 4 d (56–59d gestation) and collecting the feces samples during 8 d (57–64d gestation). Four different levels of RSM (0, 3, 6, or 9%) were supplemented in experimental diet. Experimental diets contained 3265 kcal ME/kg, 16.80% CP, 1.09% Lys, as-fed basis. All other nutrients in experimental diet were met or exceeded the NRC (1998) requirement. Each treatment diet was provided 2400g/d once daily to sows. During the whole experimental period, supplementation of RSM had no influence to BW and BF thickness of gestating sows among treatments, and their changes during the digestibility trial. In nutrient digestibility, dietary RSM levels showed no effect on digestibility of dry matter, crude protein, crude fat, and crude ash ($P = 0.60$, $P = 0.65$, $P = 0.25$, and $P = 0.52$, respectively). In blood profiles, there was no significant difference in glucose and blood urea nitrogen (BUN) concentrations among treatments. Consequently, RSM supplementation up to 9% did not affect nutrient digestibility in gestating sows.

**Key Words:** gestating sow, nutrient digestibility, rapeseed meal
doi: 10.2527/asasmw.2017.12.204

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**205 Effect of *Lactobacillus acidophilus* fermentation product on nursery pig performance and economic return.**

B. E. Bass*, J. W. Frank, *Diamond V, Cedar Rapids, IA.*

A study was conducted in a commercial research facility by a Midwest feed company to determine the effects of *Lactobacillus acidophilus* fermentation product (LFP; SynGenX®, Diamond V, Cedar Rapids, IA) on performance and economic return in weaned pigs. At weaning (20 d of age; 5.7 kg), 364

pigs were ranked based on BW and randomly allotted in a randomized complete block design to 1 of 4 dietary treatments fed in 3 phases (Table 205). Phase 1 diets contained 38 g/MT tiamulin, Phase 2 diets contained 440 g/MT chlortetracycline, and Phase 3 diets contained 55 g/MT mecadox. Phase 1 diets were typical nursery diets consisting of corn and soybean meal base, and included whey, fish meal, and plasma. Phase 2 and 3 diets were primarily corn and soybean meal. Feed and water were provided ad libitum throughout the study. Analysis of variance and orthogonal contrasts to determine linear, quadratic, or cubic responses to LFP inclusion were performed using Statistix. Pigs and feeders were weighed on d 0, 10, 20, and 34 to determine BW, ADG, ADFI, and G:F. During Phase 1 there was a significant quadratic response in ADG (76.6, 98.0, 98.0, and 87.1 g/d for Control, LFPLow, LFPMid, and LFPHigh, respectively; $P < 0.05$) and net return over feed cost ($P < 0.05$) with greater ADG and economic return observed in LFPLow and LFPMid compared to Control and LFPHigh. During Phase 3 there was a linear improvement in ADG (473.1, 481.7, 494.0, and 508.9 g/d for Control, LFPLow, LFPMid, and LFPHigh, respectively) and ADFI ($P < 0.05$) as the level of LFP inclusion increased. Additionally, there was a linear increase in ADFI ($P < 0.05$) and a tendency for a linear increase in ADG (303.9, 320.2, 323.4, and 326.1 g/d for Control, LFPLow, LFPMid, and LFPHigh, respectively; $P < 0.08$) in the overall 34 d study period as the level of LFP increased. On d 34 there was a numerical improvement in net return over feed cost ($8.15, 8.55, 8.68, and 8.60 for Control, LFPLow, LFPMid, and LFPHigh, respectively; $P = 0.24$). In conclusion, providing LFP improved ADG, ADFI, and net return compared to control-fed pigs.

**Key Words:** growth performance, *Lactobacillus acidophilus* fermentation product, weaned pig
doi: 10.2527/asasmw.2017.12.205

**Table 205.** Dietary treatments

| | *Lactobacillus acidophilus* fermentation product inclusion/MT | | |
|---|---|---|---|
| | P1 (d 0-10) | P2 (d 10-20) | P3 (d 20-34) |
| Control | 0 | 0 | 0 |
| LFPLow | 0.5 kg | 0.5 kg | 0.25 kg |
| LFPMid | 1.0 kg | 1.0 kg | 0.5 kg |
| LFPHigh | 1.5 kg | 1.5 kg | 0.75 kg |

## 206 Impact of ractopamine hydrochloride (Paylean®) on performance of heavy finishing pigs using a 3-cut marketing strategy.

J. W. Rickard[1,*], G. L. Allee[2], P. J. Rincker[3], J. P. Gooding[3], R. Acheson[4], D. R. McKenna[4], S. N. Carr[3], *[1]Illinois State University, Normal, [2]Pork Tech, LLC, Columbia, MO, [3]Elanco Animal Health, Greenfield, IN, [4]Tyson Foods, Dakota Dunes, SD.*

The objective of this study was to evaluate growth and carcass performance of heavy finishing pigs fed ractopamine hydrochloride (RAC) (7.4mg/kg) in a 3-cut marketing strategy. Two thousand one hundred and fifty-eight pigs were utilized in 88 pens of approximately 25 pigs per pen in a commercial finishing barn. Sixteen percent of the total pig population were marketed during the first marketing period, 40% were marketed in the second marketing period, and the remaining 44% were marketed during the third marketing period. Data were analyzed as a randomized complete block design (blocking factor was d of start on test) with 2 treatments and 44 replications per treatment. There were no differences ($P = 0.98$) in start weight between pigs fed RAC (121.00 kg) and pigs fed the control diet (120.99 kg). Overall, RAC carcasses (111.68 kg) were 3.92 kg heavier ($P < 0.0001$) than the control (107.76 kg), carcass dressing percent was improved ($P < 0.0001$) 0.67 (% points), loin depth was 4.95% greater ($P < 0.0001$), estimated lean was 0.99% points greater ($P < 0.0001$) (57.18 vs. 56.19) and fat depth was 6.3% lower ($P < 0.0001$) compared to the controls. Overall, RAC pigs had 0.16 kg/d increased ($P < 0.0001$) ADG (1.01 vs. 0.85 kg/d), and improved ($P < 0.0001$) G:F (0.344 vs. 0.278) while ADFI (2.96 vs. 3.06 kg/d) was lower ($P < 0.0001$) compared to control pigs. After the first 7 d of feeding, RAC pigs had increased ($P < 0.0001$) ADG (1.03 vs. 0.72 kg/d) and improved ($P < 0.0001$) G:F (0.359 vs. 0.261) compared to control pigs. Loin depth increased ($P < 0.01$) and HCW from RAC carcasses tended ($P = 0.08$) to be heavier than control carcasses (106.02 kg vs. 104.41 kg). At the end of the second marketing period (21d), RAC carcasses were 4.46 kg (112.17 vs. 107.71) heavier ($P < 0.0001$), leaner ($P < 0.0001$), and yielded more ($P < 0.0001$) than the control carcasses. RAC increased ($P < 0.0001$) ADG, improved ($P < 0.0001$) G:F, and reduced ($P < 0.0002$) ADFI compared to the controls. At the end of the third marketing period (35d), RAC carcasses were 4.15 kg (113.05 vs. 108.9) heavier ($P < 0.0001$), leaner ($P < 0.0001$), and had greater ($P < 0.0001$) dressing percent compared to the controls. RAC inclusion improved G:F ($P < 0.0008$) and reduced ($P < 0.0001$) ADFI compared to the controls. These results suggest that while improvements in growth performance from feeding RAC will generally decline after 21 d of feeding, carcass traits, particularly carcass yield and lean content, will continue to improve until d 35.

**Key Words:** 3-cut marketing, heavy finishing pig, Paylean
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## 207 A mixture of organic acids and botanicals improves the intestinal barrier functionality in vitro.

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Organic acids and botanicals are widely used in animal nutrition as antibiotic replacers or adjuvant and recent studies have highlighted their possible role as "intestinal health enhancers" via

improvement of gut barrier function. The aim of this study was to assess the impact of a mixture of organic acids and botanicals on the intestinal barrier function using a cell culture model. Caco-2 cells were seeded on transwell inserts, cultured in a high glucose DMEM+10% FBS (basal medium, BM) in 5% $CO_2$at 37°C and allowed to grow until stable. Then cells were cultured for 15 d in BM (control group), or BM added with a mixture of citric acid, sorbic acid, thymol, and vanillin at 0.2 or 1 g/L. Trans-epithelial electrical resistance (TER) was measured every other day using a voltohmmeter. At d7 and d15 since the addition of the experimental media, the paracellular permeability was measured with FITC-dextran flux and at d15 cells were harvested to assess mRNA expression of tight junction markers by qPCR. Data were analyzed with 1-way ANOVA (FITC-dextran flux and mRNA expression) or ANOVA repeated measures (TER), and the treatments had 5 independent replicates ($n = 5$). Compared to control, the blend of organic acids and botanicals at 0.2 g/L significantly improved the TER starting at 4 d since the beginning of the experiment (+13%, $P < 0.001$) and the increase remained significant throughout the experiment (on average +12%, $P < 0.05$). At d15 both treatments improved the TER in a dose-dependent way compared to control (+16% for 0.2 g/L, $P < 0.05$; +27% for 1 g/L, $P < 0.001$). FITC-dextran flux was not affected by the treatments. Tight junction mRNA expression was generally improved by the treatments: while claudin-1 was not affected, occludin tended to be improved at 1 g/L ($P < 0.2$) and zonula occludens-1 was increased in a dose-dependent manner ($P < 0.01$), as shown in Table 207. In conclusion, the mixture of organic acids and botanicals improved Caco-2 epithelial barrier integrity by increasing the TER and improving the tight junction expression and this could validate the "gut barrier-improving" mechanism of action of these additives in animal nutrition.

**Key Words:** Caco-2 cells, intestinal barrier function, organic acids and botanicals
doi: 10.2527/asasmw.2017.12.207

**Table 207.** Tight junction markers mRNA relative expression*

| | CTR | 0.2 g/L | 1 g/L | Pooled SEM | *P*-value |
|---|---|---|---|---|---|
| Claudin-1 | 1.02 | 1.17 | 1.12 | 0.10 | 0.53 |
| Occludin | 1.02 | 1.07 | 1.31 | 0.12 | 0.19 |
| Zonula occludens-1 | 1.02 | 1.35 | 1.61 | 0.10 | 0.004 |

*Normalized on 2 housekeeping genes (GAPDH and RPLP0) and calculated relative to the control group.

## 208 The interactive effects of a matrix coated organic acids blend and antibiotic supplementation in growing pigs.

M. M. Hossain[1,*], B. Jayaraman[1], S. C. Kim[2], K. Y. Lee[3], I. H. Kim[2], C. M. Nyachoti[1], *[1]Department of Animal Science, University of Manitoba, Winnipeg, MB, Canada, [2]Department of Animal Resource, and Science, Dankook University, Cheonan, South Korea, [3]Morningbio Co. Ltd, Cheonan, South Korea.*

Dietary addition of organic acids can promote nutrient digestibility, growth performance, and gut health outcomes in pigs. Thus, we investigated the effect of supplementing a matrix coated organic acids blend (MCOA) without or with antimicrobial growth promoters (AGP) in growing pig diets on growth performance, hematological profiles, diarrhea score, and in vitro fecal noxious gas emission. Ninety-six growing pigs [(Yorkshire × Landrace) × Duroc] with an average BW of 47.71 ± 1.15 kg (mean ± SD) were used in a 6-wk experiment. Based on initial BW and gender, pigs were randomly blocked and allocated to 1 of 4 experimental treatments each with 12 replicates and 2 pigs per pen. Pigs were allotted to diets containing 0 or 0.2% MCOA, and 0 or 0.25% AGP (aureomycin, Aureo S-P 250 G) according to a 2 × 2 factorial arrangement of treatments. For hematology and serum urea N (SUN) measurements, 1 pig from each pen was randomly selected, and blood samples (10 mL per pig) were collected via jugular vein puncture on d 41. The occurrence and severity of diarrhea were monitored and assessed during the whole experiment. All data were statistically analyzed using the PROC MIXED procedure of SAS. Pigs fed the diet supplemented with MCOA had higher feed efficiency (G:F) than those fed the diets without MCOA (0.38 vs. 0.36; $P = 0.030$). Moreover, AGP × MCOA supplementation tended to have higher G:F ($P = 0.083$). However, pigs fed AGP × MCOA diet had reduced SUN ($P = 0.024$). Diarrhea score was not affected ($P > 0.10$) by dietary AGP or MCOA. Pigs fed diet supplemented with AGP had reduced fecal ammonia ($NH_3$) gas emission compared to those fed without AGP (8.49 vs. 8.80 ppm; $P = 0.037$). Moreover, pigs fed diet supplemented with MCOA had reduced fecal $NH_3$ and acetic acid gas emission compared to those fed without MCOA (8.36 vs. 8.93 ppm, and 1.73 vs. 2.79 ppm; $P < 0.001$, and $P = 0.048$, respectively). In conclusion, growing pigs fed diets supplemented with MCOA had improved G:F and similar beneficial responses as those fed diets with AGP in terms of reducing serum urea N, and in vitro noxious gas emission. This suggests that supplementation of MOCA can promote G:F of growing pigs in antibiotic-free-feeding regimens.

**Key Words:** growing pigs, matrix coated organic acid blends, performance
doi: 10.2527/asasmw.2017.12.208

## 209 Effect of enzymatically fermented soybean meal and *Lactobacillus plantarum* on nursery pig performance.

A. M. Jones*, J. C. Woodworth, S. S. Dritz, M. D. Tokach, R. D. Goodband, *Kansas State University, Manhattan.*

A total of 360 pigs (PIC C-29 × 359, initial BW 5.52 kg) were used in a 45-d trial to determine the effects of enzymatically fermented soybean meal (EFS) and *Lactobacillus plantarum* (LP1) on nursery pig performance. Pigs were weaned at

approximately 18 to 20 d of age and allotted to pens blocked by BW within sex. Pens were randomly assigned to 1 of 4 dietary treatments with 10 pigs/pen and 9 replications/treatment. Dietary treatments were arranged in a 2 × 2 factorial with main effects of added EFS (0 vs. 8% replacing soybean meal) and LP1 (0 vs. 0.1%). Experimental diets were fed in 2 phases (Phase 1: d 0-14 and Phase 2: d 14-24) with a common diet fed to all pigs from d 24-45 post-weaning. From d 0-24, pigs fed the diet containing EFS tended to have decreased ($P$ = 0.088) ADFI compared to pigs fed diets without EFS; however, no evidence for differences were observed for ADG and G:F. Also, pigs fed diets containing LP1 tended to have improved ($P$ = 0.053) G:F compared to pigs fed diets without LP1, with no evidence of differences observed for ADG or ADFI. Overall (d 0-45), a LP1×EFS interaction was detected for G:F ($P$ = 0.021) where LP1 and EFS individually improved G:F, but the effects were not additive when combined. In conclusion, the addition of LP1 and EFS in nursery diets had variable responses when fed independently, but when combined, no benefit was evident.

**Key Words:** enzymatically fermented soybean meal, *Lactobacillus plantarum*, nursery pig,
doi: 10.2527/asasmw.2017.12.209

**210 Effect of diet complexity and specialty protein source on nursery pig performance.** A. M. Jones[1,*], J. C. Woodworth[1], J. M. DeRouchey[1], G. E. Fitzner[2], M. D. Tokach[1], S. S. Dritz[1], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]Hamlet Protein, Findlay, OH.*

Seven hundred twenty nursery pigs (PIC C-29 × 359, initial BW 5.83 kg and 18-20 d of age) with 10 pigs/pen and 12 replications/treatment were used in a 42-d growth study evaluating diet type (DT; complex vs. simple) and protein source (PS; fish meal, HP300, or HP800) on growth performance. Complex diets contained 20 and 10% lactose, while simple diets contained 12 and 5% lactose in Phases 1 and 2, respectively. Complex diets contained 10% oat meal in both phases, while all diets contained 2% plasma in Phase 1 only. Soybean meal and SID Lys levels were equal within phase by adjusting fish meal, HP300, and HP800. Pens were allotted to 6 treatments in a 2 × 3 factorial arrangement with main effects of DT and PS. Dietary treatments were the fixed effect and block and room served as the random effect. Phase 1 was budgeted at 2.27 kg/pig and Phase 2 was fed thereafter until d-21. A common diet was fed from d 21-42. For the overall treatment period (d 0-21), pigs fed complex had improved G:F ($P$ = 0.040) compared to pigs fed simple diets, but ADG and ADFI were not affected. Overall (d 0–42), no differences in growth were observed among treatments. In summary, the 3 specialty protein sources used resulted in similar growth. The complex diet had small positive benefits on growth during the first 21d; however, the benefits were not evident at the end of the common diet period. The general lack of responses to DT or PS could be related to health, a common ingredient quality issue or lower than expected performance from this facility.

**Key Words:** diet complexity, nursery pig, protein sources
doi: 10.2527/asasmw.2017.12.210

**211 Evaluation of berberine as an alternative to antibiotics in nursery pig diets.** E. E. Scholtz*, *South Dakota State University, Brookings.*

A study was conducted to determine the effects of berberine (plant extract) on growth performance, electrophysiological properties of small intestine mounted in Ussing chambers, and small intestinal histomorphology of weaned pigs. Twenty-four 3 wk-old weaned pigs (average initial BW = 6.35 kg) were obtained in 2 batches of 12 pigs each, and assigned to 3 experimental diets within batch (4 pigs/diet/batch). The diets included a basal diet without or with antibiotics or 3% berberine. The experiment lasted for 7 d, and at the end, body weight gain and feed consumption were determined. The pigs were then euthanized to determine duodenal, jejunal, and ileal trans-epithelial resistance (TER) and small intestinal histomorphology. Data were analyzed using Mixed procedure of SAS with batch as block and pig as experimental unit. There was no effect of

**Table 209.**

| | | | | | | Probability, $P$ < | | |
|---|---|---|---|---|---|---|---|---|
| BW, kg | CTRL | LP1 | EFS | LP1 + EFS | SEM | LP1 × EFS | LP1 | EFS |
| d 0 | 5.52 | 5.51 | 5.52 | 5.53 | 0.012 | 0.301 | 0.892 | 0.392 |
| d 24 | 10.86 | 11.04 | 10.84 | 10.98 | 0.136 | 0.890 | 0.247 | 0.751 |
| d 45 | 22.78 | 23.42 | 23.07 | 23.29 | 0.276 | 0.459 | 0.130 | 0.782 |
| d 0 to 24 | | | | | | | | |
| ADG, g | 222 | 231 | 222 | 226 | 5.8 | 0.709 | 0.294 | 0.662 |
| ADFI, g | 303 | 298 | 290 | 292 | 5.4 | 0.544 | 0.789 | 0.088 |
| G:F | 0.734 | 0.774 | 0.765 | 0.773 | 0.0122 | 0.210 | 0.053 | 0.244 |
| d 0 to 45 | | | | | | | | |
| ADG, g | 383 | 398 | 390 | 393 | 6.2 | 0.332 | 0.142 | 0.832 |
| ADFI, g | 539 | 549 | 534 | 547 | 8.5 | 0.881 | 0.178 | 0.658 |
| G:F | 0.710[a] | 0.723[b] | 0.732[b] | 0.721[ab] | 0.0050 | 0.021 | 0.826 | 0.055 |

dietary treatment on average daily gain. The average final BW was 5.92 ± 0.34 kg. However, pigs fed antibiotic-containing diet had greater ($P < 0.029$) average daily feed intake than those fed the basal diet (0.156 vs. 0.123 kg). Inclusion of berberine in the basal diet decreased ($P < 0.0001$) ADFI from 0.123 to 0.056 kg. There was no difference in villous height and crypt depth in all sections of small intestine between pigs fed antibiotic-containing diet and basal diet. Inclusion of berberine in the basal diet decreased ($P < 0.05$) crypt depth in duodenum and ileum by an average of 35% and tended to decrease ($P = 0.069$) crypt depth in jejunum by 32%. Ileal villous height was decreased ($P < 0.0001$) by 28% due to inclusion of berberine in basal diet. However, there was no effect of including berberine in basal diet on villous height in duodenum and jejunum. Pigs fed antibiotic-containing diet and basal diet had similar TER values (which reflects intestinal mucosal barrier function) in all sections of the small intestine. Inclusion of berberine in basal diet tended to decrease ($P = 0.078$) TER in duodenum from 55.53 to 44.31Ω. Berberine in the basal diet reduced feed intake, and crypt depth and villous height in the ileum, and tended to decrease TER in the duodenum. It can be concluded that inclusion of antibiotic had minimal impact on intestinal health parameters. Dietary inclusion of berberine appeared to have a negative effect on gut health; however, the influence of berberine is confounded by very low feed intake which can also negatively influence gut health.

**Key Words:** berberine, gut health, pig
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**212 Effects of mannan oligosaccharides and *Lactobacillus mucosae* on the intestinal morphology of weanling pigs challenged with *Escherichia coli* lipopolysaccharides.** Y. S. Li*, M. D. Trenhaile, D. M. van Sambeek, K. C. Moore, S. M. Barnett, S. C. Fernando, T. E. Burkey, P. S. Miller, *University of Nebraska-Lincoln, Lincoln.*

To determine the effects of feeding mannan oligosaccharides (MOS) and *Lactobacillus mucosae* (LM) on intestinal morphology of weanling pigs under immune challenge, 96 pigs (BW = 5.88 kg; d 23 post-farrowing) were randomly allotted to 16 experimental pens with a 2 × 2 factorial arrangement of treatments (4 pens per treatment; mixed gender). Diets with or without 0.1% MOS were randomly assigned to pens and $10^9$ cfu/pig LM broth or an equal volume of control broth were top-dressed daily. Pigs were given 1 of the 4 dietary treatments (control, MOS, LM, and MOS+LM) during phase-1 and phase-2 (d 0 to 7 and d 7 to 21 post-weaning, respectively). On d 14, all pigs were challenged with 100 μg/kg BW of *Escherichia coli* lipopolysaccharides (LPS). On d 15 and 21, 1 pig per pen was euthanized for collection of intestinal tissue samples. Villus height (VH), crypt depth (CD), and villus surface area of duodenal and ileal samples were measured. Data were analyzed using PROC GLIMMIX of SAS. On d 15, feeding LM tended ($P < 0.10$) to decrease ileal CD; pigs fed LM had decreased ($P < 0.05$) ileal CD compared to pigs fed the control diet, but were not different ($P > 0.10$) from the pigs fed MOS or MOS+LM diets. However, all other ileal and duodenal measurements on d 15 and 21 were not different ($P > 0.10$) among treatments. In conclusion, feeding LM may have beneficial effects on gut health of weanling pigs under LPS-challenge.

**Key Words:** gut, morphology, pig
doi: 10.2527/asasmw.2017.12.212

**Table 210.**

| | Complex | | | Simple | | | Probability, $P <$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fish meal | HP300 | HP800 | Fish meal | HP300 | HP800 | DT×PS | DT | PS |
| Phase 1, % | 7.75 | 10.25 | 10.45 | 7.75 | 10.25 | 10.45 | | | |
| Phase 2, % | 6.00 | 8.21 | 8.35 | 6.00 | 8.20 | 8.37 | | | |
| d 0,kg | 5.83 | 5.85 | 5.83 | 5.83 | 5.83 | 5.84 | 0.197 | 0.695 | 0.413 |
| d 21,kg | 9.74 | 9.76 | 9.56 | 9.55 | 9.57 | 9.54 | 0.707 | 0.160 | 0.610 |
| d 42,kg | 21.42 | 21.38 | 21.35 | 21.07 | 21.18 | 21.51 | 0.719 | 0.622 | 0.831 |
| d 0 to 21 | | | | | | | | | |
| ADG,g | 186 | 186 | 178 | 177 | 178 | 176 | 0.755 | 0.169 | 0.650 |
| ADFI,g | 247 | 253 | 248 | 244 | 255 | 248 | 0.927 | 0.973 | 0.279 |
| G:F | 0.76 | 0.73 | 0.72 | 0.72 | 0.70 | 0.71 | 0.462 | 0.040 | 0.131 |
| d 0 to 42 | | | | | | | | | |
| ADG,g | 370 | 370 | 367 | 363 | 366 | 373 | 0.625 | 0.730 | 0.866 |
| ADFI,g | 514 | 506 | 507 | 498 | 508 | 514 | 0.363 | 0.766 | 0.868 |
| G:F | 0.72 | 0.73 | 0.73 | 0.73 | 0.72 | 0.73 | 0.269 | 0.581 | 0.963 |

SEM = BW d0 (0.160); d21 (0.299); d42 (0.320); d0–21 ADG (7.6), ADFI (9.8), G:F (0.408); d0–42 ADG (9.3), ADFI (8.4), G:F (0.011)

## 213 Effects of increasing standardized ileal digestible (SID) lysine on performance of 11 to 23 Kg nursery pigs.

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A 21-d study was conducted to determine the effects of increasing SID LYS on growth performance parameters. Twenty-one days post-weaning, a total of 822 [PIC TR4 × (FAST LW x PIC L02); 11.22 kg BW] mixed-sex pigs were allotted to one of five dietary treatments in a randomized complete block design using previous treatment and weight as blocking criteria. There were 26-28 pigs per pen with 6 replications per treatment. Experimental diets were corn-soybean meal based with 10% DDGS, formulated to be iso-caloric, and fed in pellet form (3.17 mm). The 5 dietary treatments consisted of 1.10, 1.175, 1.25, 1.325, and 1.40% SID LYS and were achieved by increasing primarily soybean meal and secondarily crystalline AA (L-Lysine HCl, Methionine Hydroxy Analog, L-Threonine, L-tryptophan, L-Valine) levels maintaining a constant SID Ile:Lys of 0.55 for all treatments without adding crystalline isoleucine. Data were analyzed using general linear and NLIN procedures of SAS with initial BW used as a covariate for all response variables. Overall (Table 213), pigs fed increasing SID LYS had improved ADG and G:F (Linear, $P < 0.001$). There were no quadratic effects of increasing SID LYS ($P > 0.19$) for any response variable. Average daily gain was not a fit for any NLIN models and may indicate that the estimate is greater than 1.40%. The piecewise linear model was the best fit for G:F and estimated the requirement to be 1.32%. Mean separation indicates that the minimum SID LYS level to optimize ADG is at least 1.25%, and 1.325% for G:F.

**Key Words:** lysine, pig, requirement
doi: 10.2527/asasmw.2017.12.213

## 214 Effects of a liquid supplement and a nursery starter diet given immediately post-weaning on growth performance and morbidity and mortality of nursery pigs.

J. R. Morris[1,*], M. Ellis[1], J. E. Estrada[1], A. M. Gaines[2], C. M. Shull[2], O. F. Mendoza[2], *[1]University of Illinois at Urbana-Champaign, Urbana, [2]The Maschhoffs, LLC, Carlyle, IL.*

This study was performed to compare the effects of supplemental nutrition programs provided immediately post-weaning on growth performance and morbidity (live pigs removed from test for health reasons) and mortality. The programs were administered during the nursery period (5.2 ± 0.37 to 25.4 ± 2.66 kg BW) under commercial conditions. The study used a randomized complete block design (blocking factor = date started on test) with 3 treatments: 1) Control (4-phase standard commercial nursery dietary program); 2) Control plus a Liquid Supplement [a commercially available nutrient dense mixture of plasma proteins, electrolytes, and energy sources; via the water supply (1:128 liquid supplement:water ratio) for 7 d post-weaning]; 3) Control plus additional Nursery Starter Diet (containing high levels of milk by-products and animal protein sources; fed at 0.11 kg/pig immediately post-weaning followed by the 4-phase Control dietary program). A total of 7524 barrows and gilts were housed in mixed-sex pens of 44 (57 replicates) at a floor space 0.31 $m^2$/pig. Pigs had ad libitum access to feed and water throughout the study. Pen was the experimental unit and data were analyzed using PROC MIXED of SAS with the model accounting for the effects of nutrition

**Table 212.**

| | | | | | | *P*-values | | |
|---|---|---|---|---|---|---|---|---|
| Items, μm | Control | MOS | LM | MOS+LM | SEM | MOS | LM | MOS*LM |
| d 15 duodenum | | | | | | | | |
| VH | 322 | 344 | 368 | 340 | 35 | 0.929 | 0.565 | 0.483 |
| CD | 360 | 319 | 374 | 372 | 34 | 0.530 | 0.342 | 0.573 |
| Villus area, $\mu m^2$ | 36,350 | 41,504 | 43,979 | 39,543 | 5962 | 0.953 | 0.643 | 0.437 |
| d 15 ileum | | | | | | | | |
| VH | 329 | 312 | 354 | 290 | 32 | 0.225 | 0.968 | 0.474 |
| CD | 288[b] | 267 | 246[a] | 259 | 14 | 0.773 | 0.091 | 0.239 |
| Villus area, $\mu m^2$ | 38,023 | 36,240 | 42,575 | 32,523 | 5330 | 0.289 | 0.939 | 0.453 |
| d 21 duodenum | | | | | | | | |
| VH | 493 | 574 | 522 | 544 | 35 | 0.163 | 0.991 | 0.411 |
| CD | 479 | 469 | 461 | 425 | 30 | 0.465 | 0.321 | 0.669 |
| Villus area, $\mu m^2$ | 75,077 | 92,409 | 81,651 | 82,906 | 7212 | 0.222 | 0.843 | 0.287 |
| d 21 ileum | | | | | | | | |
| VH | 469 | 427 | 482 | 445 | 28 | 0.191 | 0.603 | 0.938 |
| CD | 303 | 285 | 273 | 289 | 23 | 0.976 | 0.587 | 0.465 |
| Villus area, $\mu m^2$ | 62,241 | 56,517 | 62,216 | 55,510 | 5329 | 0.266 | 0.925 | 0.928 |

[a-b]Means with a different superscript letter differ ($P < 0.05$).

**Table 213.** Effect of SID LYS on growth performance (d 0–21)

| SID LYS, % | 1.10 | 1.175 | 1.25 | 1.325 | 1.40 | SEM |
|---|---|---|---|---|---|---|
| Expected Total LYS, % | 1.23 | 1.31 | 1.39 | 1.48 | 1.56 | – |
| Analyzed Total LYS, % | 1.27 | 1.36 | 1.41 | 1.47 | 1.56 | – |
| Soybean meal, % | 20.9 | 23.6 | 26.3 | 29.0 | 31.8 | – |
| Crystalline LYS, % | 0.47 | 0.48 | 0.50 | 0.51 | 0.53 | – |
| ADG, g[1] | 552[b] | 545[b] | 575[ab] | 593[a] | 607[a] | 13.53 |
| ADFI, g | 802 | 772 | 775 | 775 | 779 | 13.67 |
| G:F[1] | .69[c] | .71[c] | .74[b] | .77[a] | .78[a] | .007 |
| BW Gain, kg[1] | 11.59[b] | 11.44[b] | 12.08[ab] | 12.45[a] | 12.75[a] | 0.28 |

[abcd] Within a row, means without common superscript differ ($P < 0.05$).
[1] Linear effect SID LYS ($P < 0.001$).

program, block, and replicate. Average daily gain and ADFI were greater ($P < 0.05$) for the Liquid Supplement treatment compared to the other treatments, which were similar ($P > 0.05$) for these traits [ADG: 354, 363, and 354 g (SEM 6.4); ADFI: 531, 540, and 526 g (SEM 9.1) for the Control, Liquid Supplement, and Nursery Starter Diet treatments, respectively]. There was no effect ($P > 0.05$) of treatment on G:F or mortality levels. Morbidity levels were lower ($P = 0.02$) for the Liquid Supplement treatment than the Nursery Starter Diet treatment, with the Control being intermediate and similar ($P > 0.05$) to the other treatments (2.6, 2.0, and 3.2% for the Control, Liquid Supplement, and Nursery Starter Diet treatments, respectively). The results of this study suggest that providing a Liquid Supplement in the water for 7 d post-weaning can increase growth rate and may decrease morbidity of nursery pigs.

**Key Words:** nursery, pigs, supplemental nutrition
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## 215 Growth performance of nursery pigs fed microalgae carbohydrate product.

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The objectives of this study were to evaluate the effects of a carbohydrate rich, partially de-oiled microalgae extract (MAE) in nursery pig diets on growth performance and health status. A total of 320 pigs (initial BW = 6.3 ± 2.1 kg) were used in a 42-d trial. Treatments included a control corn-soybean meal diet, and control diet with MAE inclusion as to act as a potential prebiotic (1%) or as an alternative feed ingredient (5, 10, and 20%). Diets were formulated for a 3 phase feeding program to meet or exceed NRC nutrient requirements for nursery pigs containing 3400 kcal/kg of ME. Pigs were stratified by weaning weight into 12 blocks in a complete block design, with sex distributed evenly among blocks. Pens of pigs (5 pigs/pen) were assigned randomly within block to 1 of 5 treatments. Pig weight and feed disappearance were recorded weekly. The number of pigs that showed signs of illness and received individual doses of antibiotics were recorded. Pig mortality was calculated on a treatment basis. Data were analyzed using a mixed model with pen (block × treatment) as the random effect, and period, treatment, and period x treatment as fixed effects. Linear and quadratic orthogonal polynomial contrasts were used to evaluate differences between diets with varying levels of MAE. Over 6 wk, ADFI tended ($P = 0.08$) to increase quadratically (Con:731, 1%:766, 5%:754, 10%:761, 20%:718 g) and ADG increased ($P = 0.03$) quadratically (Con:496, 1%:531, 5%:517, 10%:529, 20%:500 g) with the inclusion of MAE. The 1% and 10% treatment groups showed the greatest overall ADFI and ADG. A total of 18 out of 320 pigs were treated with antibiotics, with the control (8/60) and 20% MAE (4/60) representing the largest number of treated pigs. The largest number of dead pigs came from pigs fed the control diet (3/60) and the 5% MAE (3/60). Overall, pigs fed the 1% and 10% MAE diets had the lowest percentage of antibiotic treatments and mortality. We observed that diets with 10% and 20% inclusion levels did not flow properly in the feeders; thus, high inclusion of the MAE product may increase labor. In conclusion, an inclusion level of 1% of MAE provided the greatest improvement in ADG, ADFI, and indicators of health of nursery pigs, also indicating a potential role for MAE as a prebiotic for nursery pigs.

**Key Words:** growth performance, microalgae, nursery pigs
doi: 10.2527/asasmw.2017.12.215

## 216 Effect of a post-weaning supplemental nutrition program on the growth performance, and morbidity and mortality of nursery pigs.

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This study was performed from weaning (5.0 ± 0.45 kg BW) over 8 wk (final BW of 30.3 ± 2.83 kg) as a RCBD comparing 2 post-weaning nutritional programs (Control vs. Enhanced). The Control treatment was a 4-phase standard commercial nursery dietary program; diets met or exceeded NRC (2012) nutrient requirements. The Enhanced treatment consisted of the same 4-phase dietary program with supplementation immediately post-weaning of a commercially-available nursery starter diet (with high levels of milk by-products and animal protein sources; fed at 0.11 kg/pig) and a liquid dietary supplement (commercially available nutrient dense liquid supplement; dilution ratio supplement to water of 1:128), delivered via the water supply for 3 d post-weaning. The study used 5784 barrows and gilts housed in mixed-sex groups of 44 pigs, for a total of 66 replicates. Pigs had ad libitum access to feed and water. Pen was the experimental unit; data were analyzed using PROC MIXED of SAS; the model accounted for

the effects of treatment, block, and replicate. Body weight was greater ($P < 0.05$) for the Enhanced compared to the Control treatment at the end of wk 2, 4, and 6 (3.5%, 2.6%, and 2.0%, respectively) but not at the end of the study. The Enhanced treatment had greater ($P = 0.03$) overall ADG compared to the Control (422 vs. 413 g/d, respectively; SEM = 5.0). Compared to the Control, pigs on the Enhanced treatment had greater ADFI from start to wk 2 (200 vs. 209 g/d; SEM 0.006; $P = 0.01$) and from wk 2 to 4 (494 vs. 508 g/d; SEM 0.011; $P = 0.02$) but not for the overall 8-wk period (667 vs. 671 g/d; SEM 0.009; $P = 0.09$). Gain:feed was greater for the Enhanced treatment than the Control for the first 2 wk (0.795 vs. 0.764, kg:kg; SEM 0.0121; $P = 0.04$) but not for the overall period (0.623 vs. 0.623, kg:kg; SEM 0.0023; $P = 0.14$). Morbidity and mortality levels were numerically lower for the Enhanced treatment than the Control, but the difference was not statistically significant (5.6 vs. 6.6%; $P = 0.14$). The results of this study suggest the Enhanced nursery program improved growth performance early in the post-weaning period, but this improvement was not sustained to the end of the nursery period. Additional, larger-scale studies are needed to establish any effect of the Enhanced program used in this study on morbidity and mortality.

**Key Words:** growth, nursery pigs, supplemental nutrition
doi: 10.2527/asasmw.2017.12.216

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**217 Alternative feed additive, associated or not with antibiotic, in weaned piglets feeding: Growth performance and diets digestibility.**

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This study evaluated an alternative feed additive associated or not with colistin, in a 2 × 2 factorial arrangement, in weaned piglets feeding on ADG, ADFI, feed conversion ratio (FCR), and apparent total tract digestibility (ATTD) of DM, OM, CP, and GE. One hundred and eight crossbred piglets (5.3 ± 0.5 kg) were used in a three-phase feeding program (21-35, 36-50, 51-65 d of age), and fed the following diets: a control diet (CON), with no inclusion of growth promoter feed additive; a diet with 40 ppm of colistin (diet COL); a diet with 0.3% of alternative additive (benzoic acid and the essential oils of eugenol, thymus, and piperine- diet AA); and a diet with 0.3% of alternative additive and 40 ppm of colistin (diet AACOL). The diets were composed by corn, soybean meal, dairy products, and spray-dried blood plasma, supplemented with minerals, vitamins, and amino acids, and formulated to provide 3.40, 3.38, and 3.20 Mcal of ME/kg; 220, 215, and 190 g/kg of CP; and 14.5, 13.3, and 10.9 g/kg of digestible lysine, in phases 1, 2, and 3, respectively. A randomized block design based on initial BW was used. The data were submitted to ANOVA by the GLM procedure of SAS (9.4), and means were separated using Tukey test (5%). Alternative feed additive inclusion in the diets increased ($P < 0.05$) ADG (91.8 g vs. 114.3 g) and ADFI (163.3 g vs. 190.1 g) of piglets in phase 1, compared to pigs fed diets without the product. The alternative additive improved ($P < 0.05$) ATTD of CP in phase 1 (68.6% vs. 71.0%), ATTD of GE in phases 1 (75.2% vs. 77.4%), and 3 (77.1% vs. 79.0%), and ATTD of DM in phase 3 (77.1% vs. 79.1%). The antibiotic inclusion in the diets increased ($P < 0.05$) ATTD of CP in phase 1 (68.2% vs. 71.5%). The alternative feed additive and colistin interacted ($P < 0.05$) for ATTD of DM in phases 1 and 2, and ATTD of OM, CP, and GE in phase 2. The ATTD of DM in phases 1 and 2, and the ATTD of OM, CP, and GE in phase 2 of diets AA and COL were greater ($P < 0.05$) than of diet CON, but similar ($P > 0.05$) to diet AACOL. The alternative feed additive was effective in improving growth performance and diets digestibility in piglets soon after weaning.

**Key Words:** antibiotic, phytogenic additive, weaning
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**218 Alternative feed additive, associated or not with antibiotic, in weaned piglets feeding: Diarrhea incidence, intestinal mucosa morphology, and digestive organs weight.**

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Phytogenic additives and acidifiers are potential substitutes for antibiotics in piglets feeding. Thus, this study evaluated an alternative feed additive (benzoic acid and the essential oils of eugenol, thymus, and piperine) and colistin, in a 2 × 2 factorial arrangement, on fecal score, intestinal morphology, and relative weights of digestive organs in piglets. One hundred and eight crossbred piglets (5.3 ± 0.5 kg), 21 d old, were fed the following diets (3.40 Mcal/kg ME; 22.0% CP; and 1.45% digestible lysine): 1) control diet (CON), without inclusion of growth promoter feed additive; 2) diet with 40 ppm of colistin (COL); 3) diet with 0.3% of alternative additive (AA); 4) diet with 0.3% of alternative additive and 40 ppm of colistin (AACOL). The piglets were housed 3 per pen, with 9 replicates per diet, in a complete randomized block design based on initial BW. Fecal scores were recorded in the first 14 d of the trial, as follows: 1– normal feces; 2– doughy feces; and 3– diarrheal feces. At the 14th day of the trial, 9 animals per

diet were euthanized, their digestive organs were weighed, and tissues samples from proximal duodenum and jejunum were collected to evaluate villi height and width, crypt depth, and goblet cell count. Data were analyzed by ANOVA using the GLM procedure. The alternative feed additive inclusion in piglets diets tended ($P = 0.06$) to increase (46%) normal feces frequency, decreased ($P < 0.05$) goblet cells count (104.3 vs. 118.1) in the jejunum, and decreased ($P < 0.05$) small intestine (4.60% vs. 4.93%) and colon (1.41% vs. 1.65%) relative weights, compared to pigs not fed with the alternative additive. The use of colistin increased ($P < 0.05$) villi width (356.1 μm vs. 351.4 μm), and goblet cells count in the jejunum (115.1 vs. 107.2). Alternative additive and colistin interacted ($P < 0.05$) for crypt depth in jejunum. Piglets fed diet COL showed lower ($P < 0.05$) crypt depth than animals fed diets CON and AACOL. Piglets fed diet AA presented similar ($P > 0.05$) crypt depth compared to animals fed diets CON and AACOL. The tendency for greater normal feces frequency, the fewer goblet cells count, and the lower relative weights of small intestine and colon of piglets fed diets containing the alternative additive, compared to pigs fed CON diet, indicate that intestinal health may have been promoted by the alternative additive.

**Key Words:** diarrhea, gut health, phytogenic additive
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## 219 Effect of yeast cell wall (YCW) inclusion rate on growth performance in nursery pigs.

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To evaluate the effect of YCW on performance of nursery pigs, a total of 144 weaned piglets (BW: 5.76 ± 0.02 kg; PIC C-29 × 380) were randomly allotted to 1 of 3 dietary treatments (24 pens with 6 pigs/pen). Treatments were: 1) a nutrient adequate control (CON) with 0 mg/kg yeast cell wall, 2) CON + 250 mg/kg YCW (YCW250), and 3) CON + 1000 mg/kg YCW (YCW1000) for phase 1 (7 d), 2 (14 d) and 3 (7 d). At the end of phase 3, all pigs were fed a common diet (3.4 Mcal/kg of ME; 1.46% standardized ileal digestible Lys) for 14 d (phase 4). Pig weight and pen feed disappearance were measured at end of each phase to calculate performance. Blood was sampled from 1 pig of average BW per pen at the end of phase 3 and 4 to assess hematology characteristics. Data were analyzed as RCBD using mixed procedure of SAS with treatment as the fixed effect. PROC IML was used to generate contrast statements. Pigs fed YCW250 tended to have the improved ADG (quadratic, $P < 0.06$) and ADFI (quadratic, $P = 0.02$) in phase 2 and phases 1 and 2. However, G:F tended to decrease linearly with increasing level of YCW in phase 1 ($P = 0.07$). There were no other significant differences in ADFI, ADG, or G:F; however, at study conclusion, pigs fed YCW250 were 0.93 kg heavier than pigs fed the CON. At d28 and d42, pigs fed YCW250 had increased (quadratic, $P < 0.05$) eosinophils, red blood cells, hemoglobin, and hematocrit, and a lower platelet count compared with pigs fed the CON or YCW1000. There was no significant day by treatment interactions for blood profiles. Results indicate that supplementation of YCW at 250 mg/kg during early post-weaning improved feed intake and gain, and modulated blood cell count. However, feeding YCW above 250 mg/kg resulted in a reduction in growth performance to levels similar to that observed in pigs fed CON diets

**Key Words:** ADG, eosinophil, yeast cell wall
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## 220 Performance of nursery pigs fed a customized antibiotic-free feeding program, with or without, three different types of feed grade antibiotics.

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The objective of this study was to evaluate performance of pigs on an antibiotic-free program as compared to a program containing antibiotics in a commercial wean-to-finish research facility with a Fancom feeding system. A total of 938 weaned pigs were used with an average initial BW of 5.7 kg, 27–32 pigs/pen, and 8 replications/treatment. Pigs were blocked by BW, sow farm, sex, location within the barn and immediately placed on their randomly assigned, meal-form dietary treatments, which were: an antibiotic-free diet and no injectable antibiotics (ABF), 73 g/ton avilamycin (AVI), 400 g/ton chlortetracycline hydrochloride + 35 g/ton tiamulin hydrogen fumarate (CT), and 50 g/ton carbadox (CARB). If pigs received feed grade antibiotics, they also received individual antibiotic treatments as needed. Feed disappearance was recorded and pens of pigs were weighed on d 0 and 21, which was used to calculate ADG, ADFI, and FCR. Pigs fed AVI, CT, or CARB that were not responding to injectable antibiotic treatments were removed, tagged, and placed in sick pens. When deemed necessary to receive injectable antibiotic treatment, pigs fed ABF were removed, tagged, and placed in sick pens. Daily injectable treatments were recorded. Dead (% mortality) and pulled (% morbidity) pigs were determined at the end of d 21. Data were analyzed as a completely randomized block design using GLM procedure in Minitab with Fisher's test to determine differences between treatments. For d 0–21, pigs fed CT had a higher ADG ($P = 0.002$) compared to pigs

**Table 219.** Effect of YCW on the complete blood cell count at Day 28 and Day 42

| | CON | YCW250 | YCW1000 | SEM | *Quadratic* |
|---|---|---|---|---|---|
| Eosinophil, $10^3/\mu L$ | 0.45 | 0.71 | 0.42 | 0.08 | 0.02 |
| Red blood cells, $10^3/\mu L$ | 6.88 | 7.60 | 7.08 | 0.15 | < 0.01 |
| Haemoglobin, $10^3/\mu L$ | 9.36 | 10.18 | 9.23 | 0.25 | < 0.01 |
| Haematocrit, % | 32.04 | 36.14 | 32.17 | 0.78 | < 0.01 |
| PLT, $10^3/\mu L$ | 624.0 | 438.0 | 643.9 | 40.6 | < 0.01 |

fed CARB or ABF with AVI being intermediate; pigs fed ABF had a lower ADG compared to pigs fed AVI with CARB being the intermediate. The ABF and CARB fed pigs had a lower ADFI ($P = 0.037$) than CT with AVI being intermediate. There were no differences ($P > 0.10$) observed for FCR. There were no differences ($P > 0.10$) for % morbidity/pen; however, pigs fed ABF had a numerically higher % morbidity. Pigs fed feed grade antibiotics had a lower % mortality/pen ($P = 0.009$) in contrast with pigs fed ABF. In conclusion, the results of this experiment provide reference data for antibiotic-free feeding programs.

**Key Words:** antibiotic-free feeding program, feed grade antibiotics, performance
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## 221 Effects of feeding a multi-enzyme and probiotic bacteria blend (CORE) on performance of nursery pigs fed a highly digestible diet.

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The objective of this study was to evaluate whether performance of nursery pigs could be improved by using high levels of a multi-enzyme blend consisting of xylanase, phytase, cellulase, β-glucanase, α-amylase, and protease and a probiotic bacteria blend consisting of *Bacillus subtilis* and *Bacillus licheniformis* (CORE). For d 0 to 21, 0.3% CORE was added to two phases of a highly digestible basal diet (corn, soybean meal, fish meal, plasma, and phytase; NC1) and when CORE was added to NC1, the supplemental phytase was removed (CORE1). For d 21–42, the third phase was a corn-soy basal diet that included phytase and 3.5% added fat (NC2), and 0.3% CORE replaced the phytase and 2.5% added fat (CORE2). There were 462 weaned pigs used with an average BW of 5.2 kg with 22 pigs/pen and 10 to 11 replications/treatment in a commercial scale nursery research facility. At the beginning of the trial pigs were randomly assigned to their dietary treatment. Pens of pigs were weighed and feed disappearance was measured to calculate ADG, ADFI, and F:G for d 0, 21, and 42. Data were analyzed as a randomized complete block design using GLM procedure in Minitab with Fisher's LSD test to determine differences between dietary treatments. For d 0–21, the pigs fed CORE1 had a 7.7% higher ADG ($P = 0.024$) compared to pigs fed NC1. There was a tendency ($P = 0.090$) for pigs fed CORE1 to have a 5.9% higher ADFI than NC1. For d 21–42, where 0.3% CORE replaced both supplemental phytase and 2.5% added fat, ADG tended to increase by 5.1%. In conclusion, the addition of CORE to a highly digestible nursery diet, replacing supplemental phytase, resulted in improved ADG and ADFI, and, in late nursery, CORE successfully replaced supplemental phytase and 2.5% of added fat with no loss of performance.

**Table 220.** Summary of Day 0–21

| | ABF | AVI | CT | CARB | SE | *P*-value |
|---|---|---|---|---|---|---|
| BW, kg | 10.7[a] | 11.0[a] | 11.4[b] | 11.0[a] | 0.3 | 0.001 |
| ADG, g | 232[a] | 254[b,c] | 272[c] | 248[a,b] | 18 | 0.002 |
| ADFI, g | 310[a] | 324[a,b] | 341[b] | 315[a] | 21 | 0.037 |
| FCR | 1.34 | 1.28 | 1.26 | 1.27 | 0.12 | 0.541 |
| % morbidity/pen | 1.66 | 0.46 | 0.00 | 0.43 | 1.64 | 0.244 |
| % mortality/pen | 1.72[a] | 0.00[b] | 0.00[b] | 0.40[b] | 1.03 | 0.009 |

**Key Words:** multi-enzyme and probiotic blend, nursery pigs, performance
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## 222 Effects of dietary salt concentration on performance of 7 to 10 Kg nursery pigs.

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Two experiments evaluated the effects of added salt and Na on growth performance of 7 to 10 kg pigs. In both experiments, pigs were weaned at 21 d of age and allotted to pens by BW and gender in a randomize block design. After a 7-d common period, experimental diets were fed for 14 d. In Exp. 1, 325 barrows (DNA 200 × 400; initially 6.6 kg BW) were assigned to 1 of 5 dietary treatments with 13 replications/treatment and 5 pigs/pen. Dietary treatments included 10% dried whey, corn-soybean meal-based diets with 0, 0.2, 0.4, 0.6, or 0.8% added salt. Increasing salt increased (linear, $P = 0.015$) ADG (194, 216, 234, 254, and 253 g/d, respectively) and ADFI (309, 305, 319, 326, and 334 g/d, respectively) while G:F (0.626, 0.705, 0.732, 0.779, and 0.758, respectively) improved (quadratic, $P = 0.019$) up to 0.6% added salt (0.37% Na and 0.75% Cl). In Exp. 2, 360 pigs (DNA 241 × 600; initially 6.9 kg BW) were assigned to 1 of 4 dietary treatments with 15 replications/treatment and 6 pigs/pen. Four experimental diets included a 10% dried whey diet with 0.6% added salt (0.37% Na and 0.75% Cl); or 3 diets with 7.2% crystalline lactose containing either: 0.35% added salt (0.18% Na and 0.47% Cl); 0.78% added salt (0.35% Na and 0.72% Cl); or 1.15% potassium chloride and 0.4% sodium bicarbonate (0.35% Na and 0.45% Cl). Pigs fed the dried whey diet with 0.6% added

**Table 221.** Summary of performance data

| Day 0–21 | NC1 | CORE111 | SE | *P*-value |
|---|---|---|---|---|
| D 21 BW, kg | 11.3[a] | 11.8[b] | 0.4 | 0.015 |
| ADG, g | 291[a] | 313[b] | 19 | 0.024 |
| ADFI, g | 337[y] | 357[z] | 24 | 0.090 |
| F:G | 1.16 | 1.14 | 0.041 | 0.648 |
| Day 21–42 | NC2 | CORE2 | SE | *P*-value |
| D 42 BW, kg | 22.4[a] | 23.3[b] | 0.8 | 0.035 |
| ADG, g | 527[y] | 554[z] | 31 | 0.083 |
| ADFI, g | 746[a] | 817[b] | 53 | 0.015 |
| F:G | 1.42[a] | 1.48[b] | 0.033 | 0.003 |

salt or crystalline lactose diet with 0.78% added salt had increased ($P = 0.05$) ADG compared to pigs fed crystalline lactose with 0.35% added salt. Pigs fed the dried whey diet with 0.6% added salt had greater ($P = 0.05$) ADFI than those fed the crystalline lactose diet with 0.35% added salt, with other treatments intermediate. There was no evidence that feed efficiency was affected by dietary treatment. In conclusion, ADG and ADFI of 7 to 10 kg pigs were enhanced with a dietary Na concentration of at least 0.35%.

**Key Words:** Na, nursery pig, salt
doi: 10.2527/asasmw.2017.12.222

**223 Evaluation of nursery diet complexity on growth performance and carcass traits of pigs.** A. Tekeste*, H. Manu, P. Ren, D. Pangeni, B. Tostenson, X. Yang, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca.*

The study was conducted to investigate the effect of nursery diet complexity on growth performance and carcass traits of pigs. A total of 126 piglets (initial BW 6.30 ± 0.68 kg and 18 d old) were blocked by body weight and randomly allotted to 1 of 3 treatments, with 7 pigs/pen and 6 pens/treatment. In the nursery period (weeks 1–2, 3–4, 5–6 as phases 1, 2, and 3, respectively), piglets were fed 1 of 3 experimental diets: (1) positive control (PC; with spray-dried porcine plasma, fishmeal, antibiotics, and zinc oxide), (2) PC without antibiotics (PC-AB), and (3) negative control (NC; without spray-dried porcine plasma, fishmeal, antibiotics, zinc oxide). During the growing-finishing period, pigs were fed common diets containing no animal proteins and antibiotics. Data were analyzed using mixed model of SAS, with treatment as fixed effect and block as random effect. Tukey test was used for multiple comparisons. In phase 1, the NC group had lower ($P < 0.05$) ADG, ADFI than the other two groups and lower ($P < 0.05$) G:F compared with the PC group. The NC pigs ate less ($P < 0.05$) and tended ($P < 0.10$) to gain less than the PC-AB pigs in phase 2, Nevertheless, the NC group had higher ($P < 0.05$) G:F than the PC group in phases 2 and 3. During the entire nursery period, the NC group had lower ($P < 0.05$) ADG and ADFI than the PC-AB group, but no difference ($P > 0.05$) in G:F was observed among treatments. For the overall experimental period, the NC group ate less ($P < 0.05$) than the other two groups, and tended ($P < 0.10$) to have lower ADG relative to the PC group, but there were no effects ($P > 0.05$) of dietary treatments on feed efficiency. No difference ($P > 0.05$) on growth performance during the entire nursery phase and the whole experiment period was noticed between the PC and PC-AB groups. For the whole nursery period, ADG was 494, 532, 457 g/d, ADFI was 727, 763, 656 g/d, and G:F was 0.681, 0.698, 0.697 for the PC, PC-AB, and NC groups, respectively. Dietary treatments did not impact ($P > 0.05$) carcass characteristics. In conclusion, feeding simple nursery diets had a negative impact on growth performance in the nursery period, which could be carried over to the growing-finishing period.

**Table 222.**

| Exp. 2 (d 0–14): | | | | | | |
|---|---|---|---|---|---|---|
| Lactose source: | Whey | Lactose | Lactose | Lactose | | |
| Na source: | 0.6% salt | 0.35% salt | 0.78% salt | KCl and $NaHCO_3$ | SEM | $P <$ |
| ADG, g | 281[a] | 251[b] | 287[a] | 270[ab] | 9.5 | 0.038 |
| ADFI, g | 445[a] | 390[c] | 427[ab] | 408[bc] | 11.2 | 0.004 |
| G:F, g/kg | 631 | 643 | 671 | 661 | 13 | 0.075 |

[abc] Means with different superscripts differ $P < 0.05$.

**Key Words:** carcass traits, growth performance, nursery diet complexity
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**224 Effects of mixture of organic acids and medium chain fatty acids on growth performance, diarrhea incidence, and fecal microbial flora in weaning pigs orally challenged with enterotoxigenic *Escherichia coli* K88.** D. H. Nguyen*, X. J. Lei, J. W. Park, D. H. Baek, I. H. Kim, *Department of Animal Resource and Science, Dankook University, Cheonan, South Korea.*

The experiment was conducted to evaluate the effects of mixture of organic acids (OAs) and medium chain fatty acids (MCFAs) on the growth performance, fecal microbial flora, and diarrhea score in weaning pigs challenged with enterotoxigenic *Escherichia coli* K88. A total of 30 weaning pigs (28 ± 1 d of old, 6.24 ± 0.36 kg) were randomly divided into 1 of 3 dietary treatments on the basis of initial body weight (BW) and sex (5 replicate pens per treatment with 1 barrow and 1 gilt per pen). The dietary treatments were: (1) CON, basal diet; (2) CON + 0.2% mixture of OAs and MCFAs (MOM2); 3) CON + 0.4% mixture of OAs and MCFAs (MOM4). The mixture of OAs and MCFAs used in the experiment was provided by a commercial company (Morningbio Co., Ltd., Cheonan, South Korea). The active ingredients were 17% fumaric acid, 13% citric acid, 10% malic acid, and 1.2% MCFAs (capric and caprylic acid). During d 8 to 10, pigs were orally challenged with 5 mL enterotoxigenic *Escherichia coli* K88 ($10^9$ CFU/mL). Individual BW and feed consumption on the pen basis were recorded at the beginning, d 7, d 14, and d 21 to obtain average daily gain (ADG), average daily feed intake (ADFI), and gain to feed ratio (G:F), respectively. Throughout the experiment, compared with CON treatment, MOM2 and MOM4 groups had increased ($P < 0.05$) ADG, ADFI, and G:F with the exception of G:F during d 8 to 14. During pre- and post-challenge (d 8 to 14), the diarrhea score was lower ($P < 0.05$) in MOM2 (3.25 and 3.61, respectively) and MOM4 (3.25 and 3.68, respectively) treatments than that in CON (3.50 and 4.29, respectively) treatment. However, diarrhea score did not differ between dietary treatments between d 15

and 21 ($P > 0.05$). Fecal *Escherichia coli* concentration was decreased ($P < 0.05$) in pigs fed MOM2 (7.25 log10 CFU/g) and MOM4 (7.27 log10 CFU/g) diets when compared with those fed CON (7.42 log10 CFU/g) diet. Results indicated that dietary supplementation with the blend of OAs and MCFAs at the levels of 0.2% or 0.4% improved growth performance and reduced diarrhea as indicated by reduced diarrhea score and reduced fecal *Escherichia coli* in weaning piglets that orally challenged with enterotoxigenic *Escherichia coli* K88.

**Key Words:** growth performance, *Escherichia coli* K88, organic acids and medium chain fatty acids
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## 225 Effects of feeding a finishing diet blended with different phases of nursery diets on growth performance of nursery pigs.

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In wean-to-finish systems, nursery diets are commonly blended with leftover finishing feed from the previous group. A total of 1260 pigs (initially 5.83 ± 0.21 kg and 21 d) were housed in a commercial research facility and used in a 47-d study to determine the effects of blending finishing diet into different phases of nursery diets on growth performance. Pens of pigs were blocked by BW and gender and allotted to 1 of 4 treatments (15 pens/treatment). Treatments included: standard nursery diets throughout (Control); or standard diets with 2.5 kg/pig of late finishing feed (0.81% SID Lys) blended at the beginning of Phase 2, 3, or 4. Phase changes were based on feed budgets of 2.5, 3.7, 3.7, 9.5, and 9.5 kg/pig in phase 1 to 5, respectively. Feed additions were recorded by robotic feeding system. Data were analyzed using GLIMMIX in SAS with fixed effect of blending phase and random effects of weight block and gender. From d 0 to 7, all pigs were fed the same Phase 1 diet and had similar performance. Compared with the control, blending finishing feed into Phase 2 decreased ($P < 0.05$) ADG, ADFI, and G:F from d 7 to 14, G:F from d 21 to 28, ADG from d 28 to 35, and ADFI and G:F from d 35 to 47. Blending finishing feed into Phase 3 decreased ($P < 0.05$) ADG and G:F from d 14 to 21, ADG from d 21 to 28, and ADFI and G:F from d 35 to 47 compared with control pigs. Pigs that received finishing diet blended in Phase 4 had decreased ($P < 0.001$) ADG and G:F from d 21 to 28, but increased ($P = 0.013$) G:F from d 35 to 47. Overall, blending the finishing diet into Phase 2 decreased ($P < 0.05$) ADG and ADFI, but did not affect G:F compared with control pigs or those that had blended diet in Phase 4. Blending finishing feed into Phase 3 or 4 did not influence overall growth performance. In conclusion, feeding finishing feed during early nursery phase decreased growth performance; however, blending approximately 2.5 kg/pig of late finishing feed into nursery diets for pigs greater than 10 kg did not affect overall growth performance.

**Key Words:** feed blending, growth, nursery pig
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## 226 Soluble fiber improved growth performance of weaned pigs challenged with enterotoxigenic *Escherichia coli*.

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Our objective was to evaluate the effects of soluble (10% beet pulp) versus insoluble dietary fiber (15% low-fat corn DDGS) with or without addition of exogenous carbohydrases on fecal score and shedding as well as performance of piglets challenged with enterotoxigenic *Escherichia coli* (ETEC). Sixty piglets (approximately 21-d age; 6.90 ± 0.07 kg) were randomly allotted to 6 treatments including: 1) NC: non-challenged negative control, 2) PC: F18 ETEC challenged positive control (NE = 2.68 Mcal/kg), 3) SF: soluble fiber + ETEC (NE = 2.53 Mcal/kg), 4) IF: insoluble fiber + ETEC (NE = 2.50 Mcal/kg), and 5, 6) SF or IF with enzymes + ETEC. The soluble fiber content in control, SF, and IF was 3.20, 5.43, and 2.87%, and 5.04, 9.56, and 10.16% for insoluble fiber, respectively. Pigs were orally challenged with ETEC on d 7 (0 d post-inoculation, dpi). Pigs were housed individually to record individual BW and feed intake on d 7, 10, and 14. Fecal swabs were collected to evaluate viable ETEC shedding score (SS: ranged from 0–4 with increasing shedding). Fecal scores (FS) were visually ranked every 2 d pre-challenge and daily post-challenge using 4 scales: 1 = solid; 4 = liquid. Fecal score were analyzed using a multinomial model in PROC GENMOD and all other data were analyzed using PROC MIXED of SAS (9.4). Pigs in PC had lower final BW (8.57 vs.9.90 kg) and overall ADG (128 vs.218 g) than NC ($P < 0.05$). The SF improved ADG from 4–7 dpi (333 vs.182 g) and overall ADG (224 vs.128 g) compared with PC ($P < 0.05$). The SF and IF improved G:F pre-challenge ($P < 0.01$) and SF tended to improve G:F post-challenge ($P < 0.10$). Enzymes had no impact on growth ($P > 0.05$). The average SS in NC was lower than PC (0 vs. 2.46; $P < 0.01$). The IF tended to increase SS on 3 dpi (3.05 vs.2.00; $P = 0.065$) and decreased SS on 7 dpi (1.85 vs.3.13; $P < 0.05$) compared to PC. Pigs in SF tended to have a lower SS on 7 dpi (2.10 vs.3.13; $P = 0.071$) than PC. The SF reduced SS on 3 and 5 dpi compared with IF ($P < 0.05$). During 1–3 dpi, the odds ratio (OR) of NC in lower FS category

**Table 225.**

| | | Blended diets | | | | |
|---|---|---|---|---|---|---|
| | Control | Phase 2 | Phase 3 | Phase 4 | SEM | *P*-value |
| Overall | | | | | | |
| ADG, g | 514[a] | 493[b] | 502[ab] | 509[a] | 5.4 | 0.031 |
| ADFI, g | 736[a] | 711[b] | 720[ab] | 738[a] | 8.3 | 0.045 |

[ab]Means with different superscripts within row differ ($P < 0.05$)

was 3.96 times higher than IF ($P < 0.01$). From 4–7 dpi, IF, but not SF, reduced the lower FS OR of PC by 54% ($P < 0.05$). In conclusion, SF, but not IF, regardless of enzyme addition, improved performance of pigs challenged with F18 ETEC, without affecting fecal ETEC shedding and fecal scores.

**Key Words:** dietary fiber, *E. coli*, enzymes,
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**227 Compensatory body protein gain in newly weaned pigs.** A. D. Totafurno*, W. D. Mansilla, D. Wey, I. B. Mandell, C. F. M. de Lange, *Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada.*

The concept of compensatory growth (CG) represents a means to improve nutrient utilization and decrease costs in pork production. While CG can occur following a period of amino acid intake restriction, there is limited work examining CG in newly weaned pigs. A serial slaughter study was conducted to determine effects of Lys restriction immediately following weaning on growth performance and carcass composition. 144 Duroc x Yorkshire x Landrace pigs (initial BW of 6.9 ± 0.21 kg) were randomly allocated to one of three dietary treatments (6 pens/treatment with 8 pigs/pen; 4 barrows, 4 gilts). For 3 wk (restriction phase), pigs were fed starter diets containing 110% (Control: 15.6 g/kg), 80% (Lys80: 11.3 g/kg), or 60% (Lys60: 8.5 g/kg) of NRC (2012) requirements for Lys. After the restriction phase, all pigs were fed a common grower diet containing 120% of NRC (2012) requirements for Lys (14.6 g/kg) for 6 wk (recovery phase). During the restriction phase, pig BW gain ($P < 0.01$; 411, 373, and 319 ± 7.5 g/d, respectively for Control, Lys80, Lys60) and G:F ($P < 0.01$; 0.807, 0.716, and 0.631 ± 0.0123, respectively) decreased linearly with decreasing dietary Lys levels. At end of the restriction phase, there was a significant linear decrease in BW with decreasing dietary Lys levels ($P < 0.01$; 15.5, 14.8, and 13.6 ± 0.37 kg, respectively). In addition, there was a linear decrease in carcass weight ($P < 0.01$; 11.6, 10.9, and 10.3 ± 0.30 kg, respectively) and carcass CP content ($P < 0.01$; 16.5, 16.1, and 15.3 ± 0.19%, respectively) with decreasing dietary Lys levels in pigs slaughtered at end of restriction phase. Following completion of the recovery phase there was a trend for a linear increase in BW gain ($P = 0.06$; 844, 862, and 905 ± 19.9 g/d, respectively) and a linear increase in G:F ($P < 0.01$; 0.529, 0.552, and 0.569 ± 0.0101, respectively) with decreasing dietary Lys levels. Carcass weight ($P > 0.10$; 40.5, 40.3, and 39.6 ± 0.80 kg, respectively) and carcass CP content ($P > 0.10$; 16.8, 17.4, and 17.1 ± 0.18%, respectively) were similar across dietary treatments in pigs slaughtered at end of recovery phase. At the end of the study, BW (average of 50.5 ± 0.63 kg) was similar ($P > 0.10$) across dietary treatments. In conclusion, newly weaned pigs previously fed a diet restricted in Lys for 3 wk, achieved full CG after a 6 wk recovery period.

**Key Words:** compensatory growth, lysine restriction, piglets
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**228 Supplemental effects of fermented rice bran extracts on gut health and growth of nursery pigs.** L. Zheng*, M. E. Duarte, I. Park, S. W. Kim, *North Carolina State University, Raleigh.*

The objective of this experiment was to evaluate the supplemental effects of fermented rice bran extract (FBE, Maxcell Co., Los Angeles, CA) on growth performance, fecal score, intestinal morphology, and oxidative stress in nursery pigs. Rice bran was fermented with sucrose sources by a mixture of probiotics (*Lactobacillus plantarum*, *Bacillus subtilis*, and *Saccharomyces cerevisiae*) producing metabolites. Thirty pigs (15 barrows and 15 gilts at 6.7 ± 0.2 kg BW) were allotted in a randomized complete block design with sex and initial BW as blocks and randomly assigned to 3 treatments. Pigs were fed a basal diet supplemented with FBE at the level of 0, 5, or 10 g/kg based on 2 phases (7 and 18 d, respectively). Body weight and feed consumption were recorded on d 7, 14, 21, and 25. Fecal scores were determined to measure diarrhea severity, duodenal and jejunal mucosa samples were collected for analysis of oxidative stress, and immune responses, and jejunum segments were collected for morphology evaluation. Data were analyzed using the Mixed procedure of SAS. Increasing levels of FBE increased ADG (400 to 547 g/d, quadratic, $P < 0.05$) from d 14 to 21. Increasing levels of FBE tended to increase BW on d 21 (11.3 to 12.4 kg, quadratic, $P = 0.062$) and d 25 (13.5 to 14.7 kg, quadratic, $P = 0.064$), respectively. Increasing dietary FBE tended to increase ADFI (234 to 243 g/d, linear, $P = 0.095$) from d 0 to 14. Over the entire 25 d, increasing levels of FBE tended to increase ADG (271 to 320 g/d, quadratic, $P = 0.078$). Increasing levels of FBE decreased fecal scores (1.35 to 1.09, linear, $P < 0.05$) on d 5, during phase 1. Increasing levels of FBE increased villus height:crypt depth (2.1 to 2.4, linear, $P < 0.05$) in the jejunum. Increasing levels of FBE decreased malondialdehyde (0.75 to 0.58, μmol/g protein, linear, $P < 0.05$) and protein carbonyl (1.89 to 1.26 nmol/mg protein, linear, $P < 0.05$) in the duodenal mucosa whereas tended to decrease protein carbonyl (1.92 to 1.53 nmol/mg protein, linear, $P = 0.094$) in the jejunal mucosa. Supplementation of FBE did not affect the concentrations of immunoglobulin A and tumor necrosis factor-α in the duodenal and jejunal mucosa. In conclusion, dietary supplementation of FBE may have beneficial effects on growth performance by decreasing diarrhea occurrence, and potentially by reducing oxidative stress in the small intestine of nursery pigs.

**Key Words:** fermented rice bran extracts, gut health, nursery pigs
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**229 Use of wheat gluten in nursery diets.**
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Wheat gluten (WG) is a high protein ingredient (75% CP) that is commonly used in pet food and milk replacers, but not commonly used in swine diets. An experiment was conducted to evaluate the optimal level of WG inclusion in phase 1 diets as a partial replacement for plasma protein (PP) and fish meal (FM). Pigs ($n$ = 135, BW = 6.1 + 0.1 kg, 45 pens, 3 pigs/pen) were weaned at approximately 21 d and blocked according to weight. All diets were formulated to meet or exceed the 2012 NRC standards. All phase 1 diets had 1.50% SID Lysine and contained 27.5% whey. There were 5 dietary treatments: 1) PC (5% PP, 5% FM), 2) NC (2.5% PP, 2.5% FM), 3) NC+2.5% WG, 4) NC + 5% WG, and 5) NC + 7.5% WG. WG was added at the expense of corn. Test diets were fed for 14 d post-weaning, followed by a common phase 2 diet for an additional 7 d. The phase 2 common diet had 1.35% SID Lysine, 10% whey, and 3% FM. The study was conducted as a randomized complete block design with a positive control. Contrast statements were used to determine linear and quadratic effects of WG. Overall (0–21 d), there was a quadratic effect of the level of WG on ADG (356, 398, 377, and 362 g/d for pigs fed 0, 2.5, 5, and 7.5% WG respectively, $P < 0.05$). Pigs fed the NC had reduced ADG compared to the PC treatment (356 vs. 394 g/d, $P < 0.05$). There was a quadratic effect of level of WG on ADFI (432, 471, 446, and 433, respectively for pigs fed 0, 2.5, 5, and 7.5% WG, $P < 0.05$). Pigs fed the NC had reduced intake compared to those fed the PC (432 g/d vs. 471 g/d, $P < 0.05$). There was no effect of diet on G:F. In this study, 2.5% WG was the optimal level of inclusion. The results indicate that reduction in the content of PP and FM in the phase 1 diet results in a loss of performance which was restored with the addition of 2.5% WG.

**Key Words:** growth performance, nursery pigs, wheat gluten
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**230 Effects of dietary standardized ileal digestible Ile:Lys ratio on growth performance of 6 to 11 Kg pigs.**
A. B. Clark[1,*], M. D. Tokach[1], J. M. DeRouchey[1], S. S. Dritz[1], K. J. Touchette[2], R. D. Goodband[1], J. C. Woodworth[1], [1]*Kansas State University, Manhattan,* [2]*Ajinomoto Heartland, Inc., Chicago, IL.*

Two experiments evaluated standardized ileal digestible (SID) Ile:Lys on nursery pig growth performance. In Exp. 1, 280 pigs (PIC 327 × 1050, 6.7 kg BW) were fed experimental diets for 12 d with 8 replications and 5 pigs/pen. In Exp. 2, 280 pigs (DNA 600 × 241, 6.0 kg BW) were fed experimental diets for 18 d with 8 replications and 5 pigs/pen. Pens were allotted in a randomized complete block design to 1 of 7 treatments containing 40, 44, 48, 52, 54, 58, or 63% SID Ile:Lys. Dietary SID Lys was 1.28 and 1.24% for Exp. 1 and 2, respectively. Diets contained 1.5% spray dried blood cells and 10% field peas. Responses were evaluated with base models and dose response best fitting models. In Exp. 1, ADG increased linearly and ADFI and G:F had quadratic responses as SID Ile:Lys increased. For ADG, quadratic (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) dose response models had similar fits reporting maximum ADG at 64.7, 52.0, and 52.0% SID Ile:Lys, respectively. For ADFI, BLL breakpoint occurred at 50.6% and QP maximum at 56.2% SID Ile:Lys. In Exp. 2, ADG and ADFI increased quadratically as SID Ile:Lys increased. For ADG, BLL and QP had similar fits with maximums at 51.8% and 58.3% SID Ile:Lys, respectively. For ADFI, QP maximum was 57.2% SID Ile:Lys and BLQ breakpoint at 52.0% SID Ile:Lys. In summary, the SID Ile:Lys requirement for 6 to 11 kg pigs ranges from 52% for ADG and ADFI using broken line models to as high as 64% using quadratic models.

**Key Words:** isoleucine, nursery pigs, swine
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**231 Effects of replacing an enzymatically modified soybean meal (HP300) with a corn/yeast protein by-product (Gold Pro) on performance and health status of nursery pigs.**
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The objective was to evaluate complete replacement of enzymatically modified soybean meal (HP300, HP) with a corn/yeast protein by-product (Gold Pro, GP) during Days 0-21 post-weaning on performance and health of 1009 weaned pigs with an average BW of 6.1 kg (SE ± 0.11) with 27-31 pigs/pen and 6-8 replications/treatment in a large scale commercial research facility equipped with a Fancom feeding system. Pigs were blocked by BW, sex, sow farm, location within barn, and immediately on arrival were randomly allocated to one of five meal dietary treatments: 100HP (100%HP), 25GP (75%HP:25%GP), 50GP (50%HP:50%GP), 75GP (25%HP:75%HP), and 100GP (100%GP). All diets were formulated to meet NRC 2012 requirements. Gold Pro replaced HP300 on lb for lb basis in the ration and synthetic amino acids, minerals, and fat were added to ensure all diets were equal and met NRC 2012 requirements. Pens of pigs were weighed and feed disappearance recorded on d 0, 21, and 49, which were used to calculate ADG, ADFI, and G:F. Pigs that did not respond to injectable antibiotics were removed, tagged, and placed in sick pens. At the end of the experiment, the dead (% mortality) and pulled (% morbidity) pigs were determined. Injectable treatments were recorded daily. Data were analyzed as a randomized complete block design using GLM procedure in Minitab with Fisher's LSD to determine differences between dietary treatments. For d 0–49, there were no differences ($P = 0.113$) observed for ADG. Pigs fed 100GP had a greater overall G:F ($P = 0.027$) compared to all other treatments. Improved G:F occurred during d 21–49, when all pigs were on a

**Table 230.**

| | SID Ile:Lys, % | | | | | | | Probability, $P <$ | |
|---|---|---|---|---|---|---|---|---|---|
| Item: | 40 | 44 | 48 | 52 | 54 | 58 | 63 | Linear | Quadratic |
| Exp. 1 | | | | | | | | | |
| ADG, g[1] | 330 | 344 | 342 | 388 | 344 | 358 | 375 | 0.005 | 0.418 |
| ADFI, g[2] | 495 | 524 | 546 | 601 | 522 | 574 | 555 | 0.002 | 0.017 |
| G:F[3] | 0.669 | 0.657 | 0.628 | 0.648 | 0.658 | 0.625 | 0.676 | 0.904 | 0.043 |
| Exp. 2 | | | | | | | | | |
| ADG, g[4] | 229 | 247 | 266 | 306 | 263 | 286 | 282 | 0.001 | 0.016 |
| ADFI, g[5] | 331 | 370 | 393 | 453 | 395 | 421 | 410 | 0.001 | 0.003 |
| G:F[2] | 0.690 | 0.671 | 0.679 | 0.677 | 0.666 | 0.682 | 0.687 | 0.935 | 0.228 |

[1]SEM = 8.8 for 40, 48, 52, and 54% and 14.0 for 44, 58, and 63% SID Ile:Lys.v[2]SEM = 16.6 for ADFI, Exp. 1 and 0.0146 for G:F, Exp. 2
[3]SEM = 0.0096 for 54% SID Ile:Lys and 0.0160 for other treatments.
[4]SEM = 3.5 for 48% SID Ile:Lys and 11.5 for other treatments.
[5]SEM = 7.9 for 48% SID Ile:Lys and 17.3 for another treatments.

**Table 231.** Summary of Day 0 to 49

| | 100HP | 25GP | 50GP | 75GP | 100GP | SE | *P*-value |
|---|---|---|---|---|---|---|---|
| ADG, g | 500 | 518 | 501 | 519 | 495 | 21 | 0.113 |
| ADFI, g | 742[a,b] | 772[a] | 740[a,b] | 770[a] | 715[b] | 31 | 0.022 |
| G:F | 0.675[a] | 0.671[a] | 0.677[a] | 0.675[a] | 0.692[b] | 0.011 | 0.027 |
| % Morbidity/pen | 1.99 | 3.04 | 2.43 | 5.22 | 3.71 | 2.62 | 0.193 |
| % Mortality/pen | 4.01 | 3.93 | 3.78 | 3.87 | 2.85 | 3.75 | 0.984 |
| Treats/pen | 51.6[a] | 38.1[b] | 43.6[a,b] | 35.9[b] | 35.7[b] | 9.8 | 0.047 |

common diet, where pigs fed 100GP had a greater G:F ($P$ = 0.011; 0.653 vs. 0.634) than 100HP. No differences were observed for d 0–49% mortality/pen or % morbidity/pen. Pigs fed 100GP had 30% less antibiotic treatments per pen ($P$ = 0.047) compared to 100HP. In conclusion, using Gold Pro to replace HP300 in nursery starter rations led to improved overall G:F and a 30% reduction in individual antibiotic treatments.

**Key Words:** health status, nursery diet protein, performance
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**232 Effect of a new 6-phytase, Natuphos E, on piglet performance, ileal digestibility, and bone mineralization.** D. Torrallardona[1], M. Coelho[2,*], P. Ader[3], *[1]IRTA, Monogastric Nutrition, Constanti, Spain, [2]BASF, Humble, TX, [3]BASF SE, Lampertheim, Germany.*

The efficacy of a new phytase product (Natuphos E) at different doses was evaluated on performance, nutrient digestibility, and bone mineralization of piglets. 120 newly weaned piglets ([Duroc x Landrace] x Pietrain; 26 d of age; 7.3 kg BW) were randomly distributed by initial body weight into 40 pens (3 piglets per pen) according to a randomized block design with 8 blocks and 5 treatments. Experimental treatments consisted of a positive control diet (PC) with adequate levels of Ca and P, a negative control basal diet (NC) with limiting levels of Ca and P, and the same NC diet supplemented with 125, 250, or 500 FTU/kg of Natuphos E. Performance was measured at 21 and 42 d. Between d 18 to 21, fresh feces were obtained from each pen and the apparent total tract digestibility (ATTD) of ash, Ca, and P was measured using $TiO_2$ as indigestible marker. Finally, at d 42, one piglet per pen was euthanized and the front left hoof was obtained to measure dry matter and ash contents in *Os metacarpale III*. Phytase supplementation improved performance, mineral ATTD and bone mineralization in NC, and similar values to PC were achieved (see Table 232). In conclusion, the new phytase under study improves performance, Ca and P digestibility, and bone mineralization in piglets fed Ca and P limiting diets.

**Key Words:** bone ash, novel 6-phytase, piglets
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**233 Influence of diet contaminated with deoxynivalenol (DON) on lactating sow and litter performance.** K. L. Herkelman*, R. E. Hall, Y. Martel-Kennes, *Cooperative Research Farms, Richmond, VA.*

The objective of this experiment was to evaluate the effects of increasing concentrations of deoxynivalenol (DON) in sow lactation diets on sow and litter performance. A total of 93 primiparous and multiparous hybrid sows were blocked based on parity (first, second, and third or more), weight, and backfat thickness and assigned to one of three treatments. Sows were randomly assigned to lactation diets with less than 0.5, 1.5, or 3.0 ppm DON. Lactation diets were based on 2 sources of wheat with similar nutrient composition and analyzed concentrations of < 0.5 ppm and 6.8 ppm DON. Proportions of these 2 sources were varied to achieve lactation diets with < 0.5, 1.5, and 3.0 ppm DON. Sows were fed their respective lactation diet from the time they entered

**Table 232.** Average daily growth, gain to feed ratio, nutrient ATTD, and bone ash content and weight

| | PC | NC | 125 FTU | 250 FTU | 500 FTU | Root MSE | *P*-value |
|---|---|---|---|---|---|---|---|
| ADG 0 to 21, g | 270 | 241 | 293 | 257 | 285 | 48 | 0.23 |
| GFR 0 to 21 | 0.70 | 0.63 | 0.74 | 0.69 | 0.69 | 0.07 | 0.06 $^{Q}$ |
| ADG 21 to 42, g | 527$^{ab}$ | 418$^{c}$ | 494$^{b}$ | 493$^{b}$ | 559$^{a}$ | 40 | < 0.01 $^{L}$ |
| GFR 21 to 42 | 0.62$^{a}$ | 0.57$^{b}$ | 0.62$^{a}$ | 0.59$^{ab}$ | 0.62$^{a}$ | 0.03 | 0.04 $^{L}$ |
| ADG 0 to 42, g | 398$^{ab}$ | 329$^{c}$ | 393$^{ab}$ | 375$^{b}$ | 422$^{a}$ | 38 | < 0.01 $^{L}$ |
| GFR 0 to 42 | 0.64$^{a}$ | 0.59$^{b}$ | 0.66$^{a}$ | 0.62$^{ab}$ | 0.64$^{a}$ | 0.04 | 0.01 |
| ATTD ash, % | 59.2$^{b}$ | 58.1$^{b}$ | 59.2$^{b}$ | 64.0$^{a}$ | 65.9$^{a}$ | 3.7 | < 0.01 $^{L}$ |
| ATTD Ca, % | 54.2$^{bc}$ | 51.3$^{c}$ | 57.9$^{b}$ | 69.3$^{a}$ | 68.6$^{a}$ | 4.3 | < 0.01 $^{L,Q}$ |
| ATTD P, % | 41.2$^{a}$ | 9.8$^{d}$ | 21.0$^{c}$ | 33.3$^{b}$ | 42.0$^{a}$ | 6.8 | < 0.01 $^{L,Q}$ |
| Bone ash, g | 1.12$^{a}$ | 0.56$^{d}$ | 0.78$^{c}$ | 0.88$^{bc}$ | 1.03$^{ab}$ | 0.14 | < 0.01 $^{L}$ |
| Bone dry Wt, g | 2.65$^{ab}$ | 1.85$^{c}$ | 2.37$^{b}$ | 2.46$^{ab}$ | 2.81$^{a}$ | 0.36 | < 0.01 $^{L}$ |

$^{L, Q}$ = linear and quadratic response to phytase addition in NC diets

the farrowing room (approximately Day 110 of gestation), until weaning (20 d of lactation, on average). Increasing concentrations of DON in sow lactation diets linearly ($P < .05$) decreased total (121.3, 118.5, and 107.8 kg ± 3.1) and average daily sow feed intake (5.97, 5.95, and 5.20 kg/d ± 0.15), sow weaning weight (242.3, 240.6, and 231.6 kg ± 3.2), and backfat depth at weaning (16.3, 15.7, and 15.1 mm ± 0.3). Sow weight loss (7.1, 9.9, and 15.1 kg ± 1.7) and backfat depth loss (1.51, 2.15, and 2.51 mm ± 0.28) during lactation increased linearly ($P < 0.05$) as DON levels in the lactation diet increased. The concentration of DON in the lactation diet had no effect ($P > 0.05$) on litter size at weaning, litter performance, or pig performance during lactation. Sow health and reproductive performance during lactation was not ($P > .05$) influenced by DON levels in the lactation diet. In conclusion, increasing levels of DON in sow lactation diets decreases feed intake, increases sow body weight loss, and increases backfat loss during lactation, although pig performance does not appear to be influenced.

**Key Words:** deoxyvinalenol, lactation, sows
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**234 The effect of dietary protein for lactating sows on sow body composition and metabolism.**

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The aim of the study was to determine the effect of increased dietary protein for lactating sows on sow body composition and metabolism. Six dietary treatments with increasing concentrations of standardized ileal digestible (SID; Pedersen and Boisen, 2002) CP (104, 114, 121, 129, 139, and 150 g/kg), and Lys (5.9, 6.5, 7.0, 7.5, 8.3 and 9.0 g/kg) was fed to sows from d 2 postpartum until weaning (d 26). The ratio of dietary Met, Thr, Trp, and Val to Lys was 31, 61, 20, and 72%. Seventy-two sows (parity 2 and 3) were randomly allocated to one of the six diets and all litters were standardized to 14 piglets at d 2 postpartum. Blood samples were collected weekly and centrifuged for 10 min (1560 x *g*) at room temperature before the plasma was analyzed for glucose, lactate, NEFA, creatinine, and urea N. On Day 2 postpartum and at weaning (d 25) body water content was measured using the deuterium oxide dilution technique. Contents of body fat, protein, and ash were estimated from body water, BW, and BF using equations by Rozeboom et al. (1994). The trial was a complete block design (12 blocks of 6 sows) and in the statistical analysis the individual dietary SID CP concentration of each sow was used as input. Data were analyzed using linear and linear broken-line models that were compared using Akaike information criteria. Sows on average weaned 13.0 ± 1.2 ($P = 0.31$) piglets and the ADFI was 6.3 ± 0.6 kg/d ($P = 0.36$) with no effect of treatment. Body water and protein loss decreased with increasing dietary SID CP until a breakpoint at 130 (3.1 kg; $P < 0.05$) and 126 g SID CP (0.69 kg; $P < 0.05$), respectively. Body fat loss was not affected by dietary treatment ($P = 0.46$), whereas body ash loss decreased linearly ($Y = 2.02 – 0.02 \times SID\ CP_{diet}$) with increasing dietary SID CP ($P < 0.01$). Plasma glucose, lactate, creatinine, and NEFA were not affected by dietary treatment ($P > 0.05$). Plasma urea N increased linearly with increased dietary SID CP in week 2 (4.1 ± 0.8 mmol/L), 3 (4.7 ± 0.9 mmol/L), and 4 (4.9 ± 1.1 mmol/L) of lactation ($P < 0.001$). In conclusion, increased dietary protein concentration increased BF loss but BW loss was decreased until breakpoints were reached. Loss of body water and mobilization of body protein and ash was minimized with increased dietary SID CP. The increase in plasma urea N reflected the increase in protein intake.

**Key Words:** blood metabolites, body composition, dietary protein
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**235 Increased dietary protein for lactating sows improved sow and litter performance.**

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The aim of the current study was to determine the effect of increased dietary protein for lactating sows on litter weight gain, sow BW, back fat, and milk composition. A total of 560 sows (parity 1 to 4) were randomly allocated to one of six diets with standardized ileal digestible (SID; Pedersen and Boisen, 2002) CP at 104, 114, 121, 129, 139, and 150 g/kg and Lys (5.9, 6.5, 7.0, 7.5, 8.3, and 9.0 g/kg). The proportion of dietary Met, Thr, Trp, and Val in relation to Lys was 31, 61, 20, and 72%. The study lasted from d 2 postpartum when litters were standardized to 14 piglets until weaning (d 25). Sow BW, back fat (BF) thickness, and litter weight were recorded at d 2 and at weaning. On a subsample of 12 sows per dietary group milk samples were obtained at Days 2, 10, and 17 post partum. Prior to milk sampling the litter was removed from the sow for 30 min where after an intramuscular injection with 2 mL oxytocin was given. Milk samples were analyzed for lactose, fat, and protein. The experimental design was a complete block design and in the statistical analysis the individual dietary SID CP concentration of each sow was used. Data were analyzed using linear and linear broken-line regression models. Litter size at weaning (13.0 ± 1.2; $P = 0.31$) and ADFI (6.3 ± 0.6 kg/d; $P = 0.36$) was unaffected by treatment. Body weight change of sows decreased until a breakpoint (−0.58 kg/day) at 143 g dietary SID protein/kg, whereas the back fat change reached a maximum (−3.0 mm) at 127 g SID protein/kg. The ADG of the litter was affected by parity ($P < 0.001$) (2.53 vs. 3.07 kg/d for first vs. multiparous sows), but maximum was reached at same breakpoint (135 g dietary SID protein/kg). Milk fat, lactose, and protein at d 3 (8.1 ± 1.8%, 5.2 ± 0.6% and 5.5 ± 0.6%) and 10 (7.3 ± 1.2%, 5.3 ± 0.6% and 5.0 ± 0.4%) were not affected by treatments ($P > 0.05$). Milk lactose at d 17 decreased until a breakpoint was reached at 5.3% lactose at 121 g SID protein/kg ($P < 0.01$). Milk fat ($Y = 4.42+0.02$ x SID $CP_{diet}$) and protein ($Y = 3.63 + 0.01$ x SID $CP_{diet}$) at d 17 increased linearly ($P < 0.05$) and it decreased throughout lactation ($P < 0.001$). In conclusion, increased dietary protein concentration for lactating sows increased ADG of the litter and back fat loss of the sow, but BW loss of the sow was decreased.

**Key Words:** dietary protein, litter gain, milk composition

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**236 Got colostrum? Effect of diet and feeding level on piglet colostrum intake and piglet quality.**

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The objective of the study was to determine the effect of late gestation diet and feeding level on piglet colostrum intake and piglet quality. Second parity, composite Landrace × Large White sows ($n = 61$) were housed at the North Carolina Department of Agriculture Tidewater Research Station. At d 104 of gestation sows were randomly allocated by body condition to one of two diets, gestation (GEST) or lactation (LACT), and one of three feeding levels (1.5, 3.0, or 4.5 kg/d) in a 2 × 3 factorial design. Experimental diets were fed until farrowing. The GEST diet contained 2979 Kcal/kg ME, 0.58 SID lysine and the LACT diet contained 3322 Kcal/kg ME, 0.99 SID lysine and 2.5% added fat. At birth, piglets were individually identified and weighed (BWT). Piglets were again weighed at 24 h of age (WT24) and at 21 d of age (WWT). Colostrum intake (COLOSTRUM) was estimated as WT24-BWT. Piglet survival was calculated as litter size at weaning ÷ total number born. Data analysis was completed in SAS using PROC GLM. Fixed effects included diet, feeding level, and a covariate of litter size for all traits. Sow was the experimental unit. Average litter size at birth, 24 h, and weaning were 13.11, 12.49, and 11.05, respectively. Average piglet BWT, COLOSTRUM, and WWT were 1.16 kg, 111 g, and 5.63 kg, respectively. Total litter COLOSTRUM was not associated ($P > 0.05$) with litter size. Hence on a piglet basis, a one piglet increase in litter size reduced ($P < 0.01$) average piglet COLOSTRUM by 12.8 g. A 1 d increase in gestation length improved ($P < 0.05$) average piglet COLOSTRUM by 8.4 g. In relation to dietary treatments, average BWT did not differ ($P > 0.05$) between diets or feeding levels. Yet average COLOSTRUM was greater ($P < 0.01$) for sows fed LACT compared to those fed GEST (127 vs. 96 g). A 1 kg increase in feeding level increased ($P = 0.05$) average piglet COLOSTRUM by 9 g. Average piglet WWT was heavier ($P < 0.01$) for sows fed LACT compared to those fed GEST (5.84 vs. 5.45 kg). Both BWT CV and WWT CV were lower ($P < 0.05$) for sows fed LACT compared to those fed GEST. Sows fed LACT had similar ($P > 0.05$) piglet survival to those fed GEST (87.3 vs. 84.2%, respectively). Results showed, regardless of feeding level, feeding a lactation diet the last 10 d of gestation reduced litter variation, enhanced piglet colostrum intake and improved piglet weaning weights.

**Key Words:** colostrum, diet, sow

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**237 Effect of sow lactation crate size on litter performance and survivability.** L. L. Thomas[1,*], K. F. Coble[2], C. W. Hastad[2], M. D. Tokach[1], S. S. Dritz[1], R. D. Goodband[1], J. M. DeRouchey[1], J. C. Woodworth[1], *[1]Kansas State University, Manhattan, [2]New Fashion Pork, Jackson, MN.*

A study was conducted on a commercial sow farm in southern Minnesota, where 528 litters of pigs (PIC TR4 × (Fast LW × PIC L02)) were used to determine the effects of sow lactation crate size on litter performance and survivability. Farrowing crate length was maintained at 2.26 m, but width was adjusted to allow for treatments of 1.46, 1.65, and 1.83 m. To create the desired farrowing crate dimensions, divider panels were adjusted accordingly, taking space away from one sow's crate to give it to another. This allowed for blocks of 3 crates, where each treatment was represented. Sows were loaded into individual lactation crates at random, balancing for parity across treatments. Cross fostering occurred within 24 h of farrowing prior to obtaining litter weight in effort to equalize litter size across treatments (minimum of 6 pigs per litter). Data were analyzed using generalized mixed models where treatment was a fixed effect and block was a random effect. Born alive, piglets weaned, and pre-weaning mortality were all fitted using a binomial distribution. Regardless of treatment, there was no evidence of differences in total piglets born, percentage piglets born alive, litter birth weight, litter weaning weight, or litter ADG. In addition, no evidence for differences were observed in the percentage piglets weaned or pre-weaning mortality. In conclusion, increasing lactation crate size did not impact litter performance or pig survivability in this study.

**Key Words:** lactation, lactation crate size, sow
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**238 Feed efficiency of gestating gilts and sows under commercial conditions.** L. L. Thomas*, S. S. Dritz, M. D. Tokach, R. D. Goodband, J. C. Woodworth, J. M. DeRouchey, *Kansas State University, Manhattan.*

A study was conducted on a commercial sow farm to examine the effects of parity and stage of gestation on ADG and G:F of gestating sows. A total of 712 females (Line 1050, PIC, Hendersonville, TN) were group-housed and individually fed with electronic sow feeders. Individual scales were in the alleyway after individual feeding stations leading to the pen. Females were moved from the breeding stall to the pens on d 4 of gestation. Feed intake and BW were recorded daily throughout gestation. As a result, ADFI, ADG, and G:F were generated daily for each sow. Gilts (parity 1) and sows received 2.0 and 2.26 kg/day, respectively, of feed while 12 thin females received 3.0 kg/day (fed a common diet with 0.63% SID Lys and 3225.3 kcal/kg intake of ME). Data were divided into 3 parity groups: 1, 2, and 3+ and gestation was divided into 5 periods: d 4–15, d 16–30, d 31–60, d 61–90, and d 91–112. From d 4 to 15, ADFI and ADG were lowest for each parity group compared to the other periods of gestation ($P < 0.001$). For parity 1 sows, ADFI was lower ($P < 0.05$) compared to parity 2 and 3+ sows, which is attributed to the assigned feeding strategies. Parity 2 sows, although provided the same feed allowance, had greater ADFI during the first period ($P < 0.05$) than parity 3+ sows. Both parity and period of gestation affected ($P < 0.05$) ADG. Gain:feed was lowest from d 4–15 for each parity group ($P < 0.001$). Parity influenced ($P < 0.05$) G:F with parity 1 sows having the greatest G:F in most gestation periods. Overall, this study shows that gestation ADFI, ADG, and G:F differ based on parity and period of gestation.

**Key Words:** feed efficiency, gestation, sow
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**239 Effect of dietary calcium inclusion rate in diets for lactating sows.** A. Graham[1,*], T. Hall[1], L. Ochoa[1], L. Greiner[1], M. A. D. Goncalves[2], U. A. D. Orlando[2], J. Connor[3], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Genus PIC, Hendersonville, TN, [3]Carthage Veterinary Service, Ltd, Carthage, IL.*

Ninety-three sows (Camborough PIC) were used to evaluate the effects of dietary calcium (Ca) inclusion rate in lactating sows. Sows were allotted at the end of gestation into a RCBD (Block = Parity ≤ P2 or ≥ P3) with the following feed treatments: 0.63 vs. 0.79 vs. 0.95% total Ca with total phosphorus (P) constant at 0.63% and available P constant at 0.43%. All diets were formulated to meet or exceed NRC requirements (NRC, 2012) for major nutrient specifications. Feed was provided ad libitum to

**Table 237.**

| Item | Sow lactation crate size, m | | | SEM | Probability, $P <$ |
|---|---|---|---|---|---|
| | 2.26 × 1.46 | 2.26 × 1.65 | 2.26 × 1.83 | | |
| Total piglets born, n | 14.7 | 14.1 | 14.2 | 0.253 | 0.154 |
| Born alive, % | 91.5 | 93.1 | 92.2 | 0.593 | 0.103 |
| Litter size after equalization, n | 13.3 | 13.2 | 13.1 | 0.082 | 0.786 |
| Litter birth weight, kg | 18.2 | 18.1 | 18.1 | 0.268 | 0.941 |
| Litter weaning weight, kg | 65.6 | 67.4 | 65.7 | 1.242 | 0.466 |
| Litter ADG, kg | 2.40 | 2.48 | 2.41 | 0.045 | 0.326 |
| Piglets weaned, % | 79.2 | 79.0 | 77.4 | 1.046 | 0.288 |
| Pre-weaning mortality, % | 18.4 | 18.9 | 20.1 | 0.969 | 0.322 |
| Lactation length, d | 19.6 | 19.6 | 19.5 | 0.239 | 0.919 |

sows throughout the study and all diets were fed in meal form. Sows were weighed on entry into the farrowing rooms and an equation was used to estimate their weight 48 h post-farrow. Feed treatments were fed to sows immediately after entering the farrowing room. Daily feed intake, litter starting weight, litter wean weight, sow wean weight, wean to estrus interval, and subsequent reproductive performance were recorded. Data were analyzed as a randomized complete block using the PROC MIXED procedure of SAS with sow as the experimental unit, treatment as a fixed effect, and parity as a random effect. Data were reported as LS Means and contrasts and treatment comparisons were performed. Results were considered significant at $P \leq 0.05$ and considered a trend at $P > 0.05$ and $P \leq 0.10$. There were no significant differences in sow body weight loss, sow average daily feed intake, or piglet average daily gain as a result of increasing total Ca. Wean to estrus interval was significantly reduced (4.22, 3.98, and 4.75 d, $P = 0.03$) as the Ca level increased to 0.79% from 0.63%. Percentage of pigs removed was least for sows fed with 0.95% dietary Ca (12.88, 13.19, 6.89, $P = 0.05$) during the study. Overall, there were no significant differences or tendencies in the other measured variables. Based on the present study, there were no major sow or litter performance criteria changes for a total Ca to total P ratio from 1 to 1.5. Further studies evaluating the effects of Ca to P ratio on piglet removal rate is warranted, but in this study a higher amount of dietary calcium did not improve sow lactation or piglet growth performance significantly.

**Key Words:** calcium, lactation, sow
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**Table 238.**

| | Gestation, d | | | | | |
|---|---|---|---|---|---|---|
| | 4–15 | 16–30 | 31–60 | 61–90 | 91–112 | SEM |
| ADFI, kg | | | | | | |
| Parity 1 | $1.79^{ax}$ | $1.98^{bx}$ | $1.96^{bx}$ | $1.97^{bx}$ | $1.96^{bx}$ | 0.007 |
| Parity 2 | $2.16^{az}$ | $2.25^{by}$ | $2.26^{by}$ | $2.25^{by}$ | $2.24^{by}$ | 0.009 |
| Parity 3+ | $2.10^{ay}$ | $2.25^{by}$ | $2.27^{by}$ | $2.27^{by}$ | $2.27^{by}$ | 0.007 |
| ADG, kg | | | | | | |
| Parity 1 | $0.38^{ay}$ | $0.71^{bz}$ | $0.68^{bz}$ | $0.67^{bz}$ | $0.66^{by}$ | 0.017 |
| Parity 2 | $0.20^{ax}$ | $0.58^{dy}$ | $0.43^{bx}$ | $0.49^{bcy}$ | $0.53^{cdx}$ | 0.020 |
| Parity 3+ | $0.23^{ax}$ | $0.42^{bx}$ | $0.49^{cy}$ | $0.42^{bx}$ | $0.75^{dz}$ | 0.016 |
| G:F | | | | | | |
| Parity 1 | $0.21^{ay}$ | $0.36^{bz}$ | $0.34^{by}$ | $0.34^{bz}$ | $0.34^{by}$ | 0.008 |
| Parity 2 | $0.10^{ax}$ | $0.26^{dy}$ | $0.19^{bx}$ | $0.22^{bcy}$ | $0.24^{cdx}$ | 0.010 |
| Parity 3+ | $0.12^{ax}$ | $0.19^{bx}$ | $0.21^{bx}$ | $0.18^{bx}$ | $0.33^{cy}$ | 0.008 |

Values with different superscripts within a row$^{abcd}$ or column$^{xyz}$ differ, $P < 0.05$.

**240 Threonine:Lysine ratio requirement in lactating sows.** L. Greiner[1,*], A. Graham[1], K. J. Touchette[2], M. A. D. Goncalves[3], U. A. D. Orlando[3], J. Connor[4], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Ajinomoto Heartland, Inc., Chicago, IL, [3]Genus PIC, Hendersonville, TN, [4]Carthage Veterinary Service, Ltd, Carthage, IL.*

Camborough PIC sows ($n = 291$) were fed one of five dietary treatments to evaluate the SID Thr:Lys requirement during lactation. Sows were blocked by parity (1, 2, and 3+) and randomly allotted to one of five SID Thr:Lys ratios (52, 60, 68, 76, and 84). SID Lys was formulated to 1.03% and SID M+C:Lys was 55%. Sows were allowed 5.45 kg/day starting on the day of farrowing. All other nutrients met or exceeded the NRC requirements. Sows were allowed ad libitum access to water and piglets were cross-fostered within treatment. Data collected during the study included: sow pre-farrow body weight, sow wean weight, starting litter weight, weaning litter weight, mortality, wean to estrus interval, and subsequent total born. Data were analyzed as a randomized complete block design using PROC MIXED with sow as the experimental unit and treatment and parity as fixed effects. Competing requirement estimation models were: quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) using PROC NLMIXED. Models that differed in their Bayesian information criterion values by at least 2 points were considered to have meaningful differences in their data fit. The best-fit model was based on the best BIC value. As the SID Thr:Lys ratio increased, there was a quadratic response on ADFI (4.73, 4.57, 4.67, 4.55, and 4.60 kg/d; $P = 0.001$) and percent of sow body weight loss (−6.44, −7.89, −7.35, −6.19, and −5.81; $P = 0.004$). In addition, there was a trend for wean to estrus interval to be affected by the ratio (5.42, 4.42, 4.55, 4.46, and 4.84; $P = 0.07$). Daily litter gain was also quadratically improved as the SID Thr:Lys ratio increased (2.67, 2.67, 2.78, 2.77, and 2.68 kg/d; $P$ value = 0.001). For daily litter gain, the BLQ model was determined to be the best fit with an estimated SID Thr:Lys requirement of 65%. In conclusion, the optimal SID Thr:Lys ratio for litter growth is 65.

**Key Words:** lactation, sow, threonine ratio
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**241 Impact of feeding reduced dietary crude protein diets with crystalline amino acid supplementation in late gestation on nitrogen balance of sows.** N. Regmi[1,*], J. Babcock[1], D. Chamberlin[1], K. J. Touchette[2], J. L. De Vries[1], S. Zhang[1], N. L. Trottier[1] *[1]Michigan State University, East Lansing, [2]Ajinomoto Heartland, Inc., Chicago, IL.*

The objective of this study was to test the hypothesis that feeding pregnant sows once-per-day diets reduced in CP concentration with concomitant incremental inclusion of crystalline

AA (CAA) does not decrease whole body N retention of sows during the last week of pregnancy compared with sows fed a diet solely containing AA from feed ingredients. Two experiments were conducted, one with 28 pregnant gilts and another one with 25 pregnant multiparous sows (parity ≥ 3), each in 2 replications. Gilts and sows were allocated to 4 dietary treatments in a completely randomized design. Diets were corn–soybean meal based and contained 2,650 kcal/kg NE. The percent CP (analyzed) in diets were as followed for gilts and sows, respectively: 19.3 and 16.1 (control), 18.1 and 14.6 (Med), 16.1 and 12.6 (MedLow), and 14.2 and 11.6 (Low). Except for control diet, all diets contained CAA to meet the SID requirement for Lys, Thr, Trp, Met, and Ile during d 100 to 114 of gestation. The additional crystalline lysine in both gilt and sow diets was 0.13, 0.25, and 0.38% for the Med, MedLow, and Low diets, respectively. Sows were fed 2.21 kg once per day in the morning, starting at d 95. Analysis of N balance was conducted from d 105 to 110 of gestation by complete urine collection and the dietary marker (titanium oxide) dilution principle to determine fecal N output. Data were analyzed using a mixed model of SAS (SAS Inst. Inc., Cary, NC) and contrast statements were used to compare the Med, MedLow, and Low diets with the control diet. Number of piglets born alive, numbers stillborn and mummified piglets, and total litter weight at birth did not differ between low-protein diets and the control. In gilts, compared with the control diet (43.0 ± 2.48), N retention (g/d) did not differ ($P = 0.18$) in the Med diet (38.2 ± 2.48), tended to be lower ($P = 0.09$) in the MedLow diet (37.0 ± 2.48), and was lower ($P = 0.04$) in the Low diet (35.1 ± 2.70). In sows, compared with the control diet (37.9 ± 2.09), N retention did not differ ($P = 0.14$) in the Med diet (33.5 ± 1.93) and was lower for the MedLow (27.55 ± 1.76; $P < 0.01$) and Low diets (27.52 ± 1.90; $P < 0.01$). Feeding once-per-day diets reduced in CP beyond 2 percentage units to pregnant gilts and sows decreases N retention.

**Key Words:** amino acid, gestating sow, nitrogen balance
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**242 Effect of late gestation diet and feeding level on changes in sow weight and body condition.**

C. Garrison*, E. van Heugten, J. G. Wiegert, M. T. Knauer, *North Carolina State University, Raleigh*.

The objective was to determine the effect of diet (LGD) and feeding level (FL) on sow weight (WT) and body condition (BC) in late gestation. Second parity Landrace × Large White sows ($n = 61$) were housed at the North Carolina Department of Agriculture Tidewater Research Station. On d 104 of gestation, sows were moved to farrowing stalls and randomly allocated by BC caliper score (CS) to 1 of 2 corn–soy LGD, gestation (GEST) or lactation (LACT), and 1 of 3 FL (1.5, 3.0, or 4.5 kg/d) in a 2 × 3 factorial design. The LGD were fed until farrowing. The GEST diet contained 2,979 kcal/kg ME and 0.58 SID lysine and the LACT diet contained 3,322 kcal/kg ME, 0.99 SID lysine, and 2.5% added fat. Sow WT and CS (<12 = thin, 12–15 = ideal, and 15+ = fat) were collected on d 104 and 112 and at weaning (WEAN). Lactation feed intake (LFI) and wean-to-estrus interval (WEI) were collected. Data analysis was completed in SAS (SAS Inst. Inc., Cary, NC) using PROC GLM. Fixed effects included LGD and FL (as a linear term). No LGD × FL interactions were $P < 0.05$. Sow WT and CS traits measured after d 104 of gestation included the initial measure as a covariate. Average sow WT at d 104 was 231 kg and did not differ ($P > 0.05$) between treatments. Sow WT at d 104 and 112 and WEAN did not differ ($P < 0.05$) between LGD. Yet at d 112 of gestation, sows fed LACT had greater ($P < 0.05$) CS than those fed GEST (15.25 vs. 14.73). At WEAN, sows fed LACT had similar ($P > 0.05$) CS to GEST (12.22 vs. 11.88, respectively). Sows fed LACT had similar ($P > 0.05$) LFI and WEI to those fed GEST. A 1 kg/d increase in late gestation FL increased ($P < 0.01$) sow WT and CS on d 112 by 5.04 kg and 0.41, respectively. A 1-kg increase in late gestation FL increased ($P < 0.05$) sow WT loss during lactation by 2.84 kg but not ($P > 0.05$) CS loss. Yet overall, a 1 kg/d increase in late gestation FL tended ($P = 0.08$) to increase sow WEAN WT by 2.18 kg and improved ($P < 0.05$) WEAN CS by 0.38. Increased gestation FL did not impact ($P > 0.05$) LFI or WEI. Results indicate feeding LACT in late gestation improved sow CS at farrowing but did not increase sow WT. Increased FL the last 10 d of gestation increased late gestation WT gain, did not impair LFI, tended to increase sow WEAN WT, and increased sow CS at farrowing and at WEAN.

**Key Words:** condition, gestation, sow
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**243 Young Scholar Presentation: Heat stress alleviation in lactating sows by dietary betaine supplementation and cooling pads.**

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The first objective was to evaluate the effect of dietary betaine supplementation on sow lactation and postweaning performance during summer conditions. Sows were supplemented with either 0.00 or 0.21% dietary betaine (193 and 175 sows, respectively). Betaine-supplemented sows had 3.90% greater ADFI during lactation than control sows ($P = 0.005$). Treatment × parity interactions were significant for ADFI and BW loss ($P < 0.008$). Parity 2 betaine-supplemented sows had

0.72 kg/d greater ADFI and 6.70 kg less BW loss than parity 2 control sows ($P < 0.022$). Betaine-supplemented sows had greater ADFI in the 6- to 11-d, 12- to 16-d, and 17- to 21-d periods ($P < 0.019$). Wean-to-estrus intervals (WEI) were 0.31 d shorter ($P = 0.004$) and had different distribution ($P = 0.029$) for betaine-supplemented sows than for control sows. Greater percentages, 3.2 and 12.1% of betaine-supplemented sows, returned to estrus on d 3 and 4, respectively, than control sows. In another lactation trial, sows supplemented with 0.21% dietary betaine had 0.51 mm greater follicle diameter ($P = 0.043$) and 0.23°C lower rectal temperature ($P = 0.048$) than control sows. The second objective was to develop a cooling pad that efficiently removes excess of heat from lactating sows. Cooling pads were built with an aluminum plate surface, high-density polyethylene base, and copper pipes. Respiration rates and rectal, vaginal, and skin temperatures for 8 replicates of 10 sows were evaluated after 100 min of cooling with different constant cool water flows of 0.00 (4 sows), 0.25 (2 sows), 0.55 (2 sows), or 0.85 L/min (2 sows). The cooling was initiated 1 h after the room reached 35°C. Mean room temperature and relative humidity during the trial were 35.1 ± 0.4°C and 68.4 ± 3.2%, respectively. The 0.55 and 0.85 L/min treatments reduced respiration rates and rectal, vaginal, and skin temperatures after 80 min of cooling ($P < 0.001$). Respiration rates decreased within 20 to 40 min for sows on the 0.85 L/min treatment ($P < 0.001$). Overall, heat removal during the trial was 193, 321, and 365 W for the 0.25, 0.55, and 0.85 L/min treatments, respectively ($P < 0.001$). Betaine supplementation can alleviate some of the heat stress effects in lactating sows. Cooling pads have a greater potential than betaine to reduce heat stress in lactating sows. Initial data indicate that pulsing of cooled water results in more efficient heat transfer per liter of water.

**Key Words:** heat stress, lactation, sow
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**244 Validation of the extended matrix values for energy and amino acids of a new novel 6-phytase, Natuphos E, in weaned piglets.**

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The effect of using extended nutritional values for energy and AA (in addition to P and Ca nutritional values) for a novel 6-phytase (6-Phy; Natuphos E) was evaluated on the performance and bone mineralization of piglets. One hundred forty-four weaned piglets ([Large White × Landrace] × Pietrain; 26 d of age and 7.6 kg BW) were randomly distributed by initial BW into 48 pens (3 piglets per pen) according to a randomized block design with 8 blocks and 6 treatments. The experimental treatments consisted of a positive control diet (PC); a negative control diet with reduced levels of energy, AA, Ca, and P (NC); and the same NC diet supplemented with 250, 500, or 750 FTU/kg of 6-Phy or 500 FTU of a competitor's phytase (COM). Between 0 and 22 d and between 22 and 46 d (PS/ST phases, respectively), PC diets were formulated to provide 14.03/13.82 MJ ME/kg, 12.50/11.50 g SID Lys/kg, and 3.80/3.30 g digP/kg and the NC diets were formulated to provide 13.97/13.76 MJ ME/kg, 12.38/11.40 g SID Lys/kg, and 2.2/1.7 g digP/kg. Performance was measured at 22 and 46 d, and at the end of the trial, 1 piglet per pen was euthanized and the front left hoof was obtained to measure DM and ash contents in os metacarpale III. No statistically significant differences among treatments were observed for performance parameters during the PS phase (see Table 244). In conclusion, performance was maintained for all doses tested, and bone mineralization was not affected with doses of 500 FTU and over, with the use of extended nutritional values for Natuphos E.

**Key Words:** enzyme matrix, novel 6-phytase, piglets
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**245 Evaluating the effect of superdosing Natuphos E 5000 G phytase on nursery pig performance.**

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A total of 360 pigs (DNA 200 × 400; initially 5.9 kg) were used in a 42-d growth trial to determine the effect of superdosing a novel phytase source (Natuphos E 5000 G; BASF Corporation, Florham Park, NJ) on nursery pig growth and bone ash. Pigs were randomly allotted to pens at weaning in a randomized complete block design, and pens were allotted to 1 of 8 dietary treatments. There were 5 pigs per pen and 9 pens per treatment. Diets were fed in 3 phases (d 0–7, d 7–21, and d 21–42) with formulated total Ca:P ratios of 1.07, 1.05, and 0.93, respectively. Treatments included a negative control (NC) with 0.40, 0.30, or 0.25% aP from monocalcium P for Phases 1, 2, and 3, respectively, and NC with either 500, 1,000, 2,000, 3,000, or 4,000 FTU/kg phytase. There was also a positive control (PC) with 0.55, 0.45, or 0.40% aP from monocalcium P for Phases 1, 2, and 3 respectively, or PC with 2,000 FTU/kg phytase. On d 42, 1 pig/pen was euthanized and the right fibula was removed for bone ash analysis. From d 0 to 42, pigs fed increasing phytase in NC tended to have increased (quadratic, $P = 0.064$) ADG and (linear, $P = 0.082$) ending BW and had improved (quadratic, $P = 0.008$) G:F. Adding 2,000 FTU/kg phytase to PC did not influence ADG or ADFI but tended to improve ($P = 0.060$) G:F. Additionally, percentage bone ash increased as phytase increased in NC (linear, $P < 0.001$) and PC diets ($P < 0.001$). The NC diet with 500 FTU/kg and PC (no added phytase) were formulated to be equivalent in available Ca and P. When comparing the 2 diets, pigs fed PC had increased ($P = 0.007$) ADFI and tended to have greater ($P = 0.099$) percentage bone ash; however, pigs fed NC + 500 FTU/kg phytase had improved ($P = 0.032$) G:F. In summary,

**Table 244.** Average daily growth, G:F, and bone ash content and weight

| | PC | NC | 250 FTU | 500 FTU | 750 FTU | COM | Root MSE | *P*-value |
|---|---|---|---|---|---|---|---|---|
| ADG 0 to 22, g | 261 | 252 | 240 | 287 | 257 | 280 | 52 | 0.50 |
| GFR 0 to 22 | 0.70 | 0.74 | 0.71 | 0.75 | 0.71 | 0.75 | 0.11 | 0.90 |
| ADG 22 to 46, g | 514[b] | 445[c] | 522[b] | 531[ab] | 573[a] | 581[a] | 49 | <0.01 |
| GFR 22 to 46 | 0.58[b] | 0.57[b] | 0.61[ab] | 0.58[b] | 0.62[ab] | 0.64[a] | 0.05 | 0.03 |
| ADG 0 to 46, g | 393[b] | 352[c] | 387[bc] | 414[ab] | 422[ab] | 437[a] | 37 | <0.01 |
| GFR 0 to 46 | 0.61 | 0.61 | 0.64 | 0.63 | 0.65 | 0.67 | 0.05 | 0.11 |
| Bone ash, g | 1.74[a] | 1.24[c] | 1.47[b] | 1.69[a] | 1.68[a] | 1.68[a] | 0.19 | <0.01 |
| Bone dry wt, g | 4.76 | 4.09 | 4.46 | 4.85 | 4.50 | 4.82 | 0.54 | 0.06 |

**Table 245.**

| | Negative control | | | | | | Positive control | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | 0 | 500 | 1,000 | 2,000 | 3,000 | 4,000 | 0 | 2,000 | SEM |
| d 0 to 42 | | | | | | | | | |
| ADG, g | 369 | 380 | 396 | 387 | 395 | 381 | 400 | 398 | 10.2 |
| ADFI, g | 540 | 529 | 562 | 551 | 559 | 555 | 580 | 561 | 13.5 |
| G:F, g/kg | 684 | 713 | 705 | 702 | 707 | 686 | 689 | 709 | 7.8 |
| Bone ash, % | 44.2 | 45.2 | 47.1 | 48.0 | 48.4 | 49.1 | 47.0 | 51.3 | 0.77 |

increasing dietary phytase in NC linearly increased percentage bone ash whereas G:F was maximized at 1,000 FTU/kg. Adding phytase to PC with P and Ca formulated at NRC (2012) recommendations tended to improve feed efficiency.

**Key Words:** nursery pig, phytase, superdose
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## 246 Super dosing effects of corn-expressed phytase on bone characteristics and nutrient digestibility in nursery pigs fed diets sufficient in phosphorus and calcium.

J. K. Lee*, H. Chen, I. Park, S. W. Kim, *North Carolina State University, Raleigh*.

This study was conducted to investigate the super dosing effects of phytase from corn-expressed phytase (CEP; 3,962 FTU/g CEP; Agrivida, Inc., Medford, MA) on metacarpal bone characteristics, apparent ileal digestibility (AID) of nutrients, and gut health of nursery pigs fed corn–soybean meal diets sufficient in P and Ca (0.44 and 0.36% STTD P and 0.83 and 0.74% Ca for Phase 1 and 2, respectively, meeting nutrient requirements suggested by the NRC [2012]). Pigs (16 barrows and 16 gilts at 21 d of age with 6.2 ± 0.7 kg BW) were allotted to 4 dietary treatments ($n$ = 8) based on a randomized complete block design with initial BW and sex blocks. Pigs were fed a basal diet supplemented with ground CEP to have phytase activities at 0, 500, 1,500, or 3,000 FTU/kg based on 2 phases (Phase 1: 10 d and Phase 2: 20 d). Analyzed phytase activities were 96, 320, 1,190, and 2,210 FTU/kg in Phase 1 diets and 60, 541, 898, and 2,150 FTU/kg in Phase 2 diets, respectively. Plasma samples (d 25), metacarpal bones (d 30), ileal digesta (d 30), and tissues from the jejunum (d 30) were collected. Characteristics of metacarpal bones were evaluated by determining the composition and strength. Phase 2 diets contained titanium oxide (0.25%) as an indigestible external marker to calculate AID of nutrients. Numbers of proliferating enterocytes in crypts were counted in the jejunum using immunohistochemistry of Ki-67. Data were analyzed using polynomial contrasts in the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Increasing phytase levels increased (linear, $P < 0.05$) fat-free dry weight (2.02 to 2.72 g) and the amounts of P (0.17 to 0.25 g), Ca (0.36 to 0.52 g), and ash (0.15 to 18 g) and tended to increase (quadratic, $P = 0.058$) breaking strength (323 to 401 N at 1,500 FTU/kg) of metacarpal bones. Increasing phytase levels increased AID of CP (linear, $P < 0.05$; 69.1 to 77.4%) and tended to increase AID of ether extract (linear, $P = 0.088$; 54.9 to 65.7%) and AID of Ca (0 vs. others, $P = 0.081$; 66.6 to 72.4%). Increasing phytase levels did not affect the numbers of proliferating enterocytes in crypts of the jejunum. In conclusion, super dosing corn-expressed phytase up to 3,000 FTU/kg enhanced bone characteristics and nutrient digestibility of pigs fed diets with sufficient P and Ca meeting NRC requirements.

**Key Words:** corn-expressed phytase, digestibility, nursery pigs
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## 247 Effects of feeding corn-expressed phytase on the live performance, bone characteristics, and phosphorus digestibility of nursery pigs.

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A 41-d feeding trial was conducted to determine the efficacy of a corn-expressed phytase (CEP; Grainzyme; Agrivida) on the live performance, bone characteristics, and P digestibility of nursery pigs fed a reduced-P diet. Weaned piglets (21 ± 3 d; $n$ = 360) were acclimated on a common diet (phase 1) for 7 d before

randomization into 60 single-sex pens containing 6 pigs (6.6 ± 1.2 kg) per pen. Six treatments were fed: positive control (PC; 0.4 or 0.32% aP for phase 2 or 3 and 4, respectively), negative control (NC; 0.15% reduced aP), and 500, 1,000, 2,000, or 4,000 FTU CEP/kg added to NC in a 3-phase feeding program. Pigs were weighed on d 0, 14, 28, and 41, and feed disappearance was recorded per phase. Apparent total tract digestibility (ATTD) of P was determined by feeding a chromic oxide marker (d 28 to 35) and collecting fecal samples on d 35. On d 41, 4 pigs per pen were euthanized and metacarpal bones were collected to evaluate bone breaking strength (BBS) and ash. Data were analyzed using PROC GLM of SAS (SAS Inst. Inc., Cary, NC; block, sex, treatment, and sex × treatment interaction). Treatment least squares means were separated, and linear, quadratic, and cubic treatment effects were evaluated. Pigs fed 500 FTU CEP/kg had increased ($P < 0.05$) ADG (450 vs. 395 g/d) and ADFI (668 vs. 581 g/d) compared with NC pigs and ($P > 0.05$) ADG (473 g/d) and ADFI (686 g/d) equivalent to those of PC pigs from d 0 to 41. Pigs fed 500 FTU CEP/kg had higher ATTD of P (57%; $P < 0.05$) than both NC (32%) and PC (38%) pigs. Pigs fed 500 FTU CEP/kg had higher BBS (31 vs. 40 kg/cm$^2$) and bone ash weight (1.41 vs. 1.11 g) than NC pigs ($P < 0.05$). Pigs fed 1,000 FTU CEP/kg had BBS (45 kg/cm$^2$) and ash weight (1.51 and 1.56 g) equivalent to those of PC pigs ($P > 0.05$). Pigs fed 4,000 FTU CEP/kg had higher d 0 to 41 ADG (509 vs. 473 g/d) and bone ash weight (1.72 vs. 1.56 g) compared with PC ($P < 0.05$). There were linear ($P < 0.0001$) increases in ADG, ADFI, ATTD of P, BBS, and bone ash characteristics as CEP inclusion increased. In conclusion, 500 FTU CEP/kg improved growth, ATTD of P, BBS, and bone ash when added to a reduced-P diet, and 4,000 FTU CEP/kg increased growth beyond the PC treatment.

**Key Words:** corn-expressed phytase, growth performance, nursery pig
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**248 Improvement of ileal digestibility of dry matter and gross energy by commercial carbohydrases is associated with depression of fermentability in an in vitro digestibility determination system.**

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Efficacy of 11 commercial carbohydrases added to wheat middlings (WM) and corn distiller's dried grains with solubles (cDDGS) samples was evaluated using an in vitro enzymatic digestion system coupled with gas production analysis. For in vitro enzymatic digestion, prepared carbohydrase and phytase (Quantum Blue 5 G) solutions were added to WM and cDDGS samples at 20 times the recommended doses before gastric hydrolysis (2 h; pH = 2.0 with 4 mL of 100 mg/mL pepsin solution). Small intestinal hydrolysis occurred for 4 h at pH 6.8 in a phosphate buffer with prepared pancreatin solution (4 mL, 100 mg/mL). After enzymatic digestion, the hydrolyzed residues were filtered, dried, and pooled within treatment for subsequent in vitro inocubation in a buffered mineral solution with pig feces inoculum. The enzymatic digestion and fermentation procedures were repeated 16 and 8 times for each treatment, respectively. Gas production was measured for 72 h, and kinetics were estimated by fitting data in an exponential model. Fermentation residues were filtered and the supernatant was analyzed for VFA concentrations. Carbohydrases increased ($P < 0.05$) in vitro ileal digestibility of DM and GE in WM by 3.2 and 4.2%, respectively, but not in cDDGS. The concentrations of glucose (73.2 vs. 54.1 mg/dL) and soluble protein (1.27 vs. 1.10 mg/mL) released during hydrolysis were increased ($P < 0.05$) by the addition of several sources of carbohydrases to WM compared with the non-enzyme-treated control. Gas production (262 vs. 365 mL/g DM) was less ($P < 0.05$) and required more ($P < 0.05$) time (6.3 vs. 4.8 h) to reach half asymptote ($T/2^{-1}$) in the hydrolysis residue from WM treated with carbohydrases compared with the WM control. For cDDGS, the total gas production (358 vs. 416 mL/g DM) decreased ($P < 0.05$) and $T/2^{-1}$ (13.9 vs. 17.6 h) increased ($P < 0.05$) when several carbohydrase sources were added compared with the control. The WM control had greater disappearance of DM (45.1 vs. 49.8%) during fermentation than WM supplemented with 5 out 11 carbohydrases, whereas there were no differences observed among cDDGS with or without carbohydrases. These results suggest that exogenous carbohydrases increase in vitro ileal digestibility of DM and GE in WM but decrease fermentation in both WM and cDDGS. This implies that fiber structure may be modified by carbohydrase supplementation in the small intestine and may become more resistant to bacteria fermentation in the hindgut.

**Key Words:** distiller's dried grains with solubles, in vitro hydrolysis and fermentation, multienzyme
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**249 Effects of adding multienzymes to growing pig diets containing wheat and corn fiber sources on growth performance, nutrient digestibility, and digesta viscosity.**

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This study evaluated the effects of multienzyme supplementation on growth performance, digestibility of GE and nutrients, and characteristics of intestinal content in growing pigs fed diets containing corn distiller's dried grains with solubles (DDGS) or wheat middlings (WM). Fifty-four individually housed pigs (25.33 ± 0.41 kg) were blocked by BW and sex and randomly assigned to 1 of 6 dietary treatments ($n = 9$) in a 2 × 3 factorial design with 2 levels of carbohydrases (0 vs. 100 mg/kg; 1,500 units/g xylanase, 1,100 units/g β-glucanase, 110 units/g mannanase, and 35 units/g galactosidase) and 3 basal diets (corn–soybean control [CSB], CSB + 40% DDGS, or CSB + 30% WM). Titanium dioxide (0.5%) and phytase

(1,000 FTU/kg) were added to all diets. Pig BW and feed intake were determined weekly. On d 28, pigs were euthanized and intestinal content was collected to determine digestibility, pH, and viscosity. Pigs fed diets that contained DDGS or WM had less ($P < 0.05$) ADG (755 and 751 g/d, respectively) and ADFI (1,474 and 1,435 g/d, respectively) compared with pigs fed CSB diets (803 and 1,582 g/d, respectively). Carbohydrase supplementation tended to improve ($P < 0.10$) ADG (787 vs. 752 g/d) and ADFI (1,529 vs. 1,465 g/d) regardless of basal diets. Pigs fed CSB diets had greater ($P < 0.05$) AID and ATTD of DM, OM, and GE compared with pigs fed DDGS and WM diets. Carbohydrase supplementation improved ($P < 0.05$) AID of DM, GE, and CP and ATTD of ash in WM diets but not in DDGS or CSB diets. The liquid-to-solid ratio (centrifuged at 3,500 × g for 10 min) was negatively associated with ($P < 0.01$) peak shear stress (maximum value measured at 0.1 $s^{-1}$ shear rate for 2 min) and consistency constant (K) of jejunum, ileum, and cecum digesta. The viscosity of digesta supernatant in the jejunum and ileum was decreased ($P < 0.05$) by DDGS inclusion compared with the CSB diets. The addition of carbohydrase increased ($P < 0.05$) viscosity of cecal digesta supernatant only in the CSB diet but decreased peak shear stress (14.2 vs. 28.2 Pa; $P < 0.05$) and K (16.6 vs. 20.9 Pa; $P < 0.05$) in jejunum digesta regardless of basal diets. In conclusion, adding DDGS and WM to CSB diets decreased GE and nutrient digestibility and impaired growth performance. Carbohydrase supplementation improved digesta rheology characteristics and tended to improve growth performance of growing pigs.

**Key Words:** carbohydrases, digesta viscosity, digestibility
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**250 Effect of protease and α-galactosidase supplementation to field bean (*Vicia faba*)–based diets on growth and carcass traits of grow–finisher pigs.**

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Protease (PROT) and α-galactosidase (GAL) have been suggested to improve feed efficiency when supplemented to pig diets. This study investigated the effect of PROT and GAL supplementation to field bean–based diets on grow–finisher pigs. A total of 80 pigs (MAXGRO; Hermitage Genetics, Ireland; 39.0 ± 0.43 kg) were housed as same-gender pairs and blocked by sex (boars and gilts) and weight. Pigs were allocated to 1 of 4 dietary treatments ($n = 10$ replicates) in a 2 × 2 factorial arrangement. The factors included in the design were 1) PROT supplementation (− vs. +1,500 prot units/kg; Ronozyme ProAct; DSM, Germany) and 2) GAL supplementation (− vs.+200 galu units/kg; ITPSA, Spain). Diets were formulated with field beans (40%) and barley (54%) as the main ingredients. The diets provided 2,221 kcal NE/kg and 0.89% SID Lys. The experiment lasted 50 d. Data were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC). There was no interaction between PROT and GAL. Pigs fed PROT-supplemented diets had similar weight at d 50, similar ADG, lower ADFI ($P = 0.06$), and an improved FCR ($P < 0.05$) vs. pigs fed unsupplemented diets. Pigs fed GAL-supplemented diets had similar weight at 50 d, ADG, ADFI, and FCR ($P > 0.10$) to pigs fed unsupplemented diets. The PROT supplementation had no effect on carcass weight (88.8 vs. 88.9 ± 0.66 kg; $P > 0.10$), kill out percent (77.7 vs. 77.9 ± 0.27%; $P > 0.10$), fat depth (12.5 vs. 12.2 ± 0.39 mm; $P > 0.10$), muscle depth (60.3 vs. 59.6 ± 2.0 mm; $P > 0.10$), or lean meat percent (58.8 vs. 58.5 ± 0.48%; $P > 0.10$). The GAL supplementation had no effect on carcass weight (88.8 vs. 88.9 ± 0.66 kg; $P > 0.10$), kill out percent (77.8 vs. 77.8 ± 0.27%; $P > 0.10$), fat depth (12.7 vs. 12.1 ± 0.39 mm; $P > 0.10$), muscle depth (59.2 vs. 60.7 ± 2.02 mm; $P > 0.10$), or lean meat percent (58.3 vs. 59.0 ± 0.48%; $P > 0.10$). Protease supplementation improved the feed efficiency of pigs fed field bean and barley–based diets whereas GAL supplementation did not improve growth or feed efficiency. Supplementation with PROT or GAL did not affect carcass quality.

**Key Words:** enzymes, fava bean, pig
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**251 Beta-mannanase supplementation effects on nursery pig growth performance, feed efficiency, and serum acute phase protein concentrations.**

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Dietary b-mannans can mimic carbohydrate structures on pathogen surfaces, which may activate the innate immune system. Beta-mannanase supplementation has been proposed to reduce this immune stimulation and spare energy for growth. The objective of this experiment was to evaluate the effects of dietary mannan level, b-mannanase supplementation, and their interaction on growth performance, feed efficiency, and serum acute phase protein concentrations in nursery pigs. Pigs ($n = 480$; 10 pigs per pen) were blocked by initial weight, and pens ($n = 12$ per treatment) were randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement for a 28-d experiment with 4 phases. Two levels of dietary mannan were achieved by replacing 10% of the soybean meal in the low-mannan diet (estimated 0.36% b-mannan) with copra meal for a high-mannan diet (estimated 2.79% b-mannan). Each of these diets were fed with and without 0.05% endo-1,4-b-mannanase (Hemicell HT 1.5x; Elanco Animal Health). Serum was collected (1 pig/pen) for haptoglobin and C-reactive protein (CRP) analysis prior

to treatment initiation (baseline) and on d 28. Data were analyzed as a 2 × 2 factorial design with main effects of mannan level and b-mannanase supplementation. There were no significant interactions between mannan level and b-mannanase supplementation overall (d 0 to 28; $P = 0.852$) or within each phase ($P \geq 0.106$). Overall, the high-mannan diets decreased ADG (0.37 vs. 0.38 kg/d; $P = 0.027$) and ADFI (0.52 vs. 0.54 kg/d; $P = 0.024$) compared with low-mannan diets. A similar effect was observed only in phase 3. There were no significant b-mannanase effects on growth performance or feed efficiency ($P > 0.10$). Serum acute phase protein concentrations were similar among treatments at baseline. At d 28, haptoglobin concentrations were lower ($P \leq 0.0001$) and CRP concentrations were greater ($P \leq 0.0001$) compared with baseline values, but neither were affected by mannan level or b-mannanase supplementation ($P \geq 0.160$). Beta-mannanase supplementation tended to increase serum CRP in the high-mannan diet (290.64 mg/mL) compared with the low-mannan diet (243.49 mg/mL) with no differences compared with when the enzyme was not supplemented (average = 273.91 mg/mL; $P = 0.0791$). In conclusion, the high-mannan diets decreased ADG through decreased ADFI with no apparent effect on haptoglobin or CRP concentrations. Beta-mannanase supplementation had no impact on performance and did not affect haptoglobin or CRP concentrations differently in high-mannan diets compared with low-mannan diets.

**Key Words:** C-reactive protein, haptoglobin, hemicell
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**252 An in vitro evaluation of the effects of a protease and a *Bacillus* spp. direct-fed microbial, alone or in combination, on the microstructure and protein solubilization of a variety of feed ingredients fed to grower pigs.**

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The addition of direct-fed microbials (DFM) or protease to grower–finisher pig diets has not consistently led to growth performance improvements; however, new research suggests that there may be greater and more consistent effects of feeding protease and DFM in combination. This in vitro study aimed to investigate the effect of a protease (PRO) and *Bacillus* spp. DFM (DFM) on the structure and protein solubilization of different feed ingredients fed to growing pigs. Eight ileal cannulated barrows (30 kg initial BW) were fed 1 of 8 semipurified diets in an 8 × 8 Latin square design. The diets consisted of mostly corn–soy (19% CP), corn (6% CP), wheat (10% CP), corn distiller's dried grains with solubles (DDGS; 16% CP), SBM 46 (17% CP), SBM 48 (19% CP), canola meal (15% CP), or meat and bone meal (MBM; 14% CP) with chromic oxide. Diets were fed for 7 d with 5 d for adaptation and 2 d for ileal collection. The AID of CP was calculated. The corn–soy, wheat and SBM diets had higher AID of CP than the corn diet ($P < 0.001$), whereas the corn DDGS and MBM diets were intermediate. The AID of CP was affected by pig ($P = 0.034$) but not by period. Ileal samples from corn, wheat, and SBM 46 diets were selected from the pig with AID of CP closest to the population average and used for the in vitro study. The ileal digesta samples were incubated with no additive (control) or PRO, DFM, or PRO+DFM in a buffer solution at 40°C for 2 h. Centrifugation was used to separate the supernatant, which was analyzed in duplicate for total protein, and data was analyzed using the Fit Model platform in JMP 11. The pellet was analyzed by confocal laser scanning microscopy and scanning electron microscopy to determine internal and external microstructures, respectively. The PRO+DFM treatment increased protein solubilization of SBM compared with the control ($P = 0.02$; 1,635 vs. 730 ng/μL), but PRO and DFM alone did not. Confocal laser and scanning electron microscopy revealed that PRO+DFM was effective at degrading resistant starch in corn and aggregates of protein, lipid, and fiber in wheat and reducing the size of cell wall fragments in SBM. The PRO+DFM treatment was more effective than the individual additives at fragmenting the fibrous complexes in all 3 ingredients. In conclusion, the enzyme and DFM combination showed the greatest structural breakdown of all ingredients tested and solubilized more protein from SBM than the individual additives alone.

**Key Words:** direct-fed microbial, grower pig, protease
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**Table 250.** Effect of protease and α-galactosidase supplementation to field bean diets on growth of grow–finisher pigs

| | Protease | | | | α-galactosidase | | | |
|---|---|---|---|---|---|---|---|---|
| Item | − | + | SEM | *P*-value | − | + | SEM | *P*-value |
| 0–50 d | | | | | | | | |
| Weight 0 d, kg | 38.9 | 39.1 | 0.43 | 0.543 | 38.9 | 39.0 | 0.43 | 0.803 |
| Weight 50 d, kg | 114.1 | 114.2 | 0.79 | 0.898 | 114 | 114.3 | 0.79 | 0.779 |
| ADG, g/d | 1,068 | 1,070 | 12.51 | 0.931 | 1,067 | 1,071 | 12.5 | 0.828 |
| ADFI, g/d | 2,459 | 2,394 | 33.8 | 0.066 | 2,429 | 2,424 | 33.8 | 0.884 |
| FCR, g/g | 2.31 | 2.24 | 0.022 | <0.05 | 2.27 | 2.28 | 0.022 | 0.687 |

**253 Porcine in vitro degradation and fermentation characteristics of canola coproducts without or with fiber-degrading enzymes.** J. W. Lee[1,*], R. Patterson[2], T. A. Woyengo[1], *[1]South Dakota State University, Brookings, [2]Canadian Biosystems, Calgary, AB, Canada*.

A study was conducted to determine effects of supplementing solvent-extracted canola meal (SECM) and cold-pressed canola cake (CPCC) with fiber-degrading enzymes (multicarbohydrase) and of myrosinase in CPCC on porcine in vitro digestion and fermentation characteristics. The SECM and CPCC were obtained, and half of the CPCC was microwaved to inactivate myrosinase. Samples of SECM, CPCC, and microwaved CPCC (M-CPCC) without or with multicarbohydrase (Superzyme-CS; Canadian Bio-Systems Inc., Calgary, AB, Canada) that supplied 19,200 units of xylanase, 2,400 units of glucanase, 8,000 units of cellulase, 960 units of mannanase, 11,200 units of invertase, 80,000 units of protease, and 192,000 units of amylase per kilogram of feedstuff and of M-CPCC plus myrosinase (Sigma-Aldrich Co., St. Louis, MO) that supplied 9.9 units of myrosinase/g of feedstuff were digested using porcine pepsin and then using pancreatin. Undigested residues were subjected to porcine in vitro fermentation for 72 h. Accumulated gas production was recorded and modeled to estimate kinetics of gas production. Total VFA concentration per unit weight of residue incubated was also measured. On a DM basis, CPCC and SECM contained 29.2 and 40.1% CP, respectively. Myrosinase activity for M-CPCC (7.0 units/g) was lower than that for CPCC (9.1 units/g). The IVDDM for CPCC (63.5%) was greater ($P < 0.05$) than that for SECM (58.4%). Myrosinase did not affect IVDDM of M-CPCC. Multicarbohydrase increased ($P < 0.05$) IVDDM of M-CPCC and tended to increase ($P = 0.060$) IVDDM of CPCC but did not affect IVDDM of SECM. Total gas production for CPCC was less ($P < 0.05$) than that for SECM (89.6 vs. 105.9 mL/g DM, respectively). Multicarbohydrase reduced ($P < 0.05$) total gas production for CPCC and SECM. Total VFA production for CPCC was lower ($P < 0.05$) than that for SECM (1.99 vs. 4.29 mmol/g DM, respectively). Also, total VFA production for CPCC was lower ($P < 0.05$) than that for SECM (0.73 vs. 1.79 mmol/g DM, respectively). Myrosinase had no effect on total gas or VFA production. Also, multicarbohydrase did not affect total VFA production of the canola coproducts. In conclusion, CPCC was more digestible than SECM, whereas undigested residues of SECM were more fermentable than those of CPCC. Multicarbohydrase had limited effect on IVDDM of SECM but increased IVDDM and reduced fermentation of CPCC or M-CPCC, implying that multicarbohydrase shifted digestibility of CPCC and M-CPCC from fermentation toward digestion. Myrosinase had limited effect on IVDDM and fermentability of CPCC and SECM.

**Key Words:** canola coproducts, in vitro fermentation, pig

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**254 Effects of supplementation with a protease, carbohydrases, and phytase in reduced-nutrient diets fed from weaning to market on growth performance, nutrients digestibility, intestinal morphology, and hematological characteristics.** T. C. Tsai[1,*], H. Kim[2], X. Wang[1], J. J. Chewning[3], J. A. Apple[4], J. R. Bergstrom[5], C. V. Maxwell[1], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]University of Arkansas, Fayetteville, [3]Swine Research Services, Inc., Springdale, AR, [4]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [5]DSM Nutritional Products, Parsippany, NJ*.

To assess the impact of adding protease, alone or in combination with carbohydrases and phytase, on pig performance, weaned pigs (PIC 29 × 380; 6.8 ± 0.6 kg initial BW; $n = 328$) were blocked by BW at weaning (21 ± 3 d) and randomly allotted to 1 of 4 feeding strategies during a 7 phase wean-to-finish period. The treatments consisted of adequate-nutrient diets (by phase; CON) and reduced-nutrient (decreased soy, L-Met, Thr, and Trp) diets supplemented with 1) 0.02% of Ronozyme ProAct (protease [Prot]), 2) 0.05% Victus (carbohydrases) plus 0.01% Prot (PV), or 3) PV plus increased Ronozyme HiPhos (phytase [PVH]). Pig weight and pen feed disappearance were measured by phase to calculate growth performance. Data were analyzed as RCBD using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC), and pen was the experimental unit. In the nursery period, supplementation with Prot, PV, or PVH maintained ADG, G:F, and BW, yet ADFI was greater in PVH-fed pigs compared with CON-fed pigs. For the overall finisher period, ADG, ADFI, BW, and carcass composition were similar among treatments, but CON-fed pigs tended to have greater G:F than those fed reduced-nutrient diets. Apparent total tract digestible ash was greater in Prot-fed pigs than in CON-fed pigs at the end of nursery phase 2, whereas white blood cell (WBC) count and hematocrit were greater on d 12 for pigs fed Prot, PV, or PVH compared with those fed CON. At the end of nursery Phase 3, ATTD DM tended ($P = 0.07$) to be greater in Prot-fed pigs than in CON-fed pigs. The results indicate that supplementation with a combination of a protease, carbohydrases, and increased phytase can reduce the use of several common ingredients in swine diets and sustain growth performance, carcass quality, and nutrient digestibility.

**Key Words:** carbohydrases, low-nutrient diets, phytase, protease, wean-to-finish pigs

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**255 Using environmental swabbing to quantify the effectiveness of chemical disinfectant to reduce the quantity of porcine epidemic diarrhea virus RNA on feed manufacturing surfaces.** M. B. Muckey[1], R. A. Cochrane[1,*], J. C. Woodworth[1], S. S. Dritz[1], C. R. Stark[1], A. D. Yoder[1], J. F. Bai[1], J. Zhang[2], P. C. Gauger[2], R. G. Main[2], C. K. Jones[1], *[1]Kansas State University, Manhattan, [2]Iowa State University, Ames*.

Porcine epidemic diarrhea virus (PEDV) is a possible hazard in feed mills that could impact swine health. If the virus enters a feed mill, it quickly becomes widely distributed and is difficult to decontaminate from surfaces. The objective of this study was to evaluate a variety of liquid and dry sanitation treatments that could be used to reduce the amount of PEDV found on feed manufacturing surfaces in feed mills. This experiment was replicated 3 times and was designed as a 5 × 10 factorial with main effects of 5 different feed manufacturing surfaces and 10 sanitizing treatments. Surfaces included stainless steel, plastic, rubber, woven polypropylene tote bag, and sealed concrete coupons (103 $cm^2$). One milliliter (1 × $10^5$ $TCID_{50}$/mL) of stock PEDV was applied to each surface and allowed to completely dry for 60 min. Next, chemical treatments were applied for 15 min: 1) no sanitation treatment (control); 2) untreated rice hulls; 3) rice hulls treated with formaldehyde-based commercial product (Sal CURB; Kemin Industries Inc., Des Moines, IA), 4) liquid formaldehyde-based commercial product (Sal CURB); 5) dry commercial benzoic acid and eubiotic blend (VevoVitall and CRINA; DSM Nutritional Products Inc., Parsippany, NJ); 6) liquid ammonium chloride, isopropanol, and hydrogen peroxide–based commercial food-grade sanitizer (DrySan Duo; Ecolab, St. Paul, MN); 7) liquid hydrogen peroxide commercial product (INTERvention; Virox Technologies Inc. Ontario, Canada); 8) liquid quaternary ammonium glutaraldehyde commercial product (Synergize; Preserve International, Reno NV); 9) liquid sodium hypochlorite commercial sanitizer (Bleach; Clorox, Oakland, CA); and 10) liquid medium-chain fatty acid blend of caprylic, capronic, and capric acids. The quantity of PEDV RNA was determined using quantitative reverse transcription PCR (qRT-PCR). All main effects and interaction were highly significant ($P \leq 0.001$). Concentrated liquid Sal CURB was the sanitizer most effective at removing PEDV RNA across surfaces followed by liquid bleach (42.9, 35.2, and 26.2 CT for Sal CURB, bleach, and untreated control, respectively). Rubber belting obtained from a bucket elevator retained the most PEDV RNA of any tested surface, whereas the polyethylene tote bag retained the least (28.0 and 31.4 CT for rubber and tote bag, respectively). Additional research is necessary to identify the role of sanitizer on PEDV infectivity and to develop dry sanitizers capable of removing PEDV mRNA on animal food manufacturing surfaces.

**Key Words:** feed manufacturing surfaces, porcine epidemic diarrhea virus, sanitation
doi:10.2527/asasmw.2017.255

**256 Evaluating the roles of surface sanitation and feed sequencing on mitigating *Salmonella* enteritidis contamination on animal food manufacturing equipment.** M. Muckey*, A. D. Yoder, R. A. Cochrane, A. R. Huss, S. S. Dritz, J. C. Woodworth, C. K. Jones, *Kansas State University, Manhattan*.

The objective of this study was to evaluate the efficacy of flushing surfaces with untreated feed vs. the use of 2 different chemical sanitizers on residual surface and feed *Salmonella* enteritidis contamination. First, a *Salmonella*-negative batch of poultry feed was mixed in 9 laboratory-scale paddle mixers. A feed sample was collected, and targeted locations on surfaces within the mixer were swabbed to confirm *Salmonella*-negative status. Next, a *Salmonella*-positive batch of poultry feed was mixed and sampled, and mixer surfaces were swabbed. Mean *Salmonella* enteritidis contamination across all 9 mixers was 3.63 cfu/g for sampled feed and 1.27 cfu/$cm^2$ for surface contamination. Next, the mixers manufactured one of the following treatments (3 mixers/treatment): 1) none (control), 2) concentrated commercial product containing a eubiotic blend of essential oils (benzoic acid and blend of essential oils: thymol, eugenol, piperine, and other essential oil compounds), or 3) rice hulls treated with a 10% (wt/wt)

**Table 254.**

| | CON | Prot | PV | PVH | SEM | *P*-value |
|---|---|---|---|---|---|---|
| Nursery ADG, kg/d | 0.29 | 0.29 | 0.29 | 0.31 | 0.015 | 0.22 |
| Nursery ADFI, kg/d | $0.42^{b}$ | $0.42^{b}$ | $0.42^{b}$ | $0.45^{a}$ | 0.018 | 0.05 |
| Nursery G:F | 0.69 | 0.68 | 0.69 | 0.68 | 0.013 | 0.93 |
| End nursery BW, kg | 15.85 | 15.80 | 15.70 | 16.39 | 0.790 | 0.24 |
| Finisher ADG, kg/d | 0.87 | 0.86 | 0.84 | 0.88 | 0.015 | 0.15 |
| Finisher ADFI, kg/d | 2.33 | 2.32 | 2.34 | 2.45 | 0.054 | 0.17 |
| Finisher G:F | $0.38^{x}$ | $0.37^{xy}$ | $0.36^{y}$ | $0.36^{xy}$ | 0.005 | 0.09 |
| End BW, kg | 137.4 | 135.9 | 133.7 | 139.7 | 2.48 | 0.15 |
| Phase 2 ATTD ash, % | $80.9^{a}$ | $82.2^{b}$ | $81.6^{ab}$ | $81.0^{a}$ | 0.42 | 0.05 |
| d 12 WBC, 1,000/μL | $13.34^{b}$ | $18.15^{a}$ | $16.28^{ab}$ | $19.11^{a}$ | 1.25 | 0.03 |
| d 12 hematocrit, % | $30.7^{y}$ | $32.2^{xy}$ | $34.2^{x}$ | $34.6^{x}$ | 1.08 | 0.07 |

addition of a medium-chain fatty acid (MCFA; 1:1:1 blend of caprylic, caproic, and capric acids). Each treatment was previously weighed and manufactured prior to inoculation of *Salmonella*. After each treatment, each mixer manufactured another 2 batches of *Salmonella*-free feed (Sequence 1 and Sequence 2). Feed samples were collected and surfaces were swabbed between each batch of feed. Mixers were not physically cleaned after each sequence, only feed discharged from the mixers. Manufacturing sequence ($P < 0.0001$) but not treatment ($P > 0.05$) impacted feed or surface contamination of *Salmonella* enteritidis. There was *Salmonella*-positive residue in the batch of feed manufactured immediately after the positive control batch. However, no *Salmonella* residue was detected in batches of feed treated with either the commercial essential oil blend or MCFA. Low levels of *Salmonella* residue were observed from feed (0.7 cfu/g for commercial essential oil blend) and surfaces (0.1 cfu/cm$^2$ for MCFA) manufactured in Sequence 1, but no residue was observed by Sequence 2. This data suggests that sequencing of feed during manufacturing reduces *Salmonella*-positive contamination within animal food and on manufacturing surfaces, particularly after the second batch or with the use of chemical treatments.

**Key Words:** feed manufacturing surfaces, *Salmonella*, sanitation
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**257 Standardized ileal digestible amino acids and digestible energy contents in high-protein distiller's dried grains with solubles fed to growing pigs.**

Y. Rho*, C. Zhu, E. Kiarie, C. F. M. de Lange, *Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada*.

Chemical composition and, therefore, potential nutritive value of corn distiller's dried grains with solubles (DDGS) is constantly evolving as the ethanol industry innovates processes to improve ethanol yield. The objective of the present study was to determine standardized ileal digestibility (SID) of AA (Exp. 1) and DE (Exp. 2) contents in high-CP (approximately 45% DM) DDGS (HP). Two HP samples (HP-A and HP-B) were procured at 2 different time points from a local company and tested along with a commodity DDGS (CON) sample for comparison. Three semipurified cornstarch-based (approximately 20% CP, as-fed basis) diets were formulated with DDGS as the sole source of AA. A fourth N-free diet was prepared for endogenous N loss. In Exp. 1, 8 ileal cannulated barrows (23.9 kg BW) were used in a replicated 4 × 4 Latin square design. Pigs were fed at 2.8 times maintenance energy requirements. In each period, pigs were adjusted to diets for 5 d followed by 2 d, 8 h continuous ileal digesta collection. In Exp. 2, 9 barrows (24.9 kg BW) were assigned to the 4 diets in a repeated 4 × 4 Latin square design such that in each period, one of the diets was fed to an extra pig ($n = 9$). In each period, pigs were adjusted to diets for 7 d followed by 5 d of fecal sample collection. In the statistical analysis, diet was the fixed effect whereas period and pig were random effects. The DE content in DDGS was calculated by the difference method. The analyzed CP was 30.1, 42.3, and 43.1% DM in CON, HP-A, and HP-B samples, respectively; the corresponding values for GE were 5,067, 5,425, and 5,407 kcal/kg DM, respectively. The concentrations of fat and NDF were comparable among the DDGS samples. Except for Arg and Val, the SID values for indispensable AA were not different ($P > 0.05$) among the 3 DDGS samples. However, HP samples had greater ($P < 0.05$) SID content of indispensable protein and CP than CON samples. The SID of Lys content was 4.9, 6.1, and 7.4 g/kg DM for CON, HP-A, and HP-B, respectively, and corresponding values for Met and Thr were 4.6, 6.8, and 7.4 g/kg DM and 6.8, 9.5, and 10.1 g/kg DM, respectively. The DE content in HP samples was higher than in CON samples ($P < 0.01$; 3,614, 4,494, and 4,555 kcal/kg DM for CON, HP-A, and HP-B, respectively). In conclusion, HP DDGS had higher digestible AA and energy contents than CON DDGS.

**Key Words:** high-protein distiller's dried grains with solubles, pigs, standardized ileal digestibility of amino acids and digestible energy
doi:10.2527/asasmw.2017.257

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**258 Effects of rapeseed feeding on swine metabolome.**

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Rapeseed meal (RSM) is a rich source of AA, lipids, fiber, minerals, and vitamins. Despite its favorable nutrient content, the antinutrient properties of bioactive phytochemicals within rapeseed pose challenges in adopting rapeseed meal as a major component of swine feed. In this study, the control diet containing 14% soybean meal (SBM) and the rapeseed diet containing 20% RSM were formulated to have similar NE and standardized ileal digestible AA content. To understand the influences of RSM feeding on metabolic homeostasis, 40 nursery pigs, 17.8 ± 2.7 kg initial BW, were equally spilt into 2 groups and pair fed with control and rapeseed diets, respectively. On d 21, all pigs were sacrificed for harvesting serum, digesta, and liver samples. All samples were examined by LC-MS–based metabolomic analysis for determining the metabolic effects of these 2 diets. Rapeseed exposure markers, including sinapine, sinapic acid, and gluconapin, were identified in the digesta by an unsupervised principal component analysis (PCA) model

and metabolite characterization, Furthermore, different distribution of free AA in the intestine was observed between the 2 meals. However, feeding RSM did not significantly affect the levels of microbial metabolites in the digesta, including short-chain fatty acids and secondary bile acids, in spite of 2% greater NDF content. As for serum and liver extracts, the separation of rapeseed diet from control was achieved only in the supervised partial least squares-discriminant analysis (PLS-DA) model but not in the PCA model, suggesting that limited metabolic differences existed between the 2 feeding groups. Nevertheless, oxidized metabolites, including oxidized glutathione, cystine, and pyroglutamate, as well as the triacylglycerol:phospholipid ratio were positively correlated with rapeseed diet in the model, whereas ascorbic acid in the liver was negatively associated with it. These observed metabolic changes suggest the occurrence of oxidative stress after short-term RSM feeding and warrant further studies on their correlations with growth performance in long-term feeding.

**Key Words:** liquid chromatography-mass spectrometry, metabolomics, rapeseed
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**259 Effects of *Enterococcus faecium* on growth performance, blood parameters, relative organ weight, breast muscle meat quality, excreta microbial shedding, and noxious gas emission in broilers.** R. X. Lan[1,*], Y. M. Kim[1], H. M. Yun[1], C. M. Nyachoti[2], I. H. Kim[1], *[1]Department of Animal Resource and Science, Dankook University, Cheonan, The Republic of Korea, [2]University of Manitoba, Winnipeg, MB, Canada*.

This 5-wk study was to determine the effects of *Enterococcus faecium* (DSM 7134) on growth performance, blood parameters, relative organ weights, breast muscle meat quality, excreta microbial shedding, and noxious gas emission in broilers. A total of 816 1-d-old broilers were allocated to 4 groups with 12 replications (17 broilers/pen) according to BW (43.2 ± 0.32 g). Dietary treatment groups were 1) basal diet (CON), 2) CON + 0.05% *E. faecium* (T1), 3) CON + 0.10% *E. faecium* (T2), and 4) CON + 0.20% *E. faecium* (T3). On d 1, 21, and 35, BW and feed intake were determined. Digestibility, blood parameters, relative organ weight, and breast muscle meat quality were determined at 35 d of age. Excreta shedding of *Lactobacillus* and *Escherichia coli* and noxious gas emission were determined on d 7 and 35. Orthogonal comparison was conducted using polynomial regression to measure the linear and quadratic effects of increasing dietary supplementation of *E. faecium* with $P < 0.05$ indicating significance. From d 21 to 35 and overall, dietary *E. faecium* supplementation linearly increased ($P < 0.05$) BW gain and G:F, but from d 1 to 21, there was a linear increase ($P = 0.046$) in only G:F. On d 35, dietary *E. faecium* supplementation linearly increased ($P < 0.001$ and $P = 0.048$, respectively) the digestibility of DM and N and the relative weight of bursa of fabricius ($P = 0.041$), but no differences were observed in breast muscle meat quality, white blood cells, red blood cells, or lymphocyte counts. Dietary *E. faecium* supplementation linearly decreased ($P < 0.0001$ and $P = 0.003$, respectively) excreta *E. coli* counts on d 7 and 35, whereas excreta lactobacilli counts were linearly increased on d 35 ($P < 0.001$). On d 35, dietary *E. faecium* supplementation linearly decreased ($P = 0.002$, $P = 0.001$, and $P = 0.013$, respectively) excreta $NH_3$, $H_2S$, and total mercaptans emission, but only $H_2S$ emission was decreased ($P < 0.001$) on d 7. In conclusion, supplementation with *E. faecium* improved growth performance, the digestibility of DM and N, and the relative weight of bursa of fabricius, shifted excreta microbiota by increasing *Lactobacillus* and decreasing *E. coli* counts, and reduced excreta $NH_3$, $H_2S$, and total mercaptans gas emission.

**Key Words:** broilers, *Enterococcus faecium*, growth performance
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**260 Effect of different level of lysine and metabolic energy on growth performance and nutrient digestibility in broilers with a corn–soybean meal–canola meal–based diet.** J. Y. Zhang*, J. H. Park, J. W. Park, H. M. Yun, I. H. Kim, *Department of Animal Resource and Science, Dankook University, Cheonan, The Republic of Korea*.

Two experiments were conducted to determine the effects of different levels of Lys and ME on growth performance and nutrient digestibility in broilers with a corn–SBM–canola meal–based diet. In Exp. 1, a total of 663 broilers (41 ± 0.49 g initial BW) were arranged with 3 treatments for 5 wk: L1 (1.45, 1.30, and 1.20% Lys in the basal diet in the starter, grower, and finisher phases, respectively), L2 (1.50, 1.35, and 1.25% Lys in the basal diet in the starter, grower, and finisher phases, respectively), and L3 (1.55, 1.40, and 1.30% Lys in the basal diet in the starter, grower, and finisher phases, respectively). Each treatment had 13 pens with 17 broilers per cage. This experiment consists of 3 phases: starter phase (from d 1 to 7), grower phase (from d 7 to 21), and finisher phase (from d 21 to 35). BWG was significantly improved and the F:G ratio was significantly reduced with added grade Lys in the finisher phase and the overall phase ($P < 0.05$). In Exp. 2, a total of 544 broilers (30 d of age; 786.07 ± 17.26 g initial BW) were arranged with 4 treatments for 2 wk as a 2 × 2 factorial arrangement of treatments in a randomized complete block design to evaluate 2 levels of Lys (1.20 or 1.30% Lys in the basal diet) and 2 dietary energy (3,200 or 3,150 kcal/kg ME in the basal diet). There were 4 treatments: 1.20% Lys in high ME or low ME (3,200 or 3,150 kcal/kg ME in the basal diet) and 1.30% Lys in high or low energy. Each treatment had 8 replicate pens with 17 broilers per cage. BWG was improved by the dietary supplement of 1.30% in high energy ($P = 0.062$). The F:G ratio was induced by the dietary

supplement of 1.30% in high and low energy ($P = 0.006$ and $P = 0.067$, respectively). However, FI was decreased by the dietary supplement of 1.30% in high energy ($P = 0.020$ and $P = 0.057$, respectively). There was no difference in interaction during the experiment period ($P > 0.05$). In conclusion, adding 1.30% dietary Lys could increase BWG and FCR in the finisher phase of broilers.

**Key Words:** broilers, growth performance, lysine
doi:10.2527/asasmw.2017.260

**261 Porcine in vitro degradation and fermentation characteristics of oats.** J. W. Lee*, M. Caffe-Treml, T. A. Woyengo, *South Dakota State University, Brookings*.

This study was conducted to determine porcine in vitro digestion and fermentation characteristics of hulled and hulless oat varieties that differed in crude fat content. Treatments were hulless low-fat or high-fat oat, hulled low-fat or high-fat oat, and corn, which was included for comparison. Samples were digested with porcine pepsin and pancreatin. Undigested residues were subjected to porcine in vitro fermentation for 72 h. Gas production was measured and modeled to estimate kinetics of gas production using incubation time, maximum gas volume for $t = \infty$ and lag time before fermentation starts, and fractional rate of degradation of substrate. Total VFA concentration in fermented solutions was also measured. Corn contained 7.66% CP on a DM basis. In vitro digestibility of DM (IVDDM) for corn (66.7%) was lower ($P < 0.05$) than for hulless oat (84.3%) but similar to that for hulled oat (70.1%). Hulless oat had greater ($P < 0.05$) IVDDM than hulled oat. In vitro digestibility of DM for high-fat hulless oat was greater ($P < 0.05$) than that for low-fat hulless oat (87.6 vs. 81.0%), whereas IVDDM of hulled oat was unaffected by variety (70.5 vs. 69.7%). Total gas production for hydrolyzed residue of corn (249.5 mL/g DM) was greater ($P < 0.05$) than that of low-fat (160.1 mL/g DM) or high-fat (148.3 mL/g DM) varieties of hulless oat. Total gas production for hulless oat varieties was greater ($P < 0.05$) than that of low-fat (42.3 mL/g DM) or high-fat (42.4 mL/g DM) varieties of hulled oat. Total gas production for high-fat oat was similar to that of low-fat oat regardless of hull type. Per unit weight of feedstuff, total VFA production for corn was greater ($P < 0.05$) than that for hulless or hulled oats. Hulless oat had greater ($P < 0.05$) VFA production than hulled oat (0.57 vs. 0.31 mmol/g DM of feedstuff). Total VFA production for low-fat hulless oat was greater ($P = 0.003$) than that for high-fat hulless oat (0.71 vs. 0.41 mmol/g DM of feedstuff); there was no effect of variety on VFA of hulled oats. In conclusion, hulless oat is a better source of nutrients for pigs than hulled oat. Grain fat level may influence digestibility and fermentability of hulless oat but not of hulled oat.

**Key Words:** in vitro fermentation, oats, pig
doi:10.2527/asasmw.2017.261

**262 Nutritive value of extruded cold-pressed camelina cake for pigs.** J. W. Lee*, C. L. Levesque, T. A. Woyengo, *South Dakota State University, Brookings*.

The objectives were to determine the standardized ileal digestibility (SID) of AA and DE value of extruded cold-pressed camelina cake (CPCC) for pigs. Six ileal-cannulated barrows (47.0 kg average initial BW) were fed 3 diets in a replicated 3 × 3 Latin square design to give 6 replicates per diet. Diets included a cornstarch-based diet with CPCC or extruded CPCC and a low-casein cornstarch-based diet. The ratio of cornstarch to sugar, soybean oil, and casein in CPCC-containing diets was identical to the low-casein cornstarch-based diet to allow calculation of energy and nutrient digestibility of CPCC by the difference method. The CPCC had been produced by pressing camelina seeds at less than 42°C (barrel temperature). Extruded CPCC had been produced by extruding CPCC at approximately 95°C for 90 s followed by passing it through a 3.5-mm die at 124°C. On a DM basis, CPCC and extruded CPCC contained 44.8 and 45.8% CP, 8.95 and 8.29% ether extract, 41.8 and 48.0% NDF, 2.34 and 2.35% Lys, and 20.2 and 13.6 trypsin inhibitor units per milligram, respectively. The SID of CP and Lys for CPCC were 74.7 and 69.0%, respectively. The apparent total tract digestibility of GE for CPPC was 69.7%, whereas the DE value for CPCC was 3,485 kcal/kg of DM. Extrusion did not affect the SID of AA, apparent total tract digestibility of GE, and DE value for the cornstarch–CPCC–based diet or the CPCC. In conclusion, the CPCC evaluated in the present study could be an alternative source of AA and energy in swine diets. However, extrusion had limited effects on trypsin inhibitor activity, digestibility of AA, and DE value for CPCC fed to pigs.

**Key Words:** extruded cold-pressed camelina cake, nutrient digestibility, pig
doi:10.2527/asasmw.2017.262

**263 Evaluating pellets produced on three distinct pellet mill series.** A. D. Yoder*, M. B. Muckey, C. K. Jones, *Kansas State University, Manhattan*.

It is well accepted that pellet quality can change based on varying pelleting parameters. However, there is limited research evaluating differences among different types of pellet mills. The purpose of the experiment is to compare percentage fines and pellet durability index (PDI) of pellets produced on 3 different pellet mill models (medium scale: 3016-4, small

**Table 261.** Analyzed composition of oats (DM basis)

| | Hulless | | Hulled | |
|---|---|---|---|---|
| Item, % | Low fat | High fat | Low fat | High fat |
| CP | 15.73 | 16.29 | 12.98 | 12.57 |
| Ether extract | 6.66 | 8.67 | 6.51 | 8.06 |
| β-glucan | 5.44 | 5.08 | 5.68 | 4.82 |

scale: 1012-2, and benchtop: CL-5; California Pellet Mill Co., Crawfordsville, IN). A single swine finishing diet particle size (500 µm ± 50) was pelleted through 3 different runs on each of the pellet mills, with hot pellet temperature (88°C ± 2), conditioner retention time (30 s), die size (4 by 22 mm), length:diameter ratio (5.6), and throughput (60% of rated throughput) held constant. One composite pelleted feed sample was collected per run, cooled, and analyzed for PDI according to the Holmen NHP100 (TekPro Ltd., Norfolk, UK) and the Modified PDI method (ASABE S269.4, 2007, modified with three 19-mm hex nuts). Percentage fines were also determined as the percentage of a 4.5-kg sample that flowed through a number 6 U.S. screen. Data were analyzed using the GLIMMIX and CORR procedures of SAS version 9.4 (SAS Inst. Inc., Cary, NC). Pellet mill type impacted ($P < 0.001$) PDI as measured by the Holmen NHP100 (37.7, 57.6, and 93.8 for the 3016-4, 1012-2, and CL-5, respectively). Similarly, pellet mill type also impacted ($P < 0.001$) PDI as measured by the Modified PDI method (59.2, 67.3, and 91.2 for the 3016-4, 1012-2, and CL-5, respectively). Percentage fines was strongly correlated with PDI as measured by both the Holmen NHP100 method ($P = 0.009$; −0.807) and the Modified PDI method ($P = 0.018$; −0.759). These data underscore that clear differences exist in pellet quality among different pellet mills, even those from the same manufacturer when pelleting parameters are held constant. Caution should be used when comparing pellet quality among pellet mill types.

**Key Words:** pellet durability, pellet mill, percent fines
doi:10.2527/asasmw.2017.263

**Table 262.** Standardized ileal digestibility of CP and selected AA of unextruded and extruded cold-pressed camelina cake for growing pigs

| | Camelina cake | | | |
|---|---|---|---|---|
| Item, % | Unextruded | Extruded | SEM | *P*-value |
| CP | 73.2 | 74.7 | 2.89 | 0.72 |
| Indispensable AA | | | | |
| Lys | 70.3 | 69.0 | 2.74 | 0.73 |
| Met | 88.4 | 88.4 | 1.61 | 0.98 |
| Thr | 63.0 | 66.0 | 2.59 | 0.43 |
| Trp | 75.3 | 78.7 | 2.41 | 0.33 |

**264 Effect of substituting field beans (*Vicia faba*) for soybean meal in diets for grow–finisher pigs.**

A. Torres-Pitarch[1,2,*], E. G. Manzanilla[1], G. E. Gardiner[3], D. Torrallardona[4], J. V. O'Doherty[2], P. G. Lawlor[1], *[1]Pig Development Department, Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Ireland, [2]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin, Ireland, [3]Department of Science, Waterford Institute of Technology, Waterford, Ireland, [4]IRTA, Monogastric Nutrition, Constanti, Spain*.

Field beans (FB) availability has increased greatly in Ireland in recent years. This study examined the substitution of field beans for soybean meal in diets for grow–finisher pigs. A total of 80 pigs (38.9 ± 0.60 kg) housed in same sex pen pairs were blocked by sex and weight and allocated to 1 of 4 dietary treatments (10 replicates) in a 2 × 2 factorial arrangement. The factors were 1) diet density (high [10.0 MJ NE/kg and 9.9 g SID Lys/kg] vs. low [9.3 MJ NE/kg and 8.9 g SID Lys/kg]) and 2) FB inclusion level (0 vs. 40%). The experiment lasted 50 d. Data were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC). There was no interaction between diet density and FB inclusion. Pigs fed the low-density diets had a poorer FCR ($P < 0.001$) than pigs fed the high-density diets. Pigs fed the FB-based diets had higher final weight ($P < 0.01$), higher ADG ($P < 0.01$), higher ADFI ($P < 0.001$), and a similar FCR compared with pigs fed diets without FB. At slaughter, diet density had no effect on carcass weight (85.8 vs. 86.7 ± 0.77 kg; $P > 0.10$), kill out percent (77.4 vs. 77.7 ± 0.23%; $P > 0.10$), fat depth (11.9 vs. 11.6 ± 0.39 mm; $P > 0.10$), muscle depth (59.7 vs. 59.8 ± 2.69 mm; $P > 0.10$), and lean meat percent (59.2 vs. 59.1 ± 0.63%; $P > 0.10$). Pigs fed the FB-based diets had higher carcass weight (87.9 vs. 84.7 ± 0.77 kg; $P < 0.01$), similar kill out percent (77.5 vs. 75.6 ± 0.23%; $P > 0.10$), higher fat depth (12.4 vs. 11.1 ± 0.39 mm; $P < 0.05$), similar muscle depth (59.6 vs. 59.9 ± 2.69 mm; $P > 0.10$), and similar lean meat percent (59.5 vs. 58.8 ± 0.63%; $P > 0.10$). Higher growth, feed intake, and fat depth of pigs fed FB-based diets may indicate that the energy value used for FB in our diet formulation may have been underestimated. Field beans are a good protein source and can be included at a level of 40% in grow–finisher diets without causing deterioration in feed efficiency.

**Key Words:** grow–finisher, pig, *Vicia faba*
doi:10.2527/asasmw.2017.264

**265 Ileal digestibility of amino acids in corn condensed distiller's solubles and whole stillage for pigs.**

X. Yang*, J. Kim, D. Pangeni, A. Tekeste, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca*.

The immense growth in global bioethanol production has greatly increased the supply of byproducts such as whole stillage and condensed distiller's solubles, which could be potentially used for animal feeding. The objective of this experiment was to determine apparent ileal digestibility coefficients (AID) and standardized ileal digestibility coefficients (SID) of CP and AA in corn condensed distiller's solubles (CCDS) and corn whole stillage (CWS) when fed to pigs. A total of 18 finishing barrows with an average initial BW of 79.4 ± 4.5 kg and a simple T-cannula in the distal ileum were used in this experiment. Two test diets were formulated with CCDS or CWS as the sole source of AA, and a N-free diet was used for estimation of basal ileal endogenous losses of CP and AA. The direct procedure was used for calculation of AID and SID in the 2 coproducts. Compared with CWS, CCDS had higher SID (%) of CP (86.4 ± 2.0 vs. 79.6 ± 1.8; $P = 0.03$) and lysine (82.1 ± 3.4 vs. 74.3 ± 2.7; $P = 0.10$) but lower SID of methionine (73.0 ± 2.8 vs. 83.1 ± 1.4; $P = 0.009$) and similar SID of threonine (76.2 ± 3.4 vs. 71.0 ± 2.7; $P = 0.26$), tryptophan (86.2 ± 2.1 vs. 86.3 ± 2.9; $P = 0.98$), and cysteine (67.5 ± 2.7 vs. 68.6 ± 1.5; $P = 0.74$). The information generated from this experiment can be used for formulation of swine diets containing these 2 ethanol coproducts.

**Key Words:** amino acid digestibility, corn condensed distiller's solubles, corn whole stillage

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**266 Porcine in vitro digestion and fermentation characteristics of corn wet distiller's grains and distiller's dried grains with solubles without or with multicarbohydrase.**

C. A. Zangaro[1,*], R. Patterson[2], T. A. Woyengo[1], [1]*South Dakota State University, Brookings,* [2]*Canadian Biosystems, Calgary, AB, Canada*.

A study was conducted to determine porcine in vitro digestion and fermentation characteristics of wet distiller's grains and distiller's dried grains with solubles (DDGS) without or with multicarbohydrase (Superyme-CS; Canadian Bio-Systems Inc., Calgary, AB, Canada) that supplied 9,600 units of xylanase, 1,200 units of glucanase, 4,000 units of cellulase, 480 units of mannanase, 5,600 units of invertase, 40,000 units of protease, and 96,000 units of amylase per kilogram of feedstuff. Four-gram samples were weighed into conical flasks (5 flasks per treatment) and hydrolyzed in 2 steps using pepsin and pancreatin. Similar to the in vivo method of pigs, it is not known if the multicarbohydrase survived the digestion process. Subsequently, residues were incubated in a buffer solution with minerals and fresh pig feces as inoculum. Gas production was measured for 72 h and modeled to estimate kinetics of gas production. Concentration of VFA per unit weight of residue incubated or feedstuff was measured in fermented solutions. On a DM basis, the wet distiller's grains and DDGS contained 39.63 and 31.84% CP, respectively, and 8.1 and 9.1% ether extract, respectively. In vitro digestibility of DM (IVDDM) of wet distiller's grains (50.6%) was similar to that of DDGS (48.7%). Multicarbohydrase supplementation did not affect the IVDDM of wet distiller's grains or DDGS. Total gas production of residue incubated for wet distiller's grains was similar to that of DDGS (108.9 vs. 120.2 mL/g DM). Multicarbohydrase supplementation tended to increase ($P = 0.088$) total gas production of residue incubated for DDGS. However, multicarbohydrase did not affect the total gas production of residue incubated for wet distiller's grains. Wet distiller's grains and DDGS were similar in degradation rate of incubated residue. There was no effect of multicarbohydrase supplementation on degradation rate of incubated residue for wet distiller's grains or DDGS. Total VFA production of residue incubated for wet distiller's grains was similar to that of DDGS (6.73 vs. 6.52 mmol/g DM). Also, wet distiller's grains and DDGS were similar in individual VFA production of incubated residue. Multicarbohydrase did not affect the total or individual VFA production of residue incubated for wet distiller's grains or DDGS. In conclusion, the wet distiller's grains were more digestible than DDGS. In conclusion, the wet distiller's grains and DDGS were similar in in vitro digestibility and fermentability. The multicarbohydrase used in the current study may marginally improve in vitro digestibility of DDGS for pigs.

**Key Words:** digestibility, distiller's dried grains with solubles, pig

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**Table 264.** Effect of diet density and field bean inclusion (%) on growth performance of grow–finisher pigs

| | Diet density | | | | Field beans inclusion | | | |
|---|---|---|---|---|---|---|---|---|
| Item | High | Low | SEM | *P*-value | 0% | 40% | SEM | *P*-value |
| d 0–50 | | | | | | | | |
| Weight d 0, kg | 38.8 | 38.8 | 0.57 | 0.950 | 39.0 | 39.0 | 0.60 | 0.971 |
| Weight d 50, kg | 111.5 | 110.8 | 1.00 | 0.632 | 109.2 | 113.1 | 1.00 | <0.01 |
| ADG, g/d | 1,039 | 1,027 | 16.0 | 0.576 | 1,002 | 1,064 | 16.0 | <0.01 |
| ADFI, g/d | 2,271 | 2,364 | 36.5 | 0.079 | 2,242 | 2,394 | 36.6 | <0.001 |
| FCR, g/g | 2.19 | 2.31 | 0.023 | <0.001 | 2.24 | 2.26 | 0.020 | 0.712 |

**267 Determining starch gelatinization from grains collected at various locations within the extrusion process.** A. D. Yoder[1,*], M. B. Muckey[1], C. R. Stark[1], H. H. Stein[2], C. K. Jones[1], *[1]Kansas State University, Manhattan, [2]University of Illinois at Urbana-Champaign, Urbana*.

Starch gelatinization during feed manufacturing is recognized to improve starch digestibility in monogastric animals. One way to measure starch gelatinization is to evaluate the percentage of cooked starch (CS), or the quotient of the percentage of gelatinized starch (GS) in a sample divided by total starch (TS) in that sample. True starch gelatinization is thought to occur at temperatures above 70°C and moisture above 25%, parameters that are met during the extrusion process. Different types of grains absorb thermal energy and moisture at different rates, leading to differences in starch gelatinization, particularly at different points of the extrusion process. The objective of this experiment was to compare the percentage of cooked starch across different cereal grains at various stages of the extrusion process. Grains (corn, sorghum, and wheat) were ground via hammermill to 300 µm ± 50 and extruded in a pilot-scale extruder. Samples were analyzed for moisture, CS, GS, and TS. Data were analyzed as a 3 × 4 factorial with the 3 cereal grains and 4 locations in the extrusion process (initial, conditioner, after extrusion die, and after dryer) using the GLIMMIX procedure of SAS version 9.4 (SAS Inst. Inc., Cary, NC). The interaction between grain and location impacted ($P < 0.0003$) moisture, GS, and CS but not ($P = 0.249$) TS. The main effects of both grain type and extrusion process step impacted ($P < 0.05$) all response criteria. Although there were no initial differences ($P > 0.05$) in CS among grains, sorghum had greater ($P < 0.05$) CS than corn in samples obtained from the conditioner, with wheat being intermediate (22.7, 26.6, and 24.4% CS for corn, sorghum, and wheat, respectively). However, wheat had greater ($P < 0.05$) CS than corn or sorghum in samples collected immediately after the extruder (91.8, 90.3, and 95.8% CS for corn, sorghum, and wheat, respectively). In dried, extruded samples, CS was greatest ($P < 0.05$) in wheat followed by corn and then sorghum (90.8, 88.1, and 93.5% CS for corn, sorghum, and wheat, respectively). These findings demonstrate that, as expected, starch is cooked during the extrusion process, but the magnitude of this cook at different steps is variable in different grains. There is less potential for starch cook in sorghum than in wheat, with corn being intermediate. These data suggest that extruded wheat may have greater starch digestibility than sorghum, but additional research is needed to confirm this effect.

**Key Words:** cooked starch, extrusion, gelatinized starch
doi:10.2527/asasmw.2017.267

**268 Effect of number of dietary phases fed during the wean-to-finish period on growth performance and carcass characteristics of pigs under commercial conditions.** J. E. Estrada[1,*], M. Ellis[1], N. M. Stas[1], N. C. Cooper[1], A. M. Gaines[2], C. M. Shull[2], O. F. Mendoza[2], *[1]University of Illinois at Urbana-Champaign, Urbana–Champaign, [2]The Maschhoffs, LLC, Carlyle, IL*.

This study evaluated the effect of number of dietary phases fed during the wean-to-finish period on growth performance and carcass characteristics of pigs using a RCBD (blocking factor being day of start on test) with 3 treatments. Treatment 1 was a standard phase-feeding program with 9 dietary phases, and treatments 2 and 3 were achieved by combining dietary phases resulting in 7 or 6 dietary phases, respectively. Each dietary phase was formulated to meet the standardized ileal digestible lysine-to-energy ratio for the weight range over which the phase was fed and to meet or exceed NRC (2012) requirements for other nutrients. The study was performed in a commercial facility using a total of 3,744 animals. Pigs were housed in single-sex (barrows or gilts) groups of 78 from weaning (5.9 ± 0.29 kg BW) to 11 wk after weaning (42.9 ± 2.58 kg BW), at which point the groups were split into 2 groups of 38 until the end of the study (128.2 ± 1.92 kg). The pen of 78 pigs (16 replicates) was the experimental unit and data were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC); the model accounted for the effects of treatment, block, and replicate. Reducing the number of dietary phases had no effect ($P > 0.05$) on ADG (730, 726, and 726 g for 9, 7, and 6 dietary phases, respectively; SEM 7.0), ADFI (1,682, 1,674, and 1,665 g, respectively; SEM 19.1), G:F (0.436, 0.435, and 0.437 kg:kg, respectively; SEM 0.0010), or morbidity and mortality (9.1, 10.4, and 10.8%, respectively). There was no effect ($P > 0.05$) of the number of dietary phases on carcass yield, backfat depth, or predicted carcass lean content. The results of this study suggest that the number of dietary phases can be reduced from 9 to 6 without affecting wean-to-finish growth performance or carcass characteristics.

**Key Words:** dietary phases, growth, pig
doi:10.2527/asasmw.2017.268

**269 Growth performance and carcass traits of low- and high-fiber diet selection lines of pigs fed either low- or high-fiber diets.** J. A. Erceg*, J. G. Wiegert, R. Becerra, M. T. Knauer, E. van Heugten, *North Carolina State University, Raleigh*.

The objective of this study was to determine whether genetic selection of pigs when consuming high-fiber diets could improve growth performance of subsequent generations of grower–finisher pigs fed diets high in fiber. Barrows ($n = 175$; 45.8 ± 6.5 kg) were used in a 2 × 2 factorial RCBD with genetic line (selected high-fiber and selected control lines) and

diet (control or high fiber) as factors. Pigs were housed in pens (4 to 5 pigs/pen) with pen as the experimental unit. Genetic lines were developed by selection for lean growth in pigs consuming high-fiber or control diets for 3 generations. High-fiber diets were formulated to include 45% fibrous byproducts (15% each of distiller's dried grains with solubles [DDGS], soybean hulls, and wheat middlings) and control diets were corn–soybean meal based. A 3-phase feeding program was used with diets formulated to contain equal SID lysine-to-NE ratios between treatments within phase (control diet contained 0.93, 0.80, and 0.70% SID lysine and 2,484, 2,518, and 2,537 kcal/kg NE for Phase 1, 2, and 3, respectively; the high-fiber diet contained 0.82, 0.71, and 0.62% SID lysine and 2,187, 2,235, and 2,245 kcal/kg NE). Pigs were marketed by BW block with heavy pigs marketed on d 64 (118 ± 10.9 kg BW) and light pigs on d 78 (118 ± 10.8 kg BW). Feed disappearance and BW were recorded at the end of each phase, backfat (BF) and loin eye area (LEA) were measured using real-time ultrasound, and HCW was determined to calculate yield. Data were analyzed using PROC MIXED models with initial BW as a covariate. There were no interactions ($P > 0.11$) between diet and genetic line. Genetic line had no effects on ADG, ADFI, G:F, or caloric efficiency (gain:NE intake ratio), but the selected high-fiber line had decreased ($P < 0.05$) carcass yield (71.7 vs. 72.6%). Pigs fed high-fiber diets had lower ($P < 0.05$) ADG for Phase 1 and 2 and overall (9.3% lower), higher ADFI for Phase 3 ($P = 0.012$), lower ($P < 0.05$) G:F for Phase 2 and 3 and overall (10.2% lower), increased ($P < 0.05$) caloric efficiency for Phase 1 and 2, and reduced ($P < 0.05$) HCW (81.4 vs. 88.8, kg), LEA (16.89 vs. 18.24 $cm^2$), BF (1.66 vs. 1.98 cm), yield (70.8 vs. 73.5%), and daily lean gain (0.36 vs. 0.39 kg/d). Genetic selection for lean growth of pigs fed high-fiber diets for 3 generations did not improve carcass traits or growth performance; however, feeding high-fiber diets decreased growth performance, carcass characteristics, and daily lean gain in finishing pigs.

**Key Words:** fiber, genetic, pig
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**270 Effects of chromium methionine and zinc source on serum metabolites, endocrine parameters, and the antioxidant status of growing–finishing pigs.** X. Xu[1], Z. C. Li[1], H. L. Wang[1], L. Pan[1], X. K. Ma[1], Y. T. Xu[1], X. S. Piao[1], T. L. Ward[2], F. Ji[3,*], *[1]China Agricultural University, Beijing, China, [2]Zinpro Corporation, Eden Prairie, MN, [3]Zinpro (Wuxi) Additives Bio-Technology Co., LTD, Shanghai, China*.

The objective of this study was to evaluate the effect of chromium methionine (CrMet) in combination with different zinc sources (zinc sulfate [ZnS] vs. zinc AA complex [ZnAA]) on serum metabolites, endocrine parameters, and antioxidant status of growing–finishing pigs. One hundred eighty crossbred pigs (Duroc × Landrace × Yorkshire; 32.02 ± 1.71 kg BW) were used in a completely randomized design with 3 dietary treatments. Each treatment had 10 replicates (5 pens each of barrows or gilts) with 6 pigs per replicate. Treatment diets were corn–soybean meal diets, formulated using NRC (1998) requirements. The 3 treatments were 1) control (CON; 100 mg/kg Zn from $ZnSO_4$), 2) CON + 0.2 mg/kg Cr from CrMet (CrMet-ZnS), or 3) 50 mg/kg Zn from $ZnSO_4$ + 50 mg/kg Zn from ZnAA + 0.2 mg/kg Cr from CrMet (CrMet-ZnAA). The experiment lasted 105 d until pigs reached approximately 110 kg BW. On the morning of Day 106, after 16 h fasting, 1 pig nearest the mean BW from each pen was bled. Blood samples were obtained from the anterior vena cava, and serum was collected. Concentration of serum glucose in pigs fed CrMet-ZnS or CrMet-ZnAA was decreased compared with pigs fed CON (5.21, 5.18, and 5.82 mmol/L, respectively; $P < 0.05$). Concentration of total protein, triglycerides, serum urea nitrogen, high-density lipoprotein, low-density lipoprotein, and very-low-density lipoprotein were similar ($P > 0.05$) among treatments. Insulin was higher (15.2 vs. 13.7 μIU/mL, respectively; $P < 0.05$) and glucagon was lower (89.4 vs. 106.6 pg/mL, respectively; $P < 0.05$) in serum of pigs fed CrMet-ZnAA compared with pigs fed CON. Cortisol levels were decreased (115.4, 113.4, and 124.7 ng/mL, respectively; $P < 0.05$) in pigs fed CrMet-ZnS or CrMet-ZnAA compared with pigs fed CON. Growth hormone and insulin-like growth factor-I were not affected ($P > 0.05$) by treatments. There was an increase (7.0 vs. 6.5 units/mL and 68.1 vs. 62.5 units/mL, respectively; $P < 0.05$) in total antioxidant capacity and Cu/Zn superoxide dismutase activity, whereas, conversely, there was a decrease (5.3 vs. 5.9 nmol/mL, respectively; $P < 0.05$) in malondialdehyde in serum of pigs fed CrMet-ZnAA compared with pigs fed CON. Catalase and glutathione peroxidase were similar ($P > 0.05$) among treatments. In conclusion, the supplementation of CrMet alone or in combination with ZnAA positively affected glucose metabolism, decreased the stress hormone cortisol, and improved serum antioxidant status of growing–finishing pigs.

**Key Words:** chromium methionine, pigs, zinc amino acid complex
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**271 Revision of the simplified balance method to evaluate phosphorus excretion by growing–finishing pigs.** M. P. Létourneau Montminy[1,2,*], L. Cloutier[3], C. Couture[4], M. Marcoux[5], C. Pomar[5], *[1]Université Laval, Quebec, QC, Canada, [2]Département des sciences animales, Université Laval, Québec, QC, Canada, [3]Centre de Développement du Porc du Québec Inc., Québec, QC, Canada, [4]Laval University, Quebec, QC, Canada, [5]Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada*.

Guidelines have been developed in Quebec to maximize the benefits and minimize the risks associated with the application of livestock manure to agricultural soils. Within these

guidelines, P content of manure has to be assessed and manure application adjusted to crop needs. However, the work required to obtain a representative sample of pig slurry is considerable and must be meticulously performed to obtain accurate values. To simplify farmers' work, the simplified balance method has been proposed. This method quantifies P excretion as the difference between farm P inputs and outputs. The objective of this study was to estimate the amount of P retained by growing–finishing pigs, which is a key parameter in this method, and to highlight the factors of variation. The results of 3 trials in which pig body P content was estimated by dual X-ray absorptiometry (DXA) after receiving different levels dietary Ca and P were used. Total body and head BMD are strongly related ($R^2$ = 94%, RMSE = 0.034). Therefore, total body P retention (g/kg of BWG) can be estimated from total body BMD ($R^2$ = 78%, RMSE = 0.263) but because pig heads have very low cost and can be easily obtained from slaughterhouses, the relationship between total body P and head BMD has been proposed for use in Quebec (P retained (g/kg BWG) = 2.28 + 1.32 × head BMD (g/cm$^2$); $n$ = 92; RMSE = 0.125, $R^2$ = 94%). Afterward, 425 heads from 6 main Quebec slaughterhouses over 6 mo were collected, and total P retention was estimated with this equation. Average P retention across slaughterhouses showed limited variation (ranging from 5.04 to 5.34 g P/kg BWG, average 5.15). However, the within-slaughterhouse variation was high (SEM = 0.25 g of P/kg BWG). This later variation is an indication of the individual natural variation on bone mineralization; this observation is further supported by the fact that pigs of one of the sampled slaughterhouses received all the same diets. The current results showed that the use of a fixed 5.15 g of retained P/kg BWG is proposed for the application of the simplified balance method in Quebec growing–finishing pigs. The proposed method of estimating P retention in pigs can also be used for easy assessment of pigs' bone mineralization and for future verification and update of the P retention value to be used in the simplified balance method.

**Key Words:** environment, phosphorus, pigs
doi:10.2527/asasmw.2017.271

**272 The effects of in utero heat stress on fasting heat production in growing pigs.** N. M. Chapel[1,*], C. J. Byrd[1], D. W. Lugar[1], K. R. Stewart[2], M. C. Lucy[3], T. J. Safranski[3], L. H. Baumgard[4], J. S. Johnson[5], *[1]Purdue University, West Lafayette, IN, [2]Department of Animal Sciences, Purdue University, West Lafayette, IN, [3]University of Missouri, Columbia, [4]Iowa State University, Ames, [5]USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN.*

The study objective was to determine the effects of in utero heat stress (IUHS) on postnatal fasting heat production (FHP) in growing pigs. Based on our previous observation of increased postnatal core body temperature "set point" in IUHS pigs, we hypothesized that FHP would be greater during postnatal life. Pregnant gilts were exposed to thermoneutral (TN; $n$ = 4; cyclical 15 to 20°C) or heat stress (HS; $n$ = 4; cyclical 27 to 37°C) conditions from d 30 to 60 of gestation. At weaning, 2 median weight male pigs (1 barrow and 1 boar) were selected from each gilt ($n$ = 8 in utero thermoneutral [IUTN] and 8 IUHS pigs) and then housed in TN conditions (22.3 ± 0.1°C). Pigs were acclimated to an indirect calorimeter 1 wk prior to testing. At 84 d of age, pigs were fasted for 24 h and individually placed into an indirect calorimeter with ad libitum water access for an additional 24-h testing period (1 h acclimation + 23 h air collection). Body weight was determined before testing and was similar for all pigs ($P$ = 0.67; 30.8 ± 0.3 kg BW). Air input and output were collected using gas bags in 3 intervals (0900–1700 h, 1700–0000 h, and 0000–0800 h) and then analyzed for $CO_2$ and $O_2$ concentrations to calculate FHP and the respiratory quotient (RQ). During testing, pigs were video recorded to account for activity differences, and this was included as a covariate in the final FHP and RQ analyses. Data were analyzed using PROC MIXED in SAS 9.4 (SAS Inst. Inc., Cary, NC). No boar versus barrow differences were detected with any analysis. Overall, no differences ($P$ = 0.25) in FHP were detected between IUHS (149.1 ± 10.6 kcal/h) and IUTN (137.4 ± 8.8 kcal/h) pigs. However, FHP per kilogram BW was increased ($P$ = 0.03; 14.6%) in IUHS pigs compared with IUTN pigs, and FHP per kilogram metabolic BW was increased ($P$ = 0.05; 9.7%) in IUHS pigs versus IUTN pigs. A time effect was observed where FHP was increased ($P$ < 0.01; 19.8%) from 0900 to 1700 h compared with 1700 to 0000 h and 0000 to 0800 h. Respiratory quotient was not effected by treatment, but RQ was increased ($P$ < 0.01; 15.3%) from 1700 to 0000 h compared with 0900 to 1700 h and 0000 to 0800 h. No other differences were detected for FHP and RQ. Animal activity was not different ($P$ > 0.19) with regard to time of day, treatment, or their interaction. In summary, IUHS pigs had increased postnatal FHP compared with IUTN pigs, and this has implications toward future production efficiency in pigs gestated during hot summer months.

**Key Words:** fasting heat production, in utero heat stress, pigs
doi:10.2527/asasmw.2017.272

**273 Standardized ileal digestible lysine requirements for finishing PIC pigs under commercial conditions: A meta-analysis.** M. Goncalves, U. Orlando, W. Cast*, M. Culbertson, *Genus PIC, Hendersonville, TN.*

The objective of this meta-analysis was to evaluate the standardized ileal digestible (SID) Lys requirement for PIC finishing pigs under commercial conditions. A total of 27 commercial experiments were used in the meta-analysis with a total of 45,102 pigs. Number of pens/treatment and pigs/experiment ranged from 9 to 16 and 12 to 25, respectively. The average pen BW range in these experiments was from 23 to 135 kg. Dam lines were Camborough 1050 in 18 experiments and Camborough 29 in 9 experiments. Sire lines were PIC 337 in

24 experiments and PIC 327 in 3 experiments. Ingredient loadings values used were based on NRC (2012) recommendations. Responses were analyzed separately for each experiment using general linear and nonlinear heterogeneous variance mixed models (Gonçalves et al., 2016). Each treatment within an experiment was considered an observation ($n$ = 213) and each experiment was used as random effect. Models that differed in their Bayesian information criterion values by at least 2 points were considered to have meaningful differences in their data fit (Raftery, 1996). The requirements presented are an average of the requirement for ADG and the F:G ratio. Requirements estimates for boars were based on relative differences from barrows published by Bertram et al. (2014) and the NRC (2012). There was no interaction between sire line or dam line and treatment ($P > 0.10$). The SID Lys requirement and their SID Lys:calorie ratio equations are presented in Tables 273-01 and 273-02, respectively. The SID Lys requirements from this meta-analysis are 106, 103, and 132% of NRC (2012) recommendations for barrows, gilts, and boars after adjusting for feed intake, respectively. This is probably due to increased rate of growth and improved feed efficiency from modern PIC lines.

**Key Words:** growth, lysine, pig
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**Table 273-01**. Standardized ileal digestible (SID) Lysine percentage requirement and ADFI of PIC pigs for a diet with 2,475 kcal NE/kg

| | | BW range, kg | | | |
|---|---|---|---|---|---|
| | ADFI, kg | 25–50 | 50–75 | 75–100 | 100–135 |
| Barrows | 2.40 | 1.11 | 0.91 | 0.78 | 0.70 |
| Gilts | 2.22 | 1.16 | 0.94 | 0.80 | 0.75 |
| Boars | 1.88 | 1.39 | 1.16 | 1.00 | 0.90 |

**Table 273-02.** Standardized ileal digestible (SID) Lysine to NE ratio equations for PIC pigs

| |
|---|
| Gilts = 0.000056 × (BW, kg × 2.2046)$^2$ − 0.02844 × (BW, kg × 2.2046) + 6.6391 |
| Barrows = 0.000042 × (BW, kg × 2.2046)$^2$ − 0.02372 × (BW, kg × 2.2046) + 6.1452 |
| Boars = 0.000046 × (BW, kg × 2.2046)$^2$ − 0.02704 × (BW, kg × 2.2046) + 7.5417 |

## 274 Effects of various dietary *n*-6:*n*-3 polyunsaturated fatty acid ratios on growth performance, carcass traits, blood lipid profiles, and meat quality in finishing pigs.

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A total of 96 crossbred pigs ([Landrace × Yorkshire] × Duroc) with an average initial BW of 51.50 ± 1.56 kg were used in this 10-wk feeding trial to evaluate the effects of different dietary *n*-6:*n*-3 PUFA ratios in finishing pigs. Pigs were randomly allotted to 4 dietary treatments with 6 replications and 4 pigs per pen (2 barrows and 2 gilts). Pigs were fed a corn–soybean meal–based diet with various *n*-6:*n*-3 ratios (1:1, 5:1, 10:1, and 15:1). Pigs were weighed at the beginning of the experiment and at the end of wk 5 and 10, and feed consumption was recorded to calculate ADG, ADFI, and G:F. At the end of the experiment, blood samples were taken from 2 pigs per pen via jugular venipuncture into vacuum tubes, and serum was recovered by centrifugation at 2,000 × *g* for 30 min at 4°C. The serum concentration of total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL), and triglyceride was analyzed using an autoanalyzer (Automatic Biochemical Analyzer, RA-1000; Bayer Corp., Tarrytown, NY). After slaughter, backfat thickness and lean meat percentage were measured using a real-time ultrasound instrument (Piglot 105; SFK Technology, Herlev, Denmark). Then, a sample of the right loin was removed between the 10th and 11th ribs to determine meat quality, including meat color, sensory evaluation (color, marbling, and firmness scores), cooking loss, drip loss, pH, LM area, and water holding capacity. All data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Differences among treatment means were determined using the Tukey's range test. Growth performance, carcass traits, and meat quality characteristics were not influenced ($P > 0.10$) by dietary *n*-6:*n*-3 ratios. The serum total cholesterol and LDL cholesterol contents of pigs fed the diet with an *n*-6:*n*-3 PUFA ratio of 1:1 (1.75 and 1.01 mmol/L, respectively) were lower ($P < 0.05$) than those of pigs fed the diets with ratios of 10:1 (2.11 and 1.39 mmol/L, respectively) and 15:1 (2.18 and 1.23 mmol/L, respectively). Furthermore, the serum triglyceride contents of pigs fed the diets with *n*-6:*n*-3 PUFA ratios of 1:1 (0.58 mmol/L) and 5:1 (0.60 mmol/L) were lower ($P < 0.05$) than those of pigs fed diets with ratios of 10:1 (0.96 mmol/L) and 15:1 (0.89 mmol/L). In conclusion, lowering the dietary *n*-6:*n*-3 ratio to 1:1 to 5:1 is beneficial for lipid metabolism in finishing pigs without adverse effects on growth performance, carcass traits, and meat quality.

**Key Words:** blood lipid profiles, finishing pigs, *n*-6:*n*-3 ratios
doi:10.2527/asasmw.2017.274

## 275 Effects of KemTRACE chromium level and feeding regimen on finishing pig growth performance and carcass characteristics.

J. T. Gebhardt[1], H. S. Cemin[1,*], J. C. Woodworth[1], M. D. Tokach[1], S. S. Dritz[1], J. M. DeRouchey[1], J. A. Loughmiller[2], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]Kemin Industries, Des Moines, IA*.

A total of 1,206 pigs (PIC 337 × 1050; 48.9 kg initial BW) with 27 pigs per pen and 15 pens per treatment were used in an 84-d study to evaluate the effects of Cr supplementation (KemTRACE Chromium propionate, Kemin Industries Inc., Des Moines, IA) and feeding regimen on growth performance of finishing pigs housed under commercial conditions. Pigs

were placed in mixed-gender pens and blocked by BW in a randomized complete block design. Diets were corn–soy– distiller's dried grains with solubles (DDGS) based and were fed in 4 phases. Treatments were 1) Control, no Cr in the grower or finisher phases; 2) 200 ppb of Cr fed in both grower and finisher phases; and 3) 200 ppb of Cr fed in the grower phase and 100 ppb fed in the finisher phase. The grower phase was from 49 to 92 kg and the finisher phase was from 92 to 124 kg. Data were analyzed using PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, NC) and are presented as least squares means ± SEM. There was no evidence ($P \geq 0.197$) of a Cr supplementation effect in the grower period. In the finishing period, addition of Cr resulted in a quadratic increase ($P = 0.023$) in ADG, with the greatest performance observed at 200 ppb Cr (0.92, 0.92, and 0.94 ± 0.010 kg/d for the Control and 100 and 200 ppb added Cr, respectively), with no evidence of differences on ADFI or G:F. Overall, the addition of 200 ppb Cr in both grower and finisher phases tended to increase ($P = 0.086$) ADG compared with the control (0.89, 0.90, and 0.91 ± 0.006 kg/d for the control and 200/100 and 200/200 ppb added Cr, respectively). There was no evidence ($P \geq 0.523$) of a Cr supplementation effect on overall ADFI and G:F. Backfat was lowest ($P = 0.028$) for pigs fed 200 and then 100 ppb Cr and greatest for pigs fed 200 ppb Cr in the grower and finisher phases, with control pigs intermediate (18.4, 18.0, and 18.7 ± 0.23 mm for the Control and 200/100 and 200/200 ppb added Cr, respectively). Percentage lean was greatest ($P = 0.028$) for pigs supplemented with 200 and then 100 ppb Cr (55.1, 55.4, and 55.0 ± 0.16% for the control and 200/100 and 200/200 ppb added Cr, respectively). Dressing percentage was lowest ($P = 0.018$) for pigs fed 200 ppb Cr in both grower and finisher phases, with no difference between the other treatments (77.1, 77.1, and 76.8 ± 0.001%, respectively). There was no evidence of differences ($P > 0.10$) in HCW or loin depth. In summary, adding 200 ppb of Cr in both grower and finisher phases increased finishing ADG. Carcass characteristics were optimized with supplementation of 200 ppb Cr in the grower phase followed by 100 ppb Cr fed in the finisher phase.

**Key Words:** chromium propionate, duration, finishing pigs
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**276 Evaluation of standardized ileal digestible tryptophan:lysine ratio with and without ractopamine hydrochloride on growth performance and carcass characteristics of finishing pigs.**

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Previous research has reported that increasing the SID Trp:Lys ratio to 24.5% in finishing pigs fed ractopamine HCl (RAC) during summer months improved ADG by 70 and 37 g/d in comparison with ratios of 18 and 21%, respectively. The objective of this experiment was to determine the effects of feeding higher SID Trp:Lys ratios with and without RAC on growth performance and carcass characteristics of finishing pigs during summer months. In August 2016 (mean outside temperature 23.03°C), a total of 1,101 pigs (PIC 1050 × 327; 99.3 kg initial BW) were used in a 30-d trial. Pens of 26 or 27 pigs were randomly assigned to 6 dietary treatments arranged in a 2 × 3 factorial with main effects of RAC (0 or 10 ppm) and SID Trp:Lys ratio (20, 24, and 28%) with 7 replications per treatment. Diets with and without RAC were formulated to 0.90 and 0.66% SID Lys, respectively. Overall (d 0 to 30), a RAC × SID Trp:Lys ratio interaction was observed (linear, $P < 0.05$), where increasing SID Trp:Lys ratios improved BW, ADG, and G:F when diets contained RAC but decreased these criteria when diets did not contain RAC. Similarly, RAC × SID Trp:Lys ratio interactions were observed (linear, $P < 0.05$) for carcass criteria with improvements in carcass ADG, carcass G:F, and HCW when pigs were fed increasing SID Trp:Lys ratios in diets containing RAC. A linear decrease ($P < 0.05$) was observed in carcass ADG and carcass G:F in pigs fed higher SID Trp:Lys ratios when diets did not contain RAC. In summary, increasing SID Trp:Lys ratio above 20% improved growth and carcass performance when diets contained RAC, whereas pigs fed higher SID Trp: Lys ratio above 20% had reduced performance when diets did not contain RAC.

**Key Words:** finishing pigs, ractopamine hydrochloride, tryptophan
doi:10.2527/asasmw.2017.276

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**277 Effects of dietary electrolyte balance and crude protein on growth performance and carcass characteristics of finishing pigs from 110 to 130 kilograms.**

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Economic and environmental factors have compelled nutritionists to develop low-protein, AA-fortified diets that deliver performance equivalent to traditional formulations. In some instances, low-protein, AA-fortified diets have led to poorer performance in finishing pigs than conventional diets. Along with low CP concentrations, with crystalline AA, there is proportional decrease in dietary electrolyte balance (dEB). To evaluate the effects of dEB and determine the optimum dietary CP level in finishing pigs, 2 experiments were conducted. In Exp. 1, 288 pigs (PIC 327 × 1050; initially 110.4 kg) were used in a 20-d trial. Pens of 8 pigs were randomly assigned to 4 dietary treatments with 8 replications per trea tment. Treatments were arranged in a 2 × 2 factorial with main effects of CP (10 or 13%) and dEB (48 or 107 mEq/kg). Pigs fed 13% CP diets had greater ($P = 0.001$) ADG (0.79 vs. 0.71 kg; $P = 0.037$), final BW, and ($P < 0.001$) G:F (0.279 vs. 0.253) compared with pigs fed the 10% CP diets. Marginal significance for a CP × dEB interaction ($P = 0.083$) was observed for ADFI because intake numerically decreased when dEB was increased for pigs fed 10% CP whereas

**Table 276.**

| | Ractopamine HCl, ppm | | | | | | | Probability, $P <$ | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | 10 | | | | | |
| | SID Trp:Lys ratio, % | | | | | | | R × T[1] | |
| Item | 20 | 24 | 28 | 20 | 24 | 28 | SEM | Linear | RAC |
| ADG, kg | 0.88 | 0.84 | 0.82 | 0.98 | 1.03 | 1.03 | 0.049 | 0.012 | 0.001 |
| ADFI, kg | 2.51 | 2.44 | 2.48 | 2.39 | 2.36 | 2.42 | 0.075 | 0.351 | 0.003 |
| G:F | 0.35 | 0.34 | 0.33 | 0.41 | 0.44 | 0.42 | 0.007 | 0.010 | 0.001 |
| Final BW, kg | 125.1 | 124.1 | 123.3 | 128.0 | 130.2 | 129.3 | 2.75 | 0.030 | 0.001 |
| Carcass ADG, kg | 0.64 | 0.61 | 0.60 | 0.72 | 0.75 | 0.75 | 0.036 | 0.009 | 0.001 |
| HCW, kg | 90.6 | 90.2 | 89.5 | 93.3 | 95.0 | 94.9 | 2.14 | 0.057 | 0.001 |
| Carcass yield, % | 72.4 | 72.7 | 72.6 | 72.9 | 73.0 | 73.4 | 0.20 | 0.490 | 0.001 |

[1]R × T = RAC × SID Trp:Lys ratio.

intake increased as dEB was increased for pigs fed 13% CP diets. For carcass performance, pigs fed the diets with 13% CP had increased ($P = 0.001$) HCW and HCW ADG and improved ($P = 0.001$) HCW G:F compared with pigs fed 10% CP diets. In Exp. 2, 224 pigs (PIC 327 × 1050; initially 109.4 kg) were used in a 20-d trial. Pens of 7 pigs were assigned to 4 levels of dietary CP (10, 11, 12, and 13%) with 8 replications per treatment. For overall growth performance (d 0 to 20), increasing CP increased (linear, $P < 0.05$, and quadratic, $P < 0.10$) ADG (0.77, 0.86, 0.91, and 0.90 kg), ADFI (2.58, 2.72, 2.84, and 2.76 kg), and HCW ADG, with the greatest response for pigs fed the diet with 12% CP. Increasing diet CP also improved (linear, $P < 0.05$) G:F (0.299, 0.314, 0.322, and 0.327), NE caloric efficiency, final BW, HCW and HCW G:F. In summary, dEB in the tested range had no effects on growth performance or carcass performance. Optimum dietary CP was reached by pigs fed diets with 12% CP. Rationale for poor feed efficiency and low feed intake when pigs are fed diets with less than 12% CP remains unclear.

**Key Words:** crude protein, electrolyte balance, finishing pig
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## 278 Does chemical composition of dietary fat sources alter messenger RNA abundance of genes related to lipid digestion and metabolism in pigs?

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Our objective was to determine the effect of dietary fat source on the mRNA abundance in porcine tissues of genes related to lipid digestion, lipogenesis, and lipolysis. A total of 48 Genetiporc 6.0 × Genetiporc F25 (PIC, Inc., Hendersonville, TN) barrows (initial BW of 9.9 ± 0.6 kg) were randomly allotted to 1 of 6 dietary treatments in a 56-d experiment. Each experimental diet included 95% of a corn–soybean meal basal diet and then 5% of either cornstarch (CNTR), animal–vegetable blend (AV; iodine value [IV] = 70.9), coconut oil (COCO: IV = 1.1), corn oil (CORO; IV = 131.9), fish oil (FO; IV = 140.0), or tallow (TAL; IV = 46.0). Pigs were fed these experimental diets from d 0 to 10 and d 46 to 56 and fed a common diet from d 10 to 46. Expression normalization across samples collected postmortem (d 56) within tissue was performed by calculating a delta cycle threshold (Ct) value for each sample using *RPL32*, as transcript abundance was similar among treatments ($P > 0.10$). Delta delta Ct (ΔΔCt) values were calculated from delta Ct values using a reference sample pooled from all experimental samples within tissue. Data were analyzed using PROC MIXED with dietary treatment as a fixed effect, replicate (2 cohorts of 24 barrows each) as a random effect, and pig as the experimental unit. Including dietary fat decreased the mRNA abundance of *fatty acid synthase* in adipose tissue (AT; CNTR = −1.48, AV = 0.89, COCO = 0.26, CORO = −0.15, FO = 0.96, TAL = 1.10 ΔΔCt; $P = 0.031$). Including fat sources with greater concentrations of oleic or linoleic acid increased mRNA abundance in AT of *sterol regulatory element-binding protein-1* (CNTR = 0.59, AV = −1.64, COCO = 0.30, CORO = −2.06, FO = 1.13, TAL = 0.08 ΔΔCt; $P = 0.050$). Including CORO or no added dietary fat versus including TAL tended to increase mRNA abundance of *stearoyl CoA desaturase* in AT (CNTR = −0.71, AV = 0.09, COCO = −0.32, CORO = −1.75, FO = 0.51, TAL = 2.14 ΔΔCt; $P = 0.100$). Dietary treatment had no impact on the mRNA abundance of *acetyl CoA carboxylase* ($P = 0.377$), *ATP citrate lyase* ($P = 0.422$), or *peroxisome proliferator-activated receptor-α* ($P = 0.688$) in AT. In conclusion, the chemical composition among dietary fat sources alters the mRNA abundance of genes related in the synthesis and desaturation of fatty acids in AT.

**Key Words:** dietary fat, lipogenesis, swine
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## 279 Pigs receiving daily tailored diets have different amino acid requirements than pigs raised in conventional phase feeding systems.

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There is a large variation in nutrient requirements among pigs, and therefore, individually feeding pigs with daily tailored diets

may require different nutrient levels than when pigs are feed in groups with a single feed. Therefore, the response to different levels of Thr:Lys ratio (70, 85, 100, 115, and 130% of the 0.65 Thr:Lys ideal ratio) was studied in growing pigs raised in conventional group feeding (GF) systems or individually fed using precision feeding (PF) techniques. A 21-d trial was performed in a 2 × 5 factorial design with 110 pigs (25 kg BW ± 0.80; 11 pigs per treatment) housed in the same pen and fed using electronic feeders. Individual pigs were the experimental units. Lysine was provided at 90% and AA other than Lys and Thr were provided at 110% or more of the estimated requirements. Protein deposition (PD) was estimated using dual X-ray absorptiometry at d 1 and 21. Blood samples were collected on d 21 after 8 h of fasting, and 5 pigs per treatment were slaughtered. The chemical composition of the longissimus dorsi and other carcass muscles were estimated by near-infrared transmittance. The MIXED and NLIN procedures of SAS (SAS Inst. Inc., Cary, NC) were used to analyze the data and obtain optimal Thr: Lys ratios. Threonine intake linearly increased in PF and GF (6.28 to 11.76 vs. 6.85 to 11.01 g/d; $P < 0.05$). Lysine intake was similar (12.5 g/d) across treatments. The intersection of the linear-plateau and quadratic-plateau models for PD was obtained in GF pigs at 150 g/d and 0.65 Thr:Lys ratio whereas maximal PD was not reached in PF pigs (126 to 159 g/d). Plasma methionine and serine levels were, respectively, 11 and 7% higher in PF pigs than in GF pigs ($P < 0.05$). Carcass muscle CP was 2% higher in GF pigs (18.1%) than in PF pigs (17.8%; $P < 0.05$). Longissimus dorsi collagen tended to decrease with increasing dietary Thr in PF and GF pigs (0.61 to 0.45% vs. 0.55 to 0.54%; $P < 0.10$). Plasma albumin increased with the level of Thr in PF and GF pigs (29.1 to 34.9 g/L vs. 30.8 to 32.5 g/L; $P < 0.05$), indicating a possible defective albumin synthesis at lower Thr levels. Altogether, the Thr:Lys ratio that maximizes growing pig responses differs between conventional and precision feeding systems, and therefore, actual Thr:Lys ideal ratios may not be optimal for pigs fed with daily tailored diets.

**Key Words:** ideal protein concept, precision feeding, threonine
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**280 Evaluation of standardized ileal digestible lysine:metabolizable energy ratios in grow–finishing pigs.** L. Ochoa[1,*], A. Graham[1], B. Knopf[1], L. Greiner[1], J. Connor[2], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Carthage Veterinary Service, Ltd, Carthage, IL.*

Approximately 1,200 (400 PIC 337 × 1050 and 800 PIC 359 × C29) barrows and gilts (26.5 ± 1.9 kg) were used to evaluate 3 different SID Lys:ME ratio programs in grow–finish. Experimental diets were fed in 5 phases (26–41, 41–55, 55–82, 82–105, and 105–114 kg) with 1 of 3 SID Lys:ME ratio programs (Current, New, and Economical). The SID Lys:ME ratios by phase for each treatment were as follows: 3.17, 2.76, 2.38, 2.11, and 1.96 in the Current program; 3.60, 3.00, 2.62, 2.46, and 2.09 in the New program; and 3.22, 2.98, 2.53, 2.26, and 2.09 in the Economical program. Pigs were fed a common diet with Paylean at 4.5 g/ton and SID Lys:ME ratio of 2.87 from 114 kg to market. Diets were formulated to meet or exceed NRC requirements. Growth performance data collected was collected at the start and end of the study and at the end of each phase. Overall (start of study to end of marketing) morbidity and mortality was determined. Data were analyzed as a randomized complete block design (block = start BW) using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC), with pen as the experimental unit and treatment as the main effect. Results were considered significant at $P \leq 0.05$ and considered a trend at $P > 0.05$ and $P \leq 0.10$. Pigs on the New and Economical treatments tended to be heavier ($0.05 > P \leq 0.1$) than the Current Lys:ME ratio treatment on every interim period starting on Day 43. At the end of the finishing period (i.e., start of marketing on Day 101), pigs on the New and Economical treatments were 2.05 and 2.00 kg heavier, respectively, than pigs in the Current treatment. For the cumulative period from start to d 101, the ADG of pigs fed the New and Economical diets (0.89 and 0.89 kg/d, respectively) was greater than that of pigs fed the Current diets (0.87 kg/d). The G:F for the cumulative period Day 0 through 101 was better ($P < 0.05$) for pigs on the New treatment (0.408) than that of pigs on the Current and Economical treatments (0.401 and 0.404, respectively). However, there was no treatment effect ($P > 0.1$; 0.392, 0.396, and 0.394) for the overall period (Day 0–End of Marketing) after feeding a common diet during the marketing period. In conclusion, growth performance of pigs is improved with higher Lys:ME ratios compared with current recommendations. The use of an "Economical" formulation was able to reduce the feeding costs compared with the New recommendations while still maintaining the improvements in growth performance compared with current specifications.

**Key Words:** grow–finish, lysine, pig
doi:10.2527/asasmw.2017.280

**281 Impact of grow–finish performance and carcass characteristics in response to an increased apparent health challenge.** A. S. Cornelison[1,*], N. H. Williams[2], B. Haberl[2], M. A. Berhow[3], L. A. Karriker[1], J. Less[4], J. F. Patience[1], *[1]Iowa State University, Ames, [2]Iowa Select Farms, Iowa Falls, IA, [3]USDA, ARS, NCAUR, Peoria, IL, [4]ADM Animal Nutrition, Decatur, IL.*

A health challenge can cause significant loss of profit for a production system. The objective of this experiment was to quantify the impact of an apparent health challenge on growth performance and carcass characteristics. Within each of 3 barns, approximately 900 pigs (13.1 ± 0.2 kg) were split by weight and blocked by sex (16 barrow pens, 16 gilt pens, and 4 mixed-sex pens). Each barn was categorized based on the apparent health status as low challenge (LC), moderate

challenge (MC), or high challenge (HC). Apparent health status was determined based on results from quantitative diagnostic assessments and mortality rates. Over the duration of the study, barns were diagnosed with porcine reproductive and respiratory syndrome virus, influenza, and secondary bacterial pathogens varying in combination. Mortality was 4.1, 7.7, and 21.2% for LC, MC, and HC, respectively. All barns were marketed at a common weight (approximately 131.5 ± 1.3 kg), in a 3-cut structure. Data were analyzed using the PROC MIXED of SAS (9.3; SAS Inst. Inc., Cary, NC) with pen as the experimental unit, start weight as a covariate, apparent health status and sex as fixed effects, and block as a random effect. There was a decrease in ADG and ADFI with increased health challenge ($P < 0.01$). Feed efficiency was greatest in LC but the same in the MC and HC ($P < 0.01$). The MC and HC barns had greater HCW than the LC barn ($P < 0.01$). This was similar for percent yield ($P < 0.01$). However, there was no difference for percent lean or fat depth between the 3 health statuses ($P > 0.05$). In conclusion, there was a decrease in ADG, ADFI, and feed efficiency with an increase in health challenge. There was a difference in percent yield but no difference for percent lean or fat depth.

**Key Words:** health, porcine reproductive and respiratory syndrome virus, swine
doi:10.2527/asasmw.2017.281

**282 Effects of high neutral detergent fiber diets on the nitrogen balance of pigs fed threonine-limited diets.** J. K. Mathai[1,*], H. L. Spangler[1], H. H. Stein[1], K. J. Touchette[2], *[1]University of Illinois at Urbana-Champaign, Urbana, [2]Ajinomoto Heartland, Inc., Chicago, IL*.

An experiment was conducted to test the hypothesis that increased levels of fiber in diets fed to pigs would reduce N balance but be ameliorated with increased Thr. A total of 96 gilts (28.98 ± 2.0 kg initial BW) were housed in individual metabolism crates allowing for total and separate collection of feces and urine. Pigs were allotted to 12 diets (0.90% standardized ileal digestible [SID] Lys) with 8 replicate pigs per diet using a randomized complete block design. Diets were prepared in a 3 × 4 factorial arrangement with 3 levels of fiber (6, 11, or 15% NDF) added as wheat middlings and distiller's dried grains with solubles and 4 SID Thr:Lys concentrations (0.45, 0.50, 0.55, or 0.60). Pigs were fed experimental diets for 14 d, including a 7-d adaptation period and a subsequent 5-d urine and fecal collection period. Apparent total tract digestibility (ATTD), retention, and biological value (BV) of N were greatest ($P < 0.05$) for pigs fed diets containing 6% NDF. Retention and BV of N were greater ($P < 0.05$) in pigs fed diets with SID Thr:Lys ratios of 0.50, 0.55, and 0.60 than in pigs fed diets with a SID Thr:Lys ratio of 0.45. Results indicate that the optimal SID Thr:Lys ratio may increase with increased dietary fiber. Nitrogen balance in pigs fed diets containing 11% or more NDF may be increased with SID Thr:Lys ratios greater than 0.60.

**Key Words:** amino acids, fiber, threonine
doi:10.2527/asasmw.2017.282

**283 Effect of increasing standardized ileal digestible tryptophan:lysine ratio on growth performance of grower–finisher pigs.** T. C. Tsai[1,*], H. Kim[2], X. Wang[1], J. J. Chewning[3], J. A. Apple[4], J. E. Thomson[5], C. V. Maxwell[1], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]University of Arkansas, Fayetteville, [3]Swine Research Services, Inc., Springdale, AR, [4]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [5]Evonik Degussa Corp, Kennesaw, GA*.

Using a 5-phase feeding regime, pigs ($n = 252$) were fed either antibiotic-free control diets formulated to meet 100% SID Lys requirements and a SID Trp:Lys ratio of 18.5 or diets formulated to 93% SID Lys requirements and incorporating L-Trp at 2.5 percentage unit increments to achieve SID Trp:Lys ratios of 13.5, 16.0, 18.5, 21.0, or 23.5 during phase 1 (25 to 39 kg), 3 (71 to 86 kg), and 5 (110 to 140 kg) to determine the optimum SID Trp:Lys ratio requirements. All pigs received common corn–SBM–corn distiller's dried grains with solubles (DDGS)–based, antibiotic-free, nutrient-adequate diets during feeding phase 2 and 4, and 10 ppm ractopamine hydrochloride was included in all phase-5 diets. Average daily gain, ADFI, and BW quadratically increased, with the greatest responses observed in pigs fed a SID Trp:Lys ratio of 21 during phases 1 and 3, whereas the greatest ADG and BW observed in pigs fed a SID Trp:Lys ratio of 18.5 and greatest ADFI observed in pigs fed a SID Trp:Lys ratio of 16.0 during phase 5. The G:F was similar in phase 1 and 3 but linearly increased, with the greatest result observed in pigs fed a SID Trp:Lys ratio of 23.5 in phase 5. Hot carcass weight quadratically increased in pigs fed to a SID Trp:Lys ratio of 16.0, but 10th-rib fat depth and lean yield were similar among treatments. The optimum ADG was predicted to be 0.72, 0.75, and 1.12 kg/d in pigs fed a SID Trp:Lys ratio of

**Table 281.**

| | Health status | | | | |
|---|---|---|---|---|---|
| Item | LC | MC | HC | SEM | *P*-value |
| ADG, kg | 0.86[a] | 0.79[b] | 0.73[c] | 0.01 | <0.0001 |
| ADFI, kg | 2.05[a] | 2.00[a] | 1.82[b] | 0.04 | <0.0001 |
| G:F | 0.42[a] | 0.40[b] | 0.40[b] | 0.004 | <0.0001 |
| HCW, kg | 93.55[b] | 98.23[a] | 97.60[a] | 0.99 | <0.0001 |
| Yield, % | 72.37[b] | 74.13[a] | 73.60[a] | 0.21 | <0.0001 |
| Lean, % | 55.05 | 54.78 | 54.80 | 0.29 | 0.525 |
| Fat, mm | 18.05 | 18.54 | 18.52 | 0.39 | 0.303 |

18.2, 18.8, and 16.8 in phases 1, 3, and 5, respectively.

**Key Words:** grower/finisher pigs, titration, tryptophan
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## 284 Young Scholar Presentation: The impacts of dietary fat source on lipid digestion, absorption, deposition, and metabolism in grow–finish pigs.

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Dietary fat sources are diverse in their chemical composition (fatty acid chain length, degree of unsaturation, free fatty acid content, nonelutable material, and peroxidation status). Fat is added to swine diets to provide dietary energy when the cost per kilogram of feed or gain is advantageous. However, little information is available for producers to adequately value different sources of dietary fat based on their chemical composition. Our objective has been to determine how chemical composition of dietary fat source impacts lipid digestion, absorption, deposition, and metabolism over a series of experiments ranging from individual fed pigs in intensive studies to pigs housed under commercial conditions. Fatty acid profile, and, more specifically, dietary linoleic acid, can be used to predict carcass iodine value (iodine value = 49.94 + [7.00 × dietary linoleic acid %]; $P < 0.001$) and is a more accurate predictor of carcass iodine value than iodine value product ($R^2 = 0.95$ vs. $R^2 = 0.85$, respectively). Furthermore, the fatty acid profile of the source can alter the mRNA abundance of genes involved in de novo lipogenesis, as the highly polyunsaturated dietary fat source corn oil had more mRNA abundance of *FASN* (*fatty acid synthase*), *SCD* (*stearoyl Co-A desaturase*), and *SREBP-1* (*sterol regulatory element-binding protein 1*) than the more saturated fat source tallow ($P \leq 0.050$). Degree of unsaturation and free fatty acid content of dietary fat sources can be used to determine the digestibility of dietary lipids; for example, in nursery pigs, canola oil (90.7%) or fish oil (91.0%) had greater apparent total tract digestibility of acid hydrolyzed ether extract than the diets with the saturated fat sources palm oil (87.6%) or tallow (87.7%; $P < 0.001$), and in growing pigs, the apparent total tract digestibility of acid hydrolyzed ether extract was greater in unsaturated fat–based diets than saturated fat–based diets, although the diet containing a high free fatty acid unsaturated corn oil source was the least digestible ($P < 0.001$). In conclusion, pork producers can determine energy value, predict carcass iodine value, and determine how sources of dietary fat will be used in the pig through the analysis of the chemical composition of dietary fats.

**Key Words:** carcass iodine value, dietary fat, energy
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**Table 282.** Nitrogen balance of pigs fed diets of varying Thr and fiber concentrations

| | 6% NDF | | | | 11% NDF | | | | 15% NDF | | | | | *P*-value | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.45 SID Thr:Lys | 0.50 SID Thr:Lys | 0.55 SID Thr:Lys | 0.60 SID Thr:Lys | 0.45 SID Thr:Lys | 0.50 SID Thr:Lys | 0.55 SID Thr:Lys | 0.60 SID Thr:Lys | 0.45 SID Thr:Lys | 0.50 SID Thr:Lys | 0.55 SID Thr:Lys | 0.60 SID Thr:Lys | Pooled SEM | Fiber level | Thr level | Fiber level × Thr level |
| Fecal N output, g/5 d | 149 | 140 | 123 | 154 | 214 | 205 | 217 | 203 | 248 | 274 | 250 | 253 | 11 | <0.0001 | 0.742 | 0.341 |
| Urinary N output, g/5 d | 135 | 118 | 105 | 92 | 175 | 114 | 112 | 108 | 154 | 127 | 114 | 100 | 36 | 0.344 | <0.001 | 0.848 |
| ATTD of N, % | 82.7 | 84.3 | 85.4 | 82.1 | 73.8 | 77.1 | 75.9 | 77.3 | 72.3 | 72.7 | 74.0 | 71.4 | 1.5 | <0.0001 | 0.046 | 0.237 |
| N retention, % | 67.0 | 71.8 | 73.0 | 71.5 | 51.7 | 64.5 | 63.6 | 65.1 | 55.2 | 58.6 | 62.0 | 60.1 | 4.1 | <0.0001 | <0.0001 | 0.200 |
| BV, % | 81.1 | 84.8 | 85.5 | 87.1 | 70.4 | 83.5 | 83.8 | 84.3 | 76.3 | 80.6 | 83.8 | p 84.0 | 5.3 | 0.036 | <0.0001 | 0.442 |

**Table 283.**

| | 93% SID Lys | | | | | 100% SID Lys | | |
|---|---|---|---|---|---|---|---|---|
| | 13.50% | 16% | 18.50% | 21% | 23.50% | 18.50% | Linear | Quadratic |
| Phase 1 ADG, kg/d | 0.64 | 0.70 | 0.71 | 0.73 | 0.72 | 0.59 | <0.01 | 0.04 |
| Phase 3 ADG, kg/d | 0.65 | 0.72 | 0.74 | 0.75 | 0.70 | 0.80 | 0.26 | 0.07 |
| Phase 5 ADG, kg/d | 0.90 | 1.07 | 1.12 | 1.08 | 1.09 | 1.08 | <0.01 | <0.01 |
| Phase 1 ADFI, kg/d | 1.29 | 1.40 | 1.50 | 1.59 | 1.38 | 1.44 | 0.16 | 0.04 |
| Phase 3 ADFI, kg/d | 2.27 | 2.68 | 2.65 | 2.77 | 2.60 | 2.72 | 0.08 | 0.05 |
| Phase 5 ADFI, kg/d | 3.08 | 3.52 | 3.31 | 3.47 | 3.30 | 3.35 | 0.36 | 0.09 |
| Phase 5 G:F | 0.29 | 0.31 | 0.33 | 0.31 | 0.33 | 0.32 | <0.01 | 0.41 |
| End of phase 1 BW, kg | 37.76 | 39.09 | 39.25 | 39.73 | 39.48 | 36.67 | <0.01 | 0.04 |
| End of phase 3 BW, kg | 84.70 | 86.23 | 86.93 | 87.10 | 85.97 | 88.79 | 0.20 | 0.07 |
| End of phase 5 BW, kg | 134.50 | 140.21 | 141.39 | 139.89 | 139.87 | 141.70 | 0.02 | 0.01 |
| HCW, kg | 220.63 | 229.44 | 229.27 | 229.00 | 229.07 | 231.07 | 0.03 | 0.05 |
| Lean, % | 53.24 | 53.49 | 53.02 | 53.59 | 53.35 | 53.31 | 0.76 | 0.96 |
| 10th-rib fat depth, mm | 21.44 | 22.08 | 22.18 | 21.10 | 20.93 | 22.83 | 0.50 | 0.43 |

**285 Effects of prebiotic or organic acid supplementation on growth performance, nutrient digestibility, and plasma cytokines of weaned pigs housed under poor sanitary conditions.** B. V. Le Thanh[1,*], J. K. Htoo[2], L. F. Wang[3], R. T. Zijlstra[1], *[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, [2]Evonik Nutrition & Care GmbH, Hanau-Wolfgang, Germany, [3]University of Alberta, Edmonton, AB, Canada*.

Weaning causes changes in intestinal functions that may induce postweaning diarrhea (PWD) in newly weaned pigs. Dietary supplementation of feed additives such as prebiotics or organic acids may reduce PWD and was evaluated in 160 pigs (7.6 ± 0.9 kg BW) that were weaned at 20 d of age and housed in pens with 4 pigs. Pigs were housed under poor sanitary conditions created by spreading pooled feces from the sow herd in pens 1 d before and 1 wk after pigs were placed into pens that were not cleaned prior to or during the entire study. Diets were formulated without antibiotics and growth promoters to provide 2.42 Mcal NE/kg, 5.18 g standardized ileal digestible (SID) Lys/Mcal NE, and 21.7% CP. One week after weaning, pens blocked by areas in rooms were randomly assigned for 3 wk to 5 test diets: 1 basal diet (negative control) containing corn, wheat, canola meal, and soybean meal and 4 test diets formulated by adding 1 of the following feed additives to the basal diet: β-glucan + Zn (0.02 and 0.05%), 0.25% mannan oligosaccharides (MOS), and 1.20% potassium diformate ($HCO_2K$ [KdiF]). Data were analyzed as a randomized complete block using the mixed procedure with test diet as the fixed term and block as the random term. Following the trial start, PWD (measured as % d within wk of diarrhea incidence) increased ($P < 0.001$; time effect) and then declined (23, 52, and 28% for wk 1, 2, and 3, respectively) but did not differ among diets. Supplementation of KdiF increased ($P < 0.05$) ADG by 13%, final BW by 8.5%, apparent total tract digestibility (ATTD) of DM, CP, and GE by 3%, and predicted dietary NE value by 4% compared with the control. Supplementation of β-glucan + Zn tended to increase ($P < 0.10$) G:F by 11% during wk 1 and increased ($P < 0.05$) ATTD of DM, CP, and GE by 3% and predicted dietary NE value by 3% compared with the control. Supplementation of MOS did not affect performance, ATTD of nutrients, or predicted dietary NE value. Supplementation of β-glucan + Zn, MOS, and KdiF did not affect plasma IFN-γ and IL-1β. In conclusion, KdiF enhanced growth performance and nutrient digestibility, β-glucan + Zn enhanced nutrient digestibility but did not affect growth, and MOS did not affect any variable. Although not affecting PWD in weaned pigs housed under poor sanitary conditions, dietary supplementation of organic acid increased nutrient digestion and enhanced growth whereas dietary prebiotics did not.

**Key Words:** digestibility, feed additives, postweaning diarrhea
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**286 Effects of a yeast-based feed additive on nursery pig performance.** H. E. Williams[1,*], J. C. Woodworth[1], J. M. DeRouchey[1], S. S. Dritz[1], M. D. Tokach[1], R. E. Musser[2], R. D. Goodband[1], *[1]Kansas State University, Manhattan, [2]NUTRIQUEST, Mason City, IA*,

A total of 360 pigs (PIC C-29 × 359; initially 6.22 ± 0.008 kg BW) were used in a 42-d growth trial evaluating the effects of Evosure (NUTRIQUEST, Inc., Mason City, IA) on nursery pig performance. Evosure is a yeast-based additive to enhance weaned pig performance. Pigs were weaned at approximately 16 to 20 d of age and allotted with 10 pigs/pen and 12 replications/treatment based on initial BW and gender in a completely randomized design. The 3 dietary treatments included 1) a control diet, 2) the control diet with Evosure fed at 0.05% from d 0 to 21 followed by 0.025% from d 21 to 42, or 3) Evosure fed at 0.05% from d 0 to 42. Experimental diets were fed in 3 phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21; and Phase 3, d 21 to 42 after weaning) and in meal form. Diets were formulated to meet the pigs' nutrient requirements

for each phase of the study. Phases 1 and 2 contained specialty protein and lactose sources at decreasing levels, respectively, whereas Phase 3 was corn–soybean meal based. Overall (d 0 to 42), there was no evidence for differences ($P > 0.10$) in growth performance or final BW. Therefore, under these experimental conditions, added Evosure, regardless of level, did not impact nursery pig performance.

**Key Words:** feed additive, growth performance, nursery pig
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**Table 286.**

| Item | Control | Evosure, % | | SEM | *P*-value < |
|---|---|---|---|---|---|
| | | 0.05/0.025 | 0.05/0.05 | | |
| BW, kg | | | | | |
| d 42 | 25.5 | 25.4 | 25.5 | 0.249 | 0.980 |
| d 0 to 42 | | | | | |
| ADG, g | 456 | 455 | 459 | 5.77 | 0.905 |
| ADFI, g | 654 | 648 | 658 | 6.86 | 0.595 |
| G:F | 0.696 | 0.702 | 0.698 | 0.006 | 0.769 |

## 287 The effects of feeding narasin (Skycis) on late finishing pig performance.

M. T. Knauer[1,*], R. A. Arentson[2], *[1]North Carolina State University, Raleigh, [2]Elanco Animal Health, Greenfield, IN*.

The purpose of this study was to determine the effects of narasin (Skycis; Elanco Animal Health, Greenfield, IN) on growth and performance of pigs during late finishing. In study 1, 240 barrows (Smithfield Premium Genetics, Rose Hill, NC) were weighed (82.3 kg initial BW) and randomly allocated to 1 of 2 treatments: control (CON) or narasin 15 ppm for 35 d. All pigs were then fed CON for 7 d prior to harvest. Each treatment had 15 pens containing 8 pigs per pen (0.87 $m^2$ per pig). In study 2, 416 barrows and gilts (PIC Landrace × Large White composite females mated to Smithfield Premium Genetics) were weighed (84.5 kg initial BW) and randomly allocated to 1 of 2 treatments: control (CON) or narasin 15 ppm for 35 d. Each treatment had 26 pens containing 8 pigs per pen (0.78 $m^2$ per pig). Pigs were weighed on d 0 and 35 and at harvest to determine start weight, harvest weight, and ADG. Feed issuance and weigh backs were recorded to determine ADFI and G:F. Pigs were individually tattooed and transported to a commercial packer for harvest and collection of HCW. Data were analyzed in SAS (SAS Inst. Inc., Cary, NC) using PROC GLM. Fixed effects included treatment, room, and sex. Pen was the experimental unit. In study 1, pigs fed narasin had greater ($P < 0.05$) ADG (1.185 vs. 1.140 kg) and ADFI (3.33 vs. 3.24 kg) than pigs fed the CON diet. In study 2, gilts fed narasin tended ($P = 0.08$) to have greater ADG (1.13 vs. 1.08 kg) and had superior ($P < 0.05$) G:F (0.362 vs. 0.347) when compared with CON-fed gilts. Across both studies 1 and 2, pigs fed narasin had greater ($P < 0.05$) ADG (1.138 vs. 1.100 kg) and G:F (0.363 vs. 0.355) than pigs fed CON. Market weight CV tended ($P = 0.09$) to be lower for narasin when compared with CON (8.4 vs. 9.1%). Results showed that supplementing diets with narasin for 35 d prior to harvest significantly improved growth performance and feed efficiency of finishing pigs.

**Key Words:** growth, narasin, pig
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## 288 Effects of AminoGut and diet formulation approach on growth performance in nursery pigs.

M. A. D. Goncalves[1], M. B. Menegat[2,*], M. D. Tokach[2], S. S. Dritz[2], K. J. Touchette[3], J. M. DeRouchey[2], J. C. Woodworth[2], R. D. Goodband[2], *[1]Genus PIC, Hendersonville, TN, [2]Kansas State University, Manhattan, [3]Ajinomoto Heartland, Inc., Chicago, IL*.

Diets containing animal protein sources have more glutamine than plant protein-based diets. AminoGut (Ajinomoto Heartland, Inc., Chicago, IL) is a product containing glutamine and glutamate. This study was conducted to determine the effects of protein source and AminoGut (Gln+Glu) on growth performance in nursery pigs from 5 to 27 kg. A total of 1,134 pigs (PIC 337 × 1050; 5.3 ± 0.08 kg) were used in a 52-d trial. Pens were assigned to treatments in a randomized complete block based on initial BW (7 pens/treatment). Treatments were a 2 × 3 factorial with 2 protein sources (animal [2.5% fish meal and 4% bovine blood plasma {d 0–10} and 5% fish meal {d 10–24}] vs. plant [6.5 {d 0–10} and 5% {d 10–24} fermented soy protein]) and 3 Gln+Glu durations (0, 10, and 24 d). Diets also contained 18 (d 0–10) and 25% (d 10–24) soybean meal. The Gln+Glu addition was 0.8% from d 0 to 10 and 0.6% from d 10 to 24. From d 24 to 52, pigs were fed a common diet. Statistical analysis was performed using PROC GLIMMIX (SAS; SAS Inst. Inc., Cary, NC). From d 0 to 10, pigs fed animal protein–based diets had marginally significant greater ADG ($P = 0.074$) and increased G:F ($P = 0.016$) compared with pigs fed plant-based diets; however, after d 10, no evidence of differences was observed between pigs fed different protein sources. From d 10 to 24, pigs fed Gln+Glu had increased ADG ($P = 0.019$) and G:F ($P = 0.001$). From d 0 to 24, pigs fed Gln+Glu had marginally significant improvement in ADG ($P = 0.059$) and increased G:F ($P = 0.010$) compared with pigs not fed Gln+Glu. From d 24 to 52, pigs previously fed Gln+Glu for 10 d had marginally significant improvement in G:F ($P = 0.057$) compared with pigs not fed Gln+Glu or fed Gln+Glu for 24 d. Overall (d 0–52), there was no evidence of differences in growth performance due to Gln+Glu. In conclusion, feeding Gln+Glu for 10 d after weaning improved growth performance until d 24, but there was no carryover effect when a common diet was fed, and dietary protein source did not influence the response to Gln+Glu. Further research should evaluate Gln+Glu

supplementation for a longer duration.

**Key Words:** glutamine, nursery pig, protein source
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**289 Effects of mannan oligosaccharides and *Lactobacillus mucosae* on the growth performance and immune response of weanling pigs challenged with *Escherichia coli* lipopolysaccharides.** Y. S. Li*, M. D. Trenhaile, D. M. van Sambeek, K. C. Moore, S. M. Barnett, S. C. Fernando, T. E. Burkey, P. S. Miller, *University of Nebraska-Lincoln, Lincoln*.

Previously, dietary mannan oligosaccharides (MOS) increased fecal abundances of *Lactobacillus mucosae*, which was positively correlated with circulating IgA concentration. To determine the effects of feeding MOS and *L. mucosae* as prebiotic and probiotic sources in weanling pigs under immune challenge, 96 pigs (5.88 kg BW; d 23 after farrowing) were randomly allotted to 16 experimental pens with a 2 × 2 factorial arrangement of treatments (4 pens per treatment; mixed gender). Corn–soybean meal–based diets (without plasma or antibiotics) with or without 0.1% yeast-derived MOS (*Saccharomyces cerevisiae*) were randomly assigned to pens, and $10^9$ cfu/pig *L. mucosae* broth or a control broth were top dressed daily. Pigs were given 1 of the 4 dietary treatments (control, MOS, *L. mucosae*, and MOS + *L. mucosae*) in phase 1 and phase 2 (d 0 to 7 and d 7 to 21 after weaning, respectively) and a common diet during phase 3 (d 21 to 35 after weaning). On d 14, all pigs were challenged with 100 μg/kg BW of *Escherichia coli* lipopolysaccharides (LPS) via intraperitoneal injection. Feed disappearances and pig BW were measured weekly. Blood samples were collected weekly and on d 1 and 3 after LPS challenge. Data were analyzed using PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, NC). From d 0 to 14, feeding *L. mucosae* decreased ($P < 0.05$) G:F. From d 14 to 21, G:F (g/kg) in pigs fed *L. mucosae* (715) was greater compared with pigs fed MOS + *L. mucosae* ($P < 0.05$; 600) and the control ($P < 0.10$; 615) but was not different ($P > 0.10$) from pigs fed MOS (674). After removal of treatments (d 28 to 35), G:F was decreased ($P < 0.05$) in the *L. mucosae* treatment group. Feeding MOS- vs. non-MOS-treated diets increased IgG (mg/mL) on d 1 and 3 after LPS challenge ($P < 0.05$; 3.15 and 4.39 vs. 2.58 and 3.34, respectively) and on d 14 and 21 after weaning ($P < 0.10$; 3.68 and 4.56 vs. 2.94 and 3.72, respectively). On d 21, serum IgA concentrations (mg/mL) were greater ($P < 0.05$) in pigs fed *L. mucosae* (0.416) compared with pigs fed MOS (0.341) and MOS + *L. mucosae* (0.342) and tended to be greater ($P < 0.10$) in pigs fed *L. mucosae* vs. pigs fed control (0.347). Using d 0 ($P < 0.05$) IL-1β concentration as a covariate, circulating IL-1β in control and MOS + *L. mucosae* pigs increased ($P < 0.05$) on d 1 after LPS challenge but did not change ($P > 0.10$) in MOS and *L. mucosae* groups. In conclusion, feeding *L. mucosae* alone improved feed efficiency during the first week of LPS challenge; additionally, feeding *L. mucosae* and MOS may have beneficial effects relative to immune biomarkers.

**Table 288.**

| | Protein source | | | Gln+Glu duration, d | | | |
|---|---|---|---|---|---|---|---|
| | Plant | Animal | SEM | 0 | 10 | 24 | SEM |
| d 0 to 24 | | | | | | | |
| ADG, g | 235 | 241 | 3.67 | 230$^{x}$ | 238$^{xy}$ | 246$^{y}$ | 4.49 |
| G:F | 0.691 | 0.700 | 0.006 | 0.677$^{a}$ | 0.698$^{b}$ | 0.711$^{b}$ | 0.008 |
| d 0 to 52 | | | | | | | |
| ADG, g | 403 | 410 | 3.95 | 399 | 411 | 409 | 4.71 |
| G:F | 0.669 | 0.671 | 0.003 | 0.665 | 0.674 | 0.669 | 0.004 |

$^{a,b}$Means within a row with different superscripts differ ($P < 0.01$).
$^{x,y}$Means within a row with different superscripts differ ($P < 0.05$).

**Key Words:** growth, immunity, pig
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**290 Effects of mycotoxin-contaminated high-protein distiller's dried grains and mycotoxin mitigation additive on growth performance and plasma glucagon-like peptide-1 concentration of growing–finishing pigs.** L. Fung*, G. C. Shurson, P. E. Urriola, M. Saqui-Salces, *Department of Animal Science, University of Minnesota, St. Paul*.

The objective of this study was to investigate the effects of feeding high-protein distiller's dried grains (HP-DDG) contaminated with a mixture of mycotoxins and a possible mitigation on growth performance and plasma glucagon-like peptide-1 (GLP-1) of growing–finishing pigs. Pigs (144 mixed sex; 25 ± 2 kg initial BW) were fed either a corn–soybean meal control diet (CON; $n = 8$) or a 30% HP-DDG diet ($n = 8$) containing 0.7 mg/kg deoxynivalenol, 0.1 mg/kg fumonisins, and 56 μg/kg zearalenone for 8 wk. On wk 9, a mycotoxin mitigation intervention was applied using a blend of preservatives containing sodium metabisfulfite (PB; Defusion Plus; Provimi North America Inc., OH) resulting in 4 groups: CON, CON + 0.25% PB, 30% HP-DDG, and 30% HP-DDG + 0.25% PB. A 4-phase feeding program was used, and diets within phases were formulated to contain equal standardized ileal digestible Lys:ME ratios. Growth performance data were collected once every 2 wk and blood samples from 2 pigs/pen with weight closest to pen mean were collected on wk 8 and at the end of the experiment (wk 16) for plasma GLP-1 analysis. Data were analyzed using a mixed model with block as a random effect and diet and day × diet as fixed effects. Overall, in the first 8 wk, pigs fed HP-DDG had less ADG (0.75 vs. 0.83 kg/d; $P < 0.01$) and ADFI (1.69 vs. 1.84 kg/d; $P < 0.01$) compared with pigs fed CON. After intervention was applied at the start of wk 9, pigs fed HP-DDG had lower overall ADG compared with pigs fed HP-DDG + 0.25% PB (0.90 vs. 0.96 kg/d; $P < 0.05$) but not compared with pigs fed CON (0.90 vs. 0.92 kg/d; $P > 0.05$). There were no differences in ADG between groups fed CON, CON + 0.25% PB,

and HP-DDG + 0.25% PB ($P > 0.05$). The HP-DDG group also had lower overall ADFI compared with the CON group (2.81 vs. 2.63 kg/d; $P < 0.05$), but there were no differences among groups fed PB or CON ($P > 0.05$). Final BW for pigs fed HP-DDG (109.5 kg) was less ($P < 0.05$) than the pigs fed CON (115.1 kg), CON + 0.25% PB (116.4 kg), and HP-DDG + 0.25% PB (113.6 kg). There were no differences in plasma GLP-1 levels among treatments ($P > 0.05$) in spite differences in ADFI. Collectively, naturally occurring mycotoxins in HP-DDG had significant negative effects on ADG and ADFI but supplementation of PB alleviated those effects.

**Key Words:** high-protein distiller's dried grains, mycotoxins, swine
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**291 Effects of a multistrain *Bacillus* spp. direct-fed microbial and protease combination at different doses on apparent ileal and total tract digestibility of nutrients in growing pigs fed corn–soybean meal–based diets – A combined analysis of two studies.**

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The addition of direct-fed microbials (DFM) or protease individually to grower–finisher pig diets has not consistently led to nutrient digestibility improvements; however, new research suggests that there may be greater and more consistent effects of feeding protease and DFM in combination. The objective of these studies was to investigate the effects on nutrient digestibility of feeding a protease and multistrain *Bacillus* spp. DFM combination (PRO+DFM) at different doses to growing pigs. A combined analysis of 2 trials involving 64 ileal cannulated barrows (25 ± 2 kg BW) was conducted. Treatments included 1) corn–soybean meal–based (control) diet with 20% coproducts; 2) Dose A, control plus PRO+DFM (2,500 units/kg protease, $7.5 \times 10^4$ cfu/g DFM); 3) Dose B, control plus PRO+DFM (5,000 units/kg protease, $1.5 \times 10^5$ cfu/g DFM); and 4) Dose C, control plus PRO+DFM (7,500 units/kg protease, $2.25 \times 10^5$ cfu/g DFM). Pigs were randomly assigned to treatments, surgically equipped with a T-cannula at the distal ileum, and individually housed with 8 replicates/treatment in a randomized complete block design. Diets were fed for 14 d at 3 × maintenance energy requirement with 10 d of adaptation followed by 2 d of both fecal and ileal digesta collection. Duplicate samples were analyzed for chromic oxide and nutrients for the calculation of apparent ileal digestibility (AID) and apparent total tract digestibility (ATTD). Data from the 2 trials were pooled and analyzed using the Fit Model platform of JMP11. Means separation was determined using Tukey's honest significant difference test. A regression analysis was performed to determine the correlation between the indigestible AA fraction and the uplift in AA digestibility for each combination dose. All PRO+DFM treatments (Dose A, B, and C) increased ATTD of N compared with the control (86.8, 86.8, and 86.6 vs. 84.5%, respectively; $P = 0.01$). Dose A also increased AID of starch (90.6 vs. 87.9%; $P = 0.02$), arginine (85.5 vs. 82.9%; $P = 0.01$), valine (77.4 vs. 73.8%; $P = 0.02$), isoleucine (80.8 vs. 77.1%; $P = 0.01$), and tryptophan (73.6 vs. 65.4%; $P < 0.02$) compared with the control. Dose B and C increased the AID of tryptophan compared with the control ($P = 0.001$). The regressions demonstrated that Dose A and B resulted in an average uplift in AID of AA of 33 and 9%, respectively, compared with the control and that the uplift was positively correlated with the indigestible fraction ($P < 0.001$). No AA uplift was found with Dose C. In conclusion, the dietary supplementation of a PRO+DFM combination to growing pigs resulted in improvements in ATTD of N and AID starch and key AA in a dose-dependent manner compared with the control.

**Key Words:** direct-fed microbial, grower pig, protease
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**292 The effect of feeding Ambitine feed additive on late finishing pig performance.**

S. A. Crowder[1,*], T. L. Weeden[1], M. B. Lachmann Sevilla[1], B. De Rodas[1], T. P. Karnezos[2], *[1]Purina Animal Nutrition LLC, Shoreview, MN, [2]PMI Nutritional Additives, Shoreview, MN*.

Four hundred eighty-four late finishing pigs (106.16 kg initial BW) were used to evaluate the effect of feeding Ambitine feed additive (Ambitine FA) in a corn–soybean meal–distiller's dried grains with solubles (DDGS) diet on late finisher pig performance. Ambitine FA is a blend of plant extracts and acidifiers. Pigs were allotted in a randomized complete block design into mixed gender pens, with 11 replicates per treatment and 22 pigs per pen, and fed 1 of 2 dietary treatments. Dietary treatments were Control or Ambitine FA (0.10%) fed the last 35 d of finishing and consisted of corn–soybean meal–20% DDGS with 6.75 g of Paylean formulated to 0.95% TID lysine. Body weights were taken at Day 0, 11, 20, and 35, with corresponding ADG, ADFI, and GF calculated for each period, and top cuts were marketed at Day 11 and 20, with the remaining pigs marketed at Day 35. Data were analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit, and the model accounted for the effects of treatment, block, and replicate. Period 1 (d 0–11), ADG was increased ($P = 0.01$) with Ambitine FA treatment (1.33 vs. 1.23 kg/d). Period 1, ADFI was not significantly different between treatments. Period 1, G:F was increased ($P = 0.02$) with Ambitine FA treatment (0.462 vs. 0.437). Period 2 (d 11–20), BW were increased ($P = 0.03$) with Ambitine FA treatment (126.06 vs. 125.12 kg). In period 2, Ambitine FA increased ($P = 0.02$) ADG (1.16 vs. 1.01 kg) together with an increase ($P = 0.04$)

in G:F (0.403 vs. 0.383); however, ADFI was not significantly different between treatments. Period 3 (d 20–35), growth performance was not significantly different between treatments. Ambitine FA increased ($P = 0.01$) overall d 0 to 35 ADG (1.22 vs. 1.14 kg/d). Ambitine FA increased ($P = 0.002$) overall G:F (0.409 vs. 0.388). Plant live weight tended ($P = 0.07$) to be increased for the Ambitine FA treatment (133.34 vs. 131.62 kg). There was a trend ($P < 0.06$) for increased HCW (99.41 vs. 97.91 kg) with Ambitine FA. The results of this study suggest that feeding Ambitine FA to late finishing pigs improves growth rate, feed efficiency, and carcass weight.

**Key Words:** Ambitine, feed efficiency, pig
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**293 Impact of a direct-fed microbial at three inclusion rates on growth performance in growing and finishing pigs.** S. A. Weiland[1,*], T. Waugh[2], J. F. Patience[1], *[1]Iowa State University, Ames, [2]Kay Dee Feed Company, Sioux City, IA*.

The increasing restriction of antibiotic use in the swine industry has driven interest in antibiotic alternatives, including direct-fed microbials (DFM). The objective of this experiment was to evaluate the growth response to the addition of a direct-fed microbial (LactoPlan; KayDee Feed Co., Sioux City, IA) in the diet of grow–finish pigs. A total of 300 crossbred pigs with an average initial BW of 29.7 ± 0.3 kg were randomly assigned to 60 pens, which, in turn, were randomly assigned to 1 of 4 dietary treatments according to the completely randomized design. Dietary treatments were 1) negative control (NC), 2) NC plus 0.05% DFM, 3) NC plus 0.10% DFM, and 4) NC plus 0.20% DFM. The experiment was conducted using 4 dietary phases. Pigs were given ad libitum access to water and feed throughout the experiment and were marketed at a constant BW of approximately 125 kg. Data were analyzed using PROC MIXED of SAS (9.4; SAS Inst. Inc., Cary, NC), with initial BW as a covariate. Treatment means were separated using contrasts. There was a trend for 0.05% DFM to increase ADG and ADFI compared with the NC. The greatest response was achieved with 0.05% DFM; none of the other DFM levels achieved improvement in ADG or ADFI compared with the control diet. There was no treatment effect for G:F ($P \geq 0.10$). In conclusion, diets containing 0.05% DFM tended to improve ADG and ADFI over the NC; higher levels of DFM inclusion failed to provide benefit compared with the NC.

**Key Words:** direct-fed microbial, *Lactobacillus*, swine
doi:10.2527/asasmw.2017.293

**294 Effect of feeding formaldehyde-treated feed to pigs throughout the growing period on amino acid utilization from synthetic lysine or protein sources.** L. Ochoa[1,*], R. J. Harrell[2], A. Graham[1], M. Bienhoff[3], B. Kremer[4], J. A. Loughmiller[3], L. Greiner[1], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Professional Swine Management, Carthage, IL, [3]Kemin Industries, Des Moines, IA, [4]Kemin Industries, Inc., Des Moines, IA*.

A total of 1,113 pigs (36 ± 1.67 kg BW) were used in a 36-d study conducted as a RCBD (block = start BW) in a commercial wean-to-finish facility. Pigs were randomly allocated to the following dietary treatments: 1) Trt1, no feed disinfection/no synthetic Lys; 2) Trt2, feed disinfection (Sal CURB, Kemin)/no synthetic Lys; 3) Trt3, no feed disinfection/synthetic Lys inclusion; 4) Trt4, feed disinfection/synthetic Lys; and 5) Trt5, as Trt2 with 10% lower Lys level. For treatments 2 and 4, feed was disinfected by applying Sal CURB at 2.95 kg/t of feed in the mixer. A 2-phase feeding program was used, with phase changing on d 22 of study. Diets were based on established PIC recommendations and provided 3,300 kcal ME/kg. Standardized ileal digestible Lys levels were 1.03 (0.95% SID Lys for Trt5) and 0.91% (0.82% SID Lys for Trt5) for phases 1 and 2, respectively. Data collected included pen weights, feed intake, and animal removals. Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit and treatment as a fixed effect. Results were considered significant at $P \leq 0.05$ and considered a trend at $0.05 < P \leq 0.10$. During dietary phase 1, there was no treatment effect for BW and ADG. Feeding disinfected feed affected ($P < 0.05$) G:F of pigs fed diets without synthetic Lys (0.592 vs. 0.559 in Trt1 vs. Trt2, respectively) but had no impact ($P = 0.63$) on diets with synthetic Lys (0.526 vs. 0.521 in Trt3 vs. Trt4, respectively). During dietary phase 2, there were no differences or trends detected across treatments for any variable measured. For the overall 36-d study period, ADG (1.08, 1.07, 1.07 1.05, and 1.03 kg) and ADFI (2.10, 2.15, 2.17, 2.17, and 2.10 kg) was similar ($P > 0.15$) across treatments (Trt1 to Trt5, respectively). Overall G:F (0.510, 0.493, 0.490, 0.474, and 0.485) was negatively affected by the process of feed disinfection with or without inclusion of synthetic Lys in diets (Trt1 vs. 2, and 3 vs. 4). In addition, the combined G:F of treatments 2 and 4 (disinfected feed; 0.483) was no different than that of Trt5 (0.485). These results indicate that disinfecting feed with Sal CURB may have a negative effect on feed efficiency of pigs regardless of the level of synthetic Lys used in the diets.

**Key Words:** chemical feed disinfection, lysine, pig
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**Table 293.** Effects of a direct-fed microbial on pig growth performance and feed efficiency

| | | DFM | | | | *P*-value | | | |
|---|---|---|---|---|---|---|---|---|---|
| Item | NC | 0.05% | 0.10% | 0.20% | SEM | NC vs. DFM | NC vs. 0.05% DFM | NC vs. 0.10% DFM | NC vs. 0.20% DFM |
| Initial BW, kg | 29.5 | 29.5 | 29.5 | 29.5 | 0.25 | – | – | – | – |
| Final BW, kg | 123.7 | 125.5 | 125.8 | 124.7 | 0.49 | 0.173 | 0.180 | 0.113 | 0.679 |
| ADG, kg/d | 0.848 | 0.892 | 0.881 | 0.847 | 0.016 | 0.174 | 0.060 | 0.149 | 0.994 |
| ADFI, kg/d | 2.437 | 2.585 | 2.542 | 2.466 | 0.054 | 0.138 | 0.057 | 0.176 | 0.708 |
| G:F | 0.348 | 0.346 | 0.336 | 0.346 | 0.008 | 0.582 | 0.859 | 0.283 | 0.923 |

**295 Effect of lactose, inulin, *Lactobacillus acidophilus* fermentation product, or dietary antibiotics on nursery pig digestibility and nitrogen retention.**

J. A. Acosta[1,*], N. K. Gabler[1], J. W. Frank[2], B. E. Bass[2], J. F. Patience[1], *[1]Iowa State University, Ames, [2]Diamond V, Cedar Rapids, IA*.

The objective of this study was to determine the effect of lactose, *Lactobacillus acidophilus* fermentation product (FP; SynGenX; Diamond V, Cedar Rapids, IA), inulin, and dietary antibiotics on the apparent total tract digestibility (ATTD) of DM, GE, and N and the N retention (NR) of nursery pigs. Newly weaned pigs (approximately 21 d of age; 5.2 ± 0.15 kg initial BW; $n = 49$) were housed in metabolism crates and assigned to each of 7 treatments according to a randomized complete block design: 1) control diet, 2) 1 plus 0.1% FP, 3) 1 + 15% lactose, 4) 3 + 0.1% FP, 5) 3 + 3% inulin, 6) 3 + 0.1% FP and 3% inulin and 7) 1 + antibiotics: chlortetracycline (440 ppm) and tiamulin hydrogen fumarate (39 ppm). Feed and water were provided ad libitum throughout the experiment (15 d). Total urine output and fecal samples were collected on d 10 to 13 to determine NR, and fecal samples were also collected on d 5 to 9 as a second period to determine ATTD of DM, GE, and N (repeated measure). Titanium dioxide was used as indigestible marker. Data were analyzed using preplanned comparisons using contrasts of treatments to test the effects of antibiotics (7 vs. 1, 7 vs. 2, and 7 vs. 3), lactose (3 and 4 vs. 1 and 2), FP (2, 4, and 6 vs. 1, 3, and 5), inulin (5 and 6 vs. 3 and 4), the interaction between lactose and FP (1 and 4 vs. 2 and 3), and the interaction between FP and inulin (3 and 6 vs. 4 and 5). Pigs fed lactose had improved ATTD of DM (89.1 vs. 88.1%; $P = 0.011$) and ATTD of GE (87.7 vs. 86.5%; $P = 0.025$) compared with those that were not. However, FP, inulin, and antibiotics did not improve ATTD of DM or GE ($P > 0.10$). Lactose, FP, inulin, or antibiotics did not affect the ATTD of N ($P > 0.10$). Pigs fed lactose had increased NR compared with those that were not ($P = 0.023$); antibiotics tended to increase NR compared with pigs fed FP ($P = 0.066$), but pigs fed antibiotics were no different in NR compared with pigs fed lactose ($P > 0.10$) or the control ($P > 0.10$). Fermentation product or inulin did not improve NR ($P > 0.10$). In conclusion, lactose but not FP or inulin improved the ATTD of DM and GE and the NR. Additionally, antibiotics tended to improve NR but had no effect on the ATTD of DM or GE.

**Key Words:** antibiotic alternatives, nitrogen balance, weaned pigs

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**296 Evaluation of a bioprocessed soybean meal on nursery pig performance and immune status.**

J. Koepke*, C. L. Levesque, W. R. Gibbons, M. Brown, R. Kaushik, *South Dakota State University, Brookings*.

A total of 239 pigs (6.56 ± 0.87 kg initial BW; 21 d of age) were used in a 35-d study to investigate the effects of fish meal (FM) and spray-dried plasma (SDP) in combination with a bioprocessed soybean meal (MEPRO) on growth performance and immune responses in weaned pigs. Equal numbers of barrows and gilts were randomly allotted to 1 of 4 dietary treatments (10 pens/treatment) according to initial BW and sex: positive control (corn/soybean meal based diet) containing SDP and FM in combination (CON), SDP and MEPRO in combination ($MEPRO_{+SDP}$), FM and MEPRO in combination ($MEPRO_{+FM}$), and MEPRO. Experimental diets were fed in phase I (d 1–7 after wean) and II (d 8–21) followed by a common diet in phase III (d 22–35). Body weight and feed disappearance were measured weekly. Pigs were immunized against ovalbumin (OVA) and *Candida albicans* (CAA) on d 7 and 21 after wean. Assessment of immune response was based on dermal hypersensitivity to OVA and CAA (% increase in local swelling at 2, 6, 24, and 48 h after injection) on d 28 after wean and on primary and secondary anti-OVA IgG at d 21 and 28 after weaning. Data were analyzed using PROC MIXED with pen as the experimental unit for performance and pig as the experimental unit for immune response. Pigs fed CON were heavier ($P < 0.01$) than pigs fed $MEPRO_{+FM}$ and MEPRO and were not different from pigs fed $MEPRO_{+SDP}$ at the end of Phase I and II (6.99, 6.52, 6.60, and 6.80 ± 0.08, respectively, for Phase I and 12.47, 11.42, 11.85, and 12.18 ± 0.21, respectively, for Phase II). Hypersensitivity to OVA peaked at 2 h in pigs fed CON, $MEPRO_{+SDP}$, and $MEPRO_{+FM}$ and peaked at 6 h in pigs fed MEPRO (121.4, 165.6, 139.0, and 144.1 ± 22.9% [$P = 0.495$], respectively, at 2 h and 86.7, 114.5, 95.0, and 156.8 ± 29.4% [$P = 0.317$], respectively, at 6 h). There was a prolonged hypersensitivity response to CAA in pigs fed $MEPRO_{+SDP}$, $MEPRO_{+FM}$, and MEPRO compared with pigs fed CON (55.2, 48.2, 50.6, and 42.6 ± 11.9% [$P =$

0.873], respectively, at 2 h and 43.8, 37.5, 40.5, and 19.4 ± 14.2% [$P = 0.589$], respectively, at 6 h). Secondary anti-OVA IgG was 2-fold lower in pigs fed CON compared with pigs fed $MEPRO_{+FM}$ and MEPRO (0.78 vs. 1.56 and 1.55 ± 0.42 $OD_{450nm}$, respectively). The MEPRO is a suitable alternative for FM and/or SDP based on pig growth. The prolonged hypersensitivity response indicates an enhanced recruitment of T cells to the site of inflammation, suggesting MEPRO has an impact on pig immune function.

**Key Words:** growth performance, immune status, weaned pig
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**297 Super dosing effects of corn-expressed phytase on growth performance, bone characteristics, and nutrient digestibility in nursery pigs fed diets deficient in phosphorus and calcium.** J. K. Lee*, M. E. Duarte, S. W. Kim, *North Carolina State University, Raleigh*.

This study was conducted to determine the super dosing effects of phytase from corn-expressed phytase (CEP; Agrivida, Inc., Medford, MA) on growth performance, metacarpal bone characteristics, and apparent ileal digestibility (AID) of nutrients in nursery pigs fed corn–soybean meal diets deficient in P and Ca. Seventy pigs (21 d of age with 6.7 ± 0.6 kg BW) were individually housed and allotted to 7 treatments in a randomized complete block design with initial BW and sex blocks. A negative control diet (NC) had 0.40% ATTD of P and 0.80% Ca without supplemental phytase. The other 6 treatment diets had 0.25% ATTD of P and 0.68% Ca supplemented with phytase at 0, 500, 1,000, 2,000, 4,000, and 6,000 FTU/kg diet. Pigs were fed for 30 d (Phase 1: 10 d and Phase 2: 20 d) with ad libitum access to water and diets. Feed intake and BW were recorded every 10 d. Pigs were euthanized on d 30 to collect metacarpal bones and ileal digesta. Data were analyzed using polynomial contrasts in the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Pigs fed NC had greater ($P < 0.05$) ADG, G:F, bone P (g and %), AID of P, and bone strength than pigs fed a basal diet without phytase. Increasing phytase levels increased (linear, $P < 0.05$) BW (13.5 to 18.0 kg), ADG (230 to 370 g/d), ADFI (420 to 520 g/d), and G:F (0.54 to 0.73). Increasing phytase levels increased (linear, $P < 0.05$) weight (5.85 to 7.22 g), fat-free dry weight (1.19 to 1.73 g), the amounts of P (0.10 to 0.16 g) and ash (0.10 to 0.13 g), and breaking strength (242 to 408 N) of metacarpal bones. Increasing phytase levels increased (linear, $P < 0.05$) AID of P (78.1 to 86.1%), AID of DM (53.0 to 79.4%), AID of GE (50.3 to 78.6%), and AID of ether extract (59.8 to 75.5%). Pigs fed basal diets had smaller ($P < 0.05$) ADG, ADFI, bone P (g and %), and AID of P than pigs fed NC with phytase below 4,000 FTU/kg, whereas they did not differ ($P > 0.10$) from pigs fed NC with phytase above 4,000 FTU/kg. In conclusion, super dosing CEP up to 6,000 FTU/kg improved growth performance, bone characteristics, and nutrient digestibility in pigs fed P- and Ca-deficient diets. Pigs fed P- and Ca-deficient diets supplemented with phytase above 4,000 FTU/kg performed similar to pigs fed a diet with sufficient P and Ca.

**Key Words:** corn-expressed phytase, growth performance, nursery pigs
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**298 Validation of deuterium oxide method for estimating milk intake by piglets.** S. Zhang[1,*], N. L. Trottier[1], J. C. Marini[2], *[1]Michigan State University, East Lansing, [2]USDA-ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX.*

The objective of the study was to validate the deuterium oxide ($D_2O$) dilution technique to estimate milk intake in nursing piglets. Eight 3-d-old piglets were surgically fitted with a carotid catheter. Piglets were individually housed in cages (0.61 by 0.61 m) and fed milk replacer daily at 0700, 1100, 1500, 1900, and 2300 h. On Day 7, blood and saliva samples were taken at 0800 h and $D_2O$ (1 mL/kg BW) was intraperitoneally administered at 0900 h. Additional blood and saliva samples were collected at 1000 and 1100 h and at 24, 48, and 72 h following the 1100 h feeding on d 7. Piglets were weighed daily to adjust the volume of milk needed to meet minimum nutrient requirements. Saliva was harvested from all pigs using cotton gauze at the same time as for blood sampling. Two different approaches were used to estimate milk intake. One approach was based on piglet body composition and weight change (Abody), and the other approach was based on milk replacer composition and intake (Amilk). Data was analyzed using a mixed model, with approach, sample, and day as fixed effects and piglet as a random effect. Estimated daily milk intake (g) from $D_2O$ (EMI) did not differ between Abody and Amilk when derived from either plasma (473 ± 53 and 458 ± 53, respectively) or saliva (619 ± 52 and 613 ± 52, respectively). On d 1, daily EMI based on plasma (560 ± 57) and saliva (583 ± 55) were greater ($P < 0.01$) than the actual milk intake (AMI; 442 ± 28). On d 2 and 3, EMI based on plasma were lower ($P < 0.01$) than AMI (403 ± 57 vs. 527 ± 28, and 433 ± 57 vs. 569 ± 28, respectively). Compared with AMI, EMI based on saliva did not differ on d 2 (596 ± 55 vs. 527 ± 28) and was higher ($P < 0.05$) on d 3 (669 ± 55 vs. 572 ± 28). Overall, EMI from plasma (465 ± 49) and saliva (616 ± 49) differed ($P < 0.01$). The EMI from saliva samples (616 ± 49) differed ($P < 0.01$) from AMI (513 ± 28). Results indicate that $D_2O$ dilution approach requires additional validation studies before it can be used to accurately estimate actual milk intake.

**Key Words:** deuterium oxide, dilution, milk intake, piglets, validation
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**299 Evaluation of dietary electrolyte balance on nursery pig performance.** A. M. Jones*, J. C. Woodworth, S. S. Dritz, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, *Kansas State University, Manhattan*.

A recent study observed that nursery pigs fed and increasing dietary electrolyte balance (dEB; exceeding 150 mEq/kg) had decreased growth performance. To confirm this response, pigs ($n$ = 2,888; PIC 327 × L42; 5.2 kg initial BW) were used in a 35-d study to evaluate the effects of dEB on growth performance. There were 30 pigs/pen (60 pigs/double-sided feeder) and 12 replications (feeder)/treatment. Pens of pigs were allotted by BW and sex on arrival and randomly assigned to 1 of 4 dietary treatments. Diets were corn–soybean meal based with dried whey and other specialty protein sources used in Phase 1, with decreased amounts in Phase 2. Dietary electrolyte balance was determined using the equation dEB (mEq/kg) = (Na × 434.98) + (K × 255.74) − (Cl × 282.06). Phase 1 and 2 diets had dEB of 84, 137, 190, and 243 and 29, 86, 143, and 199 mEq/kg, respectively. Limestone was used as the main Ca source in the high-dEB diet and was replaced by increasing $CaCl_2$ in other experimental diets. The highest dEB diets required additions of 0.55 and 0.80% limestone for Phase 1 and 2, respectively. The lowest dEB diets were achieved by adding 1.17 and 1.25% $CaCl_2$ in Phase 1 and Phase 2, respectively. Dietary Ca concentrations were maintained in the 3 highest dEB diets but increased in the low-dEB diet with the increasing level of $CaCl_2$. From d 21 to 35, a common Phase 3 diet (257 mEq/kg) was fed to all pigs. Overall (d 0 to 35), increasing dEB from d 0 to 21 increased (linear, $P < 0.001$) ADG and final BW, which was the result of increased (quadratic, $P < 0.001$) G:F and a tendency for greater (linear, $P = 0.077$) ADFI. In contrast to the previous research, this study suggests that feeding increasing dietary dEB in nursery diets increased growth performance of weanling pigs.

**Key Words:** dietary electrolyte balance, growth performance, nursery pig
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**300 Comparative analysis of bacterial composition in the ileum of early postweaned piglets fed microbially enhanced soybean meal and fishmeal.** J. L. Ortman[1,*], S. M. Sinn[1], B. St-Pierre[2], C. L. Levesque[1], *[1]South Dakota State University, Brookings, [2]Animal Science Department, South Dakota State University, Brookings*.

The objective of this research was to assess bacterial populations associated with the use of microbially enhanced soybean meal (ME-PRO) and fishmeal (FM). Weaned pigs were fed 1 of 3 experimental diets: 1) control (CON) containing corn and soybean meal, 2) CON + fishmeal (FM), and 3) CON + ME-PRO (ME-PRO) in Phase I (d 0–7 after wean; FM or MEPRO at 7.5%) and Phase II (d 8–21; FM or MEPRO at 5.0%). Ileal digesta was collected from 6 pigs/diet at d 21. Digesta microbial genomic DNA was used for PCR amplification of the 16S rRNA gene (V1–V3 region) and amplicons were sequenced via the Illumina Miseq 2x300 platform. The data produced 440,999 high-quality sequences that ranged from 1,938 to 66,953 sequences/animal. Data were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC) with pig as the experimental unit and pig(treatment) as the random effect. There was no effect of treatment ($P > 0.05$) on relative abundance of genera. *Lactobacillus* appeared to be the dominant genus. Pigs were assigned to a high (≥38% relative abundance) or low category (≤10% relative abundance). In pigs fed CON and FM, 75 and 71% of the samples, respectively, were assigned to the high category compared with 50% in pigs fed ME-PRO ($\chi^2$, $P = 0.596$). Nine operational taxonomic units (OTU) made up the *Lactobacillus* genus and 3 OTU appeared to be dominant. They are closely related to *Lactobacillus amylovorus*, *Lactobacillus amylovorus*, and *Lactobacillus crispatus*

**Table 299.**

| | mEq/kg | | | | | | |
|---|---|---|---|---|---|---|---|
| | Phase 1 | | | | | | |
| | 84 | 137 | 190 | 243 | | Probability, $P$-value < | |
| | Phase 2 | | | | | | |
| | 29 | 86 | 142 | 199 | SEM | Linear | Quadratic |
| d 0 | 5.19 | 5.19 | 5.20 | 5.17 | 0.053 | 0.704 | 0.502 |
| d 21 | 9.40 | 9.78 | 10.01 | 10.21 | 0.084 | <0.001 | 0.179 |
| d 35 | 15.56 | 15.74 | 15.94 | 16.02 | 0.120 | <0.001 | 0.543 |
| d 0–21 | | | | | | | |
| ADG, g | 193 | 211 | 219 | 235 | 3.3 | <0.001 | 0.807 |
| ADFI, g | 252 | 256 | 253 | 268 | 3.9 | 0.003 | 0.103 |
| G:F | 0.77 | 0.83 | 0.87 | 0.87 | 0.008 | <0.001 | <0.001 |
| d 0–35 | | | | | | | |
| ADG, g | 290 | 295 | 299 | 306 | 3.4 | <0.001 | 0.736 |
| ADFI, g | 388 | 390 | 391 | 397 | 4.8 | 0.077 | 0.594 |
| G:F | 0.76 | 0.78 | 0.80 | 0.80 | 0.005 | <0.001 | 0.030 |

and represented 35.8, 0.96, and 2.1% relative abundance, respectively, in pigs fed CON; 23.6, 15.8, and 2.1% relative abundance, respectively, in pigs fed FM; and 9.39, 14.6, and 11.5% relative abundance, respectively, in pigs fed MEPRO. Even at relatively minor dietary inclusion, alterations in protein source can lead to microbial composition shifts in the ileum of weaned pigs.

**Key Words:** *Lactobacillus*, microbiome, weaned pigs
doi:10.2527/asasmw.2017.300

**301 Evaluation of the lysine requirement of eleven- to twenty-three-kilogram nursery pigs.** A. Graham[1,*], B. Knopf[1], L. Greiner[1], M. A. D. Goncalves[2], U. A. D. Orlando[2], J. Connor[3], *[1]Carthage Innovative Swine Solutions, LLC, Carthage, IL, [2]Genus PIC, Hendersonville, TN, [3]Carthage Veterinary Service, Ltd, Carthage, IL*.

A total of 1,200 PIC 337 × 1050 barrows and gilts (11.4 ± 1.4 kg) were placed in a wean-to-finish facility. The 5 dietary treatments were 1.10, 1.20, 1.30, 1.40, and 1.50% SID lysine. Dietary treatments were randomly allotted to pens (25 pigs/pen) blocked by gender and average pen BW. Pigs were started on experimental diets at approximately 11.4 kg BW. Prior to the study, pigs were placed on a common diet that met the lysine requirement based on BW. All diets were corn–soy based and were formulated to meet or exceed NRC (2012) requirements. Pen weights and feed intake information were collected at each phase for calculation of ADG, ADFI, and G:F. Mortalities and removals were weighed and recorded. Data were analyzed as a RCBD using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit, treatment as the fixed effect, and BW block as the random effect. Results were considered significant at $P \leq 0.05$ and a trend at $P > 0.05$ and $P \leq 0.10$. Competing requirement estimation models were quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ) using PROC NLMIXED. Models that differed in their Bayesian information criterion values by at least 2 points were considered to have meaningful differences in their data fit (Raftery, 1996). There were no significant differences detected in BW at the conclusion of the 21-d study ($P > 0.16$). There were no differences detected in ADG based on dietary treatment ($P > 0.12$). Feed intake was linearly reduced ($P < 0.003$) as SID Lys level increased. Consequently, G:F was linearly improved ($P < 0.02$) as SID Lys increased. For ADG, the QP model was determined to be the best fit ($15.5 + 153.3 \times \text{SID Lys} - 60.6 \times \text{SID Lys}^2$) with an estimated SID Lys requirement of 1.26%. The G:F was best modeled by the linear broken line model ($1/(145.7 + 19.1 \times [1.40 - \text{SID Lys}])$) with an estimated requirement of 1.40% SID Lys. In conclusion, the SID Lys requirement for ADG is 1.26% and G:F is 1.40% in 11- to 23-kg BW pigs.

**Key Words:** lysine, nursery, pig
doi:10.2527/asasmw.2017.301

**Table 300.** Relative abundance of genera (% of total reads) representing >1% of total reads in the ileal digesta of pigs fed ME-PRO or fishmeal

| Genus | CON | FM | ME-PRO | SEM | *P*-value |
|---|---|---|---|---|---|
| *Actinobacillus* | 4.61 | 2.39 | 2.39 | 2.22 | 0.687 |
| *Campylobacter* | 10.05 | 1.76 | 0.33 | 4.37 | 0.234 |
| *Escherichia*/*Shigella* | 0.24 | 2.32 | 9.14 | 4.97 | 0.421 |
| *Lactobacillus* | 49.71 | 49.20 | 36.74 | 14.06 | 0.752 |
| *Prevotella* | 8.92 | 8.16 | 8.43 | 6.42 | 0.996 |
| Unclassified Pasterurellaceae | 2.27 | 3.70 | 1.36 | 2.73 | 0.806 |

**302 Evaluation of Elarom SES in nursery pig diets with or without the inclusion of high zinc oxide or feed antimicrobials.** H. E. Williams[1,*], J. C. Woodworth[1], J. M. DeRouchey[1], S. S. Dritz[1], M. D. Tokach[1], K. Hogan[2], S. R. Webster[2], *[1]Kansas State University, Manhattan, [2]Trouw Nutrition USA, LLC., Highland, IL*.

Weaned pigs ($n = 360$; initially 5.2 ± 0.04 kg BW) were used in a 42-d study evaluating the effects of feeding Elarom SES in combination with high levels of ZnO and/or antimicrobials on nursery pig performance and fecal consistency. Elarom SES (Trouw Nutrition USA, Highland, IL) is a commercially available blend of short- and medium-chain fatty acids and slow-release organic acids designed to enhance growth performance and gut health. Pigs were weaned at approximately 21 d and allotted to pens with 9 replications/treatment based on initial BW in a completely randomized design. Experimental treatments were arranged as a 2 × 2 × 2 factorial. The 8 treatment diets included Elarom SES (none vs. 0.2%), additional ZnO (none vs. 3,000 ppm in phase 1, 2,000 ppm in phase 2, and none in phase 3), and antimicrobial regimen (none vs. 440 ppm CTC and 38.5 ppm Denagard in phase 1 and 55 ppm Mecadox in phases 2 and 3). Experimental diets were fed in meal form in 3 phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21; and Phase 3, d 21 to 42). Overall, an Elarom SES × ZnO × antimicrobial interaction was observed for ADG ($P = 0.043$) and G:F ($P = 0.010$). Adding antibiotics to the diet increased ($P < 0.013$) ADG and ADFI, but there were no main effects of ZnO or Elarom SES observed. There were no individual or overall treatment effects ($P > 0.100$) or treatment × day interactions ($P = 0.53$) observed for fecal consistency. In summary, some benefits in performance were observed when adding certain combinations of feed additives in the diet compared with including them alone or when all 3 were fed together.

**Key Words:** feed additive, growth performance, nursery pig
doi:10.2527/asasmw.2017.302

**Table 301.** Evaluation of lysine requirement in 11- to 23-kg nursery pigs

| | Trt 1 | Trt 2 | Trt 3 | Trt 4 | Trt 5 | | Probability, *P*-value < | |
|---|---|---|---|---|---|---|---|---|
| | SID Lys | | | | | | | |
| | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | SEM | Linear | Quadratic |
| ADG | 0.50 | 0.52 | 0.50 | 0.51 | 0.49 | 0.01 | 0.34 | 0.12 |
| ADFI | 0.76 | 0.77 | 0.75 | 0.74 | 0.72 | 0.02 | 0.003 | 0.18 |
| G:F | 0.663 | 0.671 | 0.671 | 0.695 | 0.687 | 0.010 | 0.02 | 0.85 |

**Table 302.**

| | Elarom SES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | − | + | − | − | + | + | − | + | |
| | ZnO | | | | | | | | |
| | − | − | + | − | + | − | + | + | |
| | Antimicrobial | | | | | | | | |
| | − | − | − | + | − | + | + | + | SEM |
| d 0 to 21 | | | | | | | | | |
| ADG, g[a,b] | 206 | 195 | 224 | 240 | 242 | 243 | 258 | 268 | 7.03 |
| G:F[b,c] | 0.826 | 0.808 | 0.816 | 0.886 | 0.859 | 0.858 | 0.885 | 0.890 | 0.014 |
| d 21 to 42 | | | | | | | | | |
| ADG, g[a,d] | 532 | 526 | 478 | 549 | 533 | 507 | 539 | 475 | 15.01 |
| G:F[a,b,d] | 0.709 | 0.706 | 0.676 | 0.676 | 0.698 | 0.668 | 0.684 | 0.631 | 0.008 |
| d 0 to 42 | | | | | | | | | |
| ADG, g[b,d,e] | 369 | 360 | 351 | 391 | 388 | 373 | 397 | 372 | 9.05 |
| G:F[d,e] | 0.738 | 0.731 | 0.716 | 0.730 | 0.741 | 0.720 | 0.739 | 0.705 | 0.006 |

[a]ZnO ($P < 0.05$).
[b]Antimicrobial ($P < 0.05$).
[c]Elarom × ZnO ($P < 0.05$).
[d]Elarom SES × antimicrobial ($P < 0.05$).
[e]Elarom SES × ZnO × antimicrobial ($P < 0.05$).

**303 Effect of natural feed additives as alternatives to in-feed antibiotics on the performance of nursery pigs.**

S. M. Mendoza[1,*], G. R. Murugesan[1], E. Hendel[1], E. Kadas-Toth[2], A. Kovacs[2], *[1]BIOMIN America Inc., San Antonio, TX, [2]BIOMIN Holding GmbH, Getzersdorf, Austria*.

This study was designed to evaluate natural feed additives as alternatives to in-feed antibiotics on nursery pig performance. Natural feed additives used in the present study consist of 1) Biotronic Top3 (a blend of formic, propionic, and acetic acids combined with cinnamaldehyde and permeabilizing complex; BIOMIN Holding GmbH) and 2) Digestarom P.E.P. (a phytogenic blend of oregano, anise, and citrus oil and fructooligosaccharide; BIOMIN Holding GmbH). Weaned pigs (PIC 280 × 1050; $n = 480$; 6.22 ± 1.4 kg BW; 22 d) were housed 10 pigs per pen for a total of 48 pens and assigned within weight blocks to 1 of 4 dietary treatments (12 pens/diet). Pigs were fed 2 phases of experimental diets (0–8 d and 8–22 d after weaning). Diets were corn–soybean meal–dry whey based and contained 4.35 and 4.10 g SID lysine/Mcal ME for phases 1 and 2, respectively. The dietary treatments were 1) basal diet with no additive (NC), 2) NC + 50 ppm carbadox in phase 1 and 50 ppm neomycin + 50 ppm oxytetracycline in phase 2 (PC), 3) NC + 50 ppm carbadox in phase 1 and 0.1% of Biotronic Top3 in phase 2 (C+OA), and 4) NC + 0.1% of Biotronic Top3 + 0.0125% of Digestarom P.E.P. (OA+EO) in both phases. Body weight and feed disappearance were measured weekly. A mixed model was used to examine the effect of diet, weight block was used as the random effect, and multiple comparisons were evaluated using a *t* test. Pigs receiving PC had greater BW (11.19 kg; $P = 0.001$) compared with pigs receiving NC (10.53 kg) but did not differ from pigs receiving C+OA (11.03 kg; $P = 0.382$) and OA+EO (10.85 kg; $P = 0.074$) whereas BW did not differ between pigs receiving OA+EO and pigs receiving NC ($P = 0.100$). Pigs fed PC (226 g/d) and C+OA (215 g/d) had higher ADG compared with pigs fed NC (193 g/d; $P \leq 0.024$), but they did not differ from pigs fed OA+EO (210 g/d; $P \geq 0.101$). Feed intake was not significantly different among groups ($P = 0.242$). The G:F was increased with the addition of antibiotics and/or natural antimicrobials compared with NC (0.805 for PC, 0.771 for C+OA, 0.774 for OA+EO, and 0.722 for OA+EO; $P \leq 0.01$). The present study suggests that Biotronic Top3 can be an effective tool to replace neomycin and oxytetracycline when pigs were previously fed carbadox during the first phase. In addition, the combination of Biotronic Top3 and Digestarom P.E.P. provided a viable natural

alternative to replace in-feed antibiotics.

**Key Words:** carbadox, organic acids, phytogenics
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**304 Effect of particle size of soy protein concentrate on amino acid digestibility and concentration of metabolizable energy and effects of soy protein concentrate on growth performance of weanling pigs.** G. A. Casas[1,2,*], C. Huang[3], H. H. Stein[2], *[1]Universidad Nacional de Colombia, Bogota, Colombia, [2]University of Illinois at Urbana-Champaign, Urbana, [3]Beijing TongLiXingKe Agriculture Science & Technology Co. Ltd, BEIJING, China*.

Two experiments were conducted to determine the standardized ileal digestibility (SID) of AA and the concentration of ME in soy protein concentrate (SPC) ground to 3 particle sizes and in soybean meal and fish meal when fed to weanling pigs. An additional experiment was conducted to determine effects on growth performance of including SPC in diets fed to weanling pigs. In Exp. 1, diets containing soybean meal, fish meal, or SPC ground to a mean particle size of 70, 180, or 700 μm as the only source of AA were fed to weanling barrows (12.90 ± 1.51 kg initial BW) that had a T-cannula installed in the ileum. In Exp. 2, 36 barrows (13.70 ± 1.86 kg BW) were allotted to a corn-based diet or diets containing corn and soybean meal, fish meal, or SPC ground to the 3 particle sizes. In Exp. 3, 160 pigs (7.06 ± 1.07 kg initial BW) were allotted to 4 dietary treatments and 8 pens per treatment with 5 pigs per pen. Diets included a control diet containing fish meal and spray dried plasma protein and diets in which fish meal, spray dried plasma protein, or both fish meal and spray dried plasma protein were replaced by SPC ground to 180 μm. Pigs were fed 1 of 4 diets during phase 1 and a common diet in phase 2. Results indicated that the SID of Lys tended ($P = 0.078$) to be greater in SPC ground to 180 μm than in soybean meal and that the SID of Arg and Trp were greater ($P < 0.05$) in SPC ground to 70 or 180 μm than in SPC ground to 700 μm. There were no differences in the ME among corn, soybean meal, fish meal, and SPC ground to 70, 180, or 700 μm, and the ME of SPC ground to 70, 180, or 700 μm was 3,683, 3,903, and 3,886 kcal/kg DM, respectively. Substitution of spray dried plasma protein and fish meal by SPC ground to 180 μm in diets fed during phase 1 had no effect on pig growth performance. In conclusion, reduction of the particle size of SPC may improve digestibility of some indispensable AA but did not affect concentration of ME. Soy protein concentrate may replace animal proteins in diets fed to weanling pigs without affecting growth performance.

**Key Words:** amino acid digestibility, energy digestibility, soy protein concentrate
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**305 A review and evaluation of antibiotic alternatives in the literature.** W. P. Schweer[1,*], J. F. Patience[1], K. Schwartz[1], D. Linhares[1], C. Rademacher[1], H. K. Allen[2], C. L. Loving[2], A. Ramirez[1], N. K. Gabler[1], *[1]Iowa State University, Ames, [2]USDA National Animal Disease Center, Ames, IA*.

In the coming years, there will be an increase in the use of feed-grade antibiotic alternatives in swine production due to restrictions on feed-grade antibiotics for pig performance and/or treatment. As a result, there is a need to understand effective ways to evaluate dietary antibiotic alternatives in swine production. A review of published literature was performed to determine how different antibiotic alternatives influenced growth performance. The antibiotic alternatives evaluated were prebiotics, probiotics, resistant starch/fiber, botanicals, organic acids, lysozymes, oligosaccharides, yeast, and zinc and copper. Searches were performed on PubMed, CAB Abstracts, ScienceDirect, Agricola, and Web of Science for each category. Research papers were included if they were original research, were published in a peer reviewed journal between 1990 and January 2016, and included any pig performance parameter (ADG, ADFI, and G:F) or mortality in the abstract. If determined acceptable, data were extracted from each paper, including disease challenge, number/treatment, pigs/pen, age of pig, duration of study, start BW, diet components, and whether performance or mortality was positively or negatively impacted or not changed. This lead to a total of 773 papers with 1,698 studies evaluated. Antibiotic alternatives improved ADG in 29.3% of studies whereas performance was unchanged or declined in 65.9 and 3.3% of studies, respectively, compared with pigs fed no antibiotics. In studies that improved ADG, pigs averaged 24 d old and weighed 9.7 kg. These studies lasted 24 d, on average, with 13/treatment and 7 pigs/pen. The most effective antibiotic alternatives were probiotics, organic acids, and zinc/copper, where an improvement in ADG was reported in 38.7, 33.8, and 42.6% of studies, respectively. Within each category, there was an attempt to determine factors that may have led to improved performance. About one-third of probiotic studies that reported improved ADG used a combination of probiotics whereas another third used a strain of *Lactobacillus*. After evaluating zinc and copper, it was determined that 3,000 and 2,500 ppm of zinc were used in 16.5 and 11% of studies, respectively. No other factors could be determined in other categories. In summary, antibiotic alternatives can improve performance in pigs but there may be a specific age, BW, or duration of feeding that can optimize the response. With the data obtained, we can better design and evaluate antibiotic alternative research for the swine industry.

**Key Words:** antibiotic alternative, review, swine
doi:10.2527/asasmw.2017.305

**306 Effect of lactose, inulin, *Lactobacillus acidophilus* fermentation product, or dietary antibiotics on intestinal function of nursery pigs.** J. A. Acosta[1,*], N. K. Gabler[1], J. W. Frank[2], B. E. Bass[2], J. F. Patience[1], [1]*Iowa State University, Ames,* [2]*Diamond V, Cedar Rapids, IA*.

The objective of this study was to determine the effect of lactose (LA), *Lactobacillus acidophilus* fermentation product (FP; SynGenX; Diamond V, Cedar Rapids, IA), inulin, and dietary antibiotics on intestinal function of nursery pigs. Forty-nine newly weaned pigs (approximately 21 d of age; 5.2 ± 0.2 kg initial BW) were housed in metabolism crates and randomly assigned to 1 of 7 treatments: 1) control diet (CT), 2) 1 plus 0.1% FP, 3) 1 plus 15% lactose, 4) 3 plus 0.1% FP, 5) 3 plus 3% inulin, 6) 3 plus 0.1% FP and 3% inulin, and 7) 1 plus chlortetracycline (440 ppm) and tiamulin–hydrogen–fumarate (39 ppm). At d 5, pigs were orally given lactulose and mannitol to assess small intestinal permeability. At d 15, all pigs were euthanized to assess intestinal morphology. Data were analyzed using preplanned contrasts to test the effects of antibiotics (7 vs. 1, 7 vs. 2, and 7 vs. 3), LA (3 and 4 vs. 1 and 2), FP (2, 4, and 6 vs. 1, 3, and 5), inulin (5 and 6 vs. 3 and 4), the interaction between LA and FP (1 and 4 vs. 2 and 3), and the interaction between FP and inulin (3 and 6 vs. 4 and 5). There were no differences in lactulose or mannitol recovery or lactulose:mannitol ratio ($P > 0.10$). Antibiotics tended to decrease villus height (VH) in the jejunum (−80 μm; $P = 0.065$) and decreased VH in the ileum (−107 μm; $P = 0.007$) compared with LA. Antibiotics tended to decrease ileum VH (−68 μm) compared with FP ($P = 0.074$). There was an interaction between LA and FP in the jejunum ($P = 0.036$) and ileum ($P = 0.014$); LA and FP provided alone increased VH (+64 μm in the jejunum and +68 μm in the ileum) compared with the combination of FP and LA or when neither of the products were added. Inulin had no effect in jejunum or ileum VH. Jejunum or ileum crypt depth (CD) did not differ, except for antibiotics that increased CD in the ileum compared with CT (+86 μm; $P = 0.001$), FP (+101 μm; $P < 0.001$), and LA (+85 μm; $P = 0.002$). There was no difference in VH:CD ratio in the jejunum; in the ileum, there was an interaction between lactose and FP ($P = 0.009$); LA and FP provided alone increased the VH:CD ratio (+0.34) compared with the combination of FP and LA or when neither of the products was added. In the ileum, pigs fed antibiotics had a decreased VH:CD ratio compared with FP (−0.61; $P = 0.001$) and LA (−0.66; $P = 0.002$). In conclusion, although none of the products affected small intestinal permeability, lactose and FP alone (but not in combination) increased villus height of weaned pigs.

**Key Words:** intestinal morphology, lactulose, weaned pigs

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## PHYSIOLOGY SYMPOSIUM: MOLECULAR EVENTS IMPACTING PRODUCTION OF FERTILE GAMETES

**307 Precision animal breeding to make genetically castrated animals for improved animal welfare and alternative breeding applications.** T. S. Sonstegard[*], S. C. Fahrenkrug, D. Carlson, *Recombinetics, Inc., St Paul, MN*.

The main purposes of surgical castration are to reduce aggressive behavior of males and remove "boar taint" from pork. Because of issues related to animal welfare, European swine industry leaders voluntarily signed a declaration to abandon all forms of surgical castration by January 2018. Alternatives, such as vaccinations against boar taint or marker selection against taint, possibly have negative effects on carcass yield and libido, respectively. As an alternative, we report the efficacy of precision cross-breeding, also known as gene editing, as a means for elimination of surgical castration. A single edited cell line (*KISSR* −/−) derived from a White Composite male pig was used for SCNT. All porcine cloning of TALen edited gene knock-out cell lines was done at Minitube of America. Blastocysts were transferred into 3 recipients, which resulted in 2 successful pregnancies yielding 19 piglets (2 stillbirths). The 17 remaining animals were raised to 90.72 to 102.06 kg (200 to 225 lbs). The KISSR KO edit was diagnostically confirmed as was lack of testicular development. The animals looked and acted (low aggression) like barrows in good health and were phenocopies of humans with hypogonadotropic hypogonadism. We attempted to initiate testicular development in these pigs using hormone therapy as a potential method to rescue reproductive competency and/or check for their integrity as potential recipients for germ cell line transfer. Puberty induction studies were set up with 3 groups of *KISSR* KO cloned male pigs (each $n = 4$): 1) control/sham injected, 2) FSH/slow release treatment, and 3) GnRH treatment. The GnRH protocol was not expected to induce puberty; but testosterone, LH, and FSH levels could be determined to support future testing of hormone treatments. All animals were humanely euthanized for subsequent histology and gene expression studies. The hormone-treated testes increased mass and structural histology strongly supported the potential for recovery of sperm production with a more efficacious treatment even though sperm were not detected in any group. Current studies are underway to compare growth efficiencies between normal, castrated, and KISSR KO pigs. These results are needed to validate the market value of genetic castration. We also are testing alternative gene knockouts to maintain testicle development without germ cell development. Overall, we demonstrated that genome editing can be used to benefit animal welfare by eliminating stressful management practices

in a single generation and that the potential to propagate these lines is possible through hormone therapy.

**Key Words:** castration, germ cell transplantation, GPR54

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**308 A transgenic boar model to elucidate the role of gonadotropin-releasing hormone 2 and its receptor in regulating testes and sperm function.**

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Boar subfertility represents a major limitation to swine production, reducing conception rate and litter size. Critical to reproductive function, the classical form of GnRH (GnRH1) promotes secretion of the gonadotropins; however, the second mammalian isoform (GnRH2) is a poor stimulator of gonadotropin release. A receptor specific to GnRH2 (GnRHR2) has been identified in mammals, although gene coding errors prevent the production of a full-length protein in most species. In contrast, the GnRHR2 is functional in swine, allowing us to establish in the boar that 1) GnRH2 and its receptor are more abundant within the testis compared with the hypothalamus and anterior pituitary gland, 2) GnRHR2 are present on Leydig cells, 3) exogenous GnRH2 stimulates testosterone secretion from testicular explants, and 4) GnRH2 stimulates testosterone release in vivo as effectively as GnRH1, despite minimal secretion of the conventional androgen stimulator, LH. In addition, we have found GnRH2 on developing germ cells, immunolocalized GnRHR2 to the connecting piece of mature sperm, and detected GnRH2 in seminal plasma. To further examine the function of GnRH2 and its receptor within the porcine testis, we produced a swine line with reduced endogenous GnRHR2 levels (GnRHR2 knockdown [KD]). During pubertal development, hemizygous GnRHR2 KD boars tended ($P < 0.06$) to have lower serum testosterone concentrations than littermate controls (1.6 vs. 4.2 ng/mL), although LH levels were similar ($P > 0.90$). Predicted testis volumes of GnRHR2 KD males were smaller than controls (331.8 vs. 374.8 $cm^3$; $P < 0.05$), despite similar BW ($P > 0.05$). In mature boars, diurnal testosterone secretion was reduced by 80% in GnRHR2 KD compared with control animals (0.8 vs. 4.1 ng/mL; $P < 0.05$). Furthermore, GnRHR2 mRNA levels were diminished by 70% in transgenic vs. control testes ($P < 0.001$). These data suggest that GnRH2 acts directly on Leydig cells to stimulate steroidogenesis, independent of LH secretion. In addition, computer-assisted sperm analysis indicated that ejaculates from GnRHR2 KD boars tended to have less motile sperm ($P = 0.10$) and reduced sperm concentration ($P < 0.10$) than littermate control males, potentially due to lower testosterone levels and/or fewer GnRHR2 on germ cells. A better understanding of how GnRH2 and its receptor regulate testicular function will lead to new technologies to improve fertility in boars, enhancing the sustainability/profitability of pork producers. Partially supported by NIFA Hatch (NEB-26-199; BRW) and AFRI (2011-67015; CAL) funds. The USDA is an equal opportunity provider and employer.

**Key Words:** GnRH2, GnRH2 receptor, testicular function

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**309 MicroRNA and extracellular vesicle mediated cellular communication within the bovine follicle.**

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During ovarian follicular development, a rich and complex fluid containing numerous proteins, nucleic acids, and other macromolecules accumulates within the follicular antrum to effectively isolate and simultaneously nurture the cumulus–oocyte complex. Recent studies have shown that extracellular vesicles (EV), which include both exosomes and microvesicles, are abundant within antral fluid and are a rich source of microRNA (miRNA). Small RNA sequencing (RNaseq) analyses have identified miRNA that are differentially abundant dependent on the stage of development of the bovine antral follicle. Furthermore, our laboratory and several others have now also demonstrated that follicular fluid EV can elicit functional effects on ovarian granulosa cells and cumulus–oocyte complexes. Extracellular vesicles isolated from small 3- to 5-mm bovine follicles were shown to stimulate ovarian granulosa cell proliferation, whereas EV from larger periovulatory follicles (>9 mm diameter) exhibited a diminished ability to stimulate cell proliferation. Ongoing studies are evaluating the factors (e.g., lipid, RNA, protein) that might be responsible for these effects seen in the EV using a combination of proteomic and RNaseq strategies. We also observed that EV from small follicles were more readily taken up by granulosa cells, which might partly explain their increased activity. We are currently evaluating whether CD81, an established EV biomarker that is differentially expressed in EV from small follicles versus EV from large follicles, is important in this differential uptake by granulosa cells. Interestingly, we have also observed that EV isolated from periovulatory follicles from cows prior to the LH surge are rich in CD81, whereas those isolated immediately following the LH surge have very few CD81-positive EV. This is particularly interesting, as previous studies in mice have demonstrated that loss of CD81 caused a pronounced decrease in sperm/egg fusion, although the specific mechanism of action by which CD81 facilitates the process of fertilization remains to be determined. In addition to stimulating granulosa cell proliferation, EV have been shown to impact another key physiologic event within the periovulatory follicle, the expansion of cumulus granulosa cells surrounding the oocyte. We showed that bovine EV from both small and large follicles were able to stimulate cumulus expansion; however, they had

divergent effects on gene expression within the cumulus. In conclusion, we believe that EV may present a novel cell-to-cell signaling mechanism that allows mural granulosa cells to interact with the cumulus and oocyte and vice versa. Funded by NIH-HD082484

**Key Words:** extracellular vesicle, follicle, microRNA
doi:10.2527/asasmw.2017.309

**310 High-throughput sequencing methods (RNA sequencing and Poly(A)-sequencing) to characterize full-length messenger RNA in transcriptionally silent bull sperm; Potential noninvasive measures of bull fertility.**

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Sperm production is a highly regulated cell differentiation event that is characterized by spatiotemporal control of gene and protein expression. Extensive co- and post-transcriptional processing of male germ cell transcript 3′ untranslated regions (UTR) occurs to coordinate the unique developmental events of spermatogenesis that impact sire fertility. An emerging cotranscriptional regulatory process of spermatogenesis is differential polyA site (PAS) selection in the 3′ UTR, termed alternative polyadenylation. The messenger RNA (mRNA) population that remains in the terminally differentiated spermatozoa has the potential as a molecular marker for sire fertility because the characteristics of this mRNA population may reflect gene expression patterns that occurred during spermatogenesis. Furthermore, full-length mRNA may have a functional role in early embryonic development. The high-throughput sequencing methods RNA sequencing (RNA-Seq) and Poly(A)-sequencing (PolyA-Seq) can reveal the full mRNA and 3′ UTR use profiles in bull sperm as a fingerprint of spermatogenic gene expression regulation. From RNA-Seq analysis, the oligo-dT selected bovine spermatozoal transcript profile is a heterogeneous population of degraded and full-length predominantly nuclear-encoded mRNA. Highly abundant spermatozoal transcripts included *PRM1*, *HMGB4*, and mitochondrial-encoded transcripts. Full-length transcripts comprised 66% of the top 368 transcripts (FPKM > 100) and amplification of the full-length transcript or 5′ and 3′ ends was confirmed for selected transcripts. In these studies, we compared the oligo-dT selected spermatozoal transcript profiles of higher fertility (conception rate [CR] 1.8 to 3.5) and lower fertility (CR −2.9 to −0.4) sires using RNA-Seq. A total of 3,227 and 5,366 transcripts were identified in the higher and lower fertility populations, respectively. Although transcripts common between the 2 populations were identified (2,422 transcripts), several transcripts were also unique to the fertility populations, including 805 transcripts that were unique to the higher fertility population and 2,944 transcripts that were unique to the lower fertility population. From gene ontological analysis, the transcripts unique to each fertility population differed in Biological Processes (BP), including enrichment of regulatory transcripts for growth and protein kinase activity in the higher-fertility bulls. Biological variation in transcript presence among individual sires was also found, and transcripts with a correlation to sire fertility were identified. We are currently investigating 3′ UTR use in bovine spermatozoa to investigate fertility-related patterns of alternative polyadenylation.

**Key Words:** bull, fertility, spermatozoa
doi:10.2527/asasmw.2017.310

**311 Characterization of proteins in the bovine epididymal and seminal fluid and proteins attached to epididymal and ejaculated sperm.**

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During final maturation, sperm lose their ability to biosynthesize, repair, grow, and divide. They have minimal metabolic function and, therefore, become completely dependent on their environment. In the epididymis, sperm are stored for a long period of time, but on ejaculation, motility is increased and lifespan is decreased from several weeks to hours. The objective of this experiment was to identify differences in proteins that are both in the environment (fluid) and attached to the sperm in both the epididymis and following ejaculation by LCMS-MS. Ejaculated and epididymal (after slaughter) sperm were collected from each of 9 bulls. Following collection, spermatozoa were washed with a high ionic solution to remove any proteins attached to the sperm, samples were then pooled, and proteins were identified by LCMS-MS at the University of Minnesota Mass Spectrometry facility. Data were analyzed using the Scaffold software package with a false discovery rate set at 1%, a minimum of 1 peptide to identify a protein, and minimum of a 50% confidence in the identity of the protein. Total unique spectra count was then used to determine proteins found in one sample but not the other or found in both samples. In the fluid (epididymal and ejaculated), there were 208 proteins identified in epididymal fluid that were not identified in ejaculated fluid, 75 proteins identified in ejaculated fluid that were not identified in epididymal fluid, and 103 proteins identified in both, for a total of 386 proteins identified in the fluid samples. Among proteins stripped from the sperm, there were 113 proteins identified from the epididymal samples there were not identified in the ejaculated samples, 77 samples identified from the ejaculated samples that were not identified in epididymal samples, and 221 proteins identified in both, for a total of 411 proteins identified that were attached to sperm. There were 69 proteins identified attached to sperm that were not identified in fluid samples and 49 proteins identified in fluid samples that were not identified in the samples attached to sperm. Therefore, a large number of proteins change between the epididymis and

ejaculation; further investigation of proteins attached to the sperm and in the fluid environment that were not found in ejaculated samples may provide insight into the processes that allow sperm to be stored for extended periods of time in the epididymis but not after ejaculation. The USDA is an equal opportunity provider and employer.

**Key Words:** epididymis, ejaculation, sperm
doi:10.2527/asasmw.2017.311

## PHYSIOLOGY

**312 Young Scholar Presentation: Effective use of SexedUltra sex-sorted semen for timed artificial insemination of beef heifers.** J. M. Thomas[1,*], J. W. C. Locke[1], R. Vishwanath[2], J. B. Hall[3], M. R. Ellersieck[1], M. F. Smith[1], D. J. Patterson[1], *[1]University of Missouri, Columbia, [2]Sexing Technologies Inc., DeForest, WI, [3]Department of Animal & Veterinary Sciences, University of Idaho, Moscow*.

An experiment was designed to evaluate the relative fertility of SexedUltra sex-sorted semen compared with conventional, non-sex-sorted semen when used among beef heifers in conjunction with split-time AI following the 14-d CIDR-PG protocol. Units of conventional semen were generated with 25.0 $\times 10^6$ live cells per 0.5-mL straw prior to freezing, and units of sex-sorted semen were generated using the SexedUltra Genesis III sorting technology with $4.0 \times 10^6$ live cells per 0.25-mL straw prior to freezing. Sex-sorted units were sorted to contain X chromosome–bearing sperm cells at an accuracy level of >93%. Estrus was synchronized for 851 heifers in 4 locations using the 14-d CIDR-PG protocol: controlled internal drug release (CIDR) insert (1.38 g progesterone) on Day 0, CIDR removal on Day 14, and administration of prostaglandin $F_{2\alpha}$ (PG; 25 mg intramuscularly) on Day 30. Estrus detection aids were applied at PG on Day 30 to evaluate estrous response rate, and split-time AI was performed based on estrous response. At 66 h after PG (Day 33), heifers having expressed estrus received timed AI. Heifers failing to express estrus by 66 h received timed AI 24 h later (90 h after $PGF_{2\alpha}$ on Day 34). Heifers failing to express estrus by 90 h were administered GnRH (100 µg intramuscularly) concurrent with AI. Heifers were preassigned to treatment (insemination with conventional or sex-sorted semen), and treatments were balanced within each location based on source, reproductive tract score, and weight. Heifers were exposed for natural service beginning 14 d after AI for the remainder of a 60-d breeding season. Across locations, pregnancy rates to AI were higher ($P = 0.02$) for heifers inseminated with conventional semen (60%; 257/429) compared with sex-sorted semen (52%; 218/422). Higher pregnancy rates to AI ($P < 0.0001$) were obtained among heifers that expressed estrus prior to AI than among heifers that failed to express estrus prior to AI at 90 h. Total pregnancy rates at the end of the 60-d breeding season did not differ between heifers that received sex-sorted semen at AI (89%; 376/422) and heifers that received conventional semen at AI (89%; 382/429). Although pregnancy rates to AI were higher among heifers inseminated with conventional semen, the pregnancy rates observed with SexedUltra sex-sorted semen suggest that split-time AI following the 14-d CIDR-PG protocol is an effective platform for use of sex-sorted semen in timed AI of beef heifers.

**Key Words:** estrus synchronization, sexed semen, timed artificial insemination
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**313 The use of testicular fine needle aspiration, histology, and immunohistochemistry for Sertoli and germ cell determination in peripubertal bulls.** N. Negrin Pereira[1,*], P. Borowicz[1], B. Neville[2], J. Flaten[1], C. R. Dahlen[1], *[1]Department of Animal Sciences, North Dakota State University, Fargo, [2]Central Grasslands Research Extension Center, Streeter, ND*.

The relationship between the Sertoli cell population and number of germ cells within testicular tissue is a potential indicator of fertility in different mammalian species. Determining the population of Sertoli cells in peripubertal bulls may be a useful tool in identifying potential daily sperm production. Androgen receptors (AR) are expressed exclusively on Sertoli cells within the seminiferous tubule, making them a potential target for Sertoli cell enumeration via immunohistochemistry. The objective of this study was to compare techniques of fine needle aspiration (FNA), histology, and immunohistochemistry to determine Sertoli and germ cell counts in the bull. Testicular parenchyma samples were obtained from 14 peripubertal Angus and Shorthorn bulls (287 ± 3.3 d of age; 310 ± 10 kg). Smears for FNA were produced after collection with 22-gauge (FNA-F) and 16-gauge (FNA-G) needles, and tissues were cut for hematoxylin/eosin staining (HE) or incubated with mouse monoclonal antibody for androgen receptor immunofluorescence and counterstained with DAPI (ARIF). Pictures of HE-stained specimens were assessed by manual count based on Sertoli cell morphology and ARIF were assessed by image analysis software ImagePro Premier based on AR-positive vs. counterstained cells. Germ-to-Sertoli cells ratio (GSR) was calculated dividing the total number of germ cells by the total number of Sertoli cells within a seminiferous tubule section. Mean of all GSR were determined for each testicle, and the results of each technique were compared using the correlation procedure of SAS (SAS Inst. Inc., Cary, NC). Differences were considered significant when $P < 0.05$. A positive correlation ($r = 0.58$) was observed ($P = 0.0015$) between GSR obtained via HE and ARIF. In addition, a positive correlation ($r = 0.686$) was observed between GSR

obtained via FNA-F and FNA-G techniques ($P = 0.001$). No significant correlations were observed ($P \geq 0.366$), however, between GSR obtained via FNA (3.60 ± 0.47 and 3.59 ± 0.39 for FNA-F and FNA-G, respectively) and from tissue cuts (5.27 ± 0.41 and 4.44 ± 0.59 for HE and ARIF, respectively). The immunohistochemistry fluorescent method against AR we evaluated was a specific and novel tool for determining Sertoli cell populations in peripubertal bulls.

**Key Words:** androgen receptors, Sertoli, techniques
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**314 Physiological adaptations in the gastrointestinal tract detected by a fecal RNA method and blood inflammatory biomarkers in neonatal dairy calves undergoing a mild diarrhea.**

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Diarrhea is a major cause of morbidity and mortality in dairy calves less than 1 mo old. Exfoliated gastrointestinal epithelial (EGE) cells isolated from fecal samples of neonatal dairy calves could be used to study transcriptional changes in the gastrointestinal (GI) tract due to nutrition or physiological adaptations to diarrhea. Eight newborn male Jersey calves were used from birth to 5 wk of age and housed in individual pens at the Oregon State University Dairy Center. After birth, calves received 1.9 L of colostrum from their respective dams. Calves had ad libitum access to water and starter grain and were fed twice daily a total of 5.6 L whole milk. Blood samples were collected weekly for inflammatory profiling from wk 0 to 5. Fecal score (FS) was recorded daily throughout the experiment. Fresh fecal samples were collected weekly for RNA isolation from EGE for RT-qPCR analysis. Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Orthogonal contrasts were used to evaluate linear or quadratic effects over time. Statistical significance and tendencies were declared at $P < 0.05$ and $P \leq 0.15$, respectively. Fecal score increased over time ($P < 0.01$), with a maximal (2.6 ± 0.3) score at wk 2. The blood inflammatory biomarkers ceruloplasmin and haptoglobin had a time effect ($P \leq 0.05$) that was reflected in a positive quadratic effect ($P \leq 0.04$) over time. A trend ($P = 0.10$) for a time effect on IL-6 was observed, which was explained by a positive quadratic effect ($P = 0.01$) over time. The concentration of serum amyloid A decreased ($P < 0.01$) over time. The mRNA expression of proinflammatory related genes *TLR4*, *TNFA*, *IL8*, and *IL1B* had a time effect ($P < 0.01$), where a positive quadratic effect ($P = 0.05$) was observed for all. A trend for a time effect was observed for *NFKB1* expression ($P = 0.07$), where this expression linearly increased ($P = 0.04$) over time. A time effect ($P \leq 0.04$) was observed for the cell membrane transporters *SLC5A1* and *AQP3*, where both genes expressed a negative quadratic effect ($P \leq 0.05$) over time. Overall, these data provide evidence for the use of the fecal RNA method as a tool to evaluate transcriptomic changes in the GI tract of dairy calves experiencing scours, and also, such a method could shed light in the molecular adaptations of the GI tract to dietary effects.

**Key Words:** dairy calves, gut health, transcriptional changes
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**315 Immunomodulation in heifers fed endophyte-infected tall fescue seed.**

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Effects of heat stress and endophyte-infected fescue seed consumption on changes in cell-mediated immune function were measured by interferon-γ (IFN-γ) production using flow cytometry. Twelve Angus heifers (285 ± 28 kg) were randomly assigned to individual stalls for 11 wk and assigned to either an endophyte-infected (E+; 10 μg ergovaline + ergovalinine/kg BW) or endophyte-free (E–) diet fed at 1.8 × NEm. Diets contained 12.5% fescue seed, 30.1% cottonseed hulls, 39.0% cracked corn, 12.7% supplement, 4.7% molasses, and 1.0% MGA (0.5 mg/heifer per day) and met protein and mineral requirements. Weekly 45-mL blood samples were collected from each heifer. Heifers were adapted to pens for 3 wk at thermoneutral temperatures and fed the E– diet, with samples collected during this period used as covariates. Phase 1 (P1) included 1 wk of heat stress with all animals on the E– diet. Heat stress periods consisted of cycling ambient temperature between 32 (daytime) and 22°C (nighttime). Treatment diets were applied during Phase 2 (P2; 3 wk) with continued heat stress exposure. All heifers were fed the E– diet and returned to thermoneutral temperatures during Phase 3 (P3). Peripheral blood mononuclear cells (PBMC) were isolated from each sample and counted. Peripheral blood mononuclear cells were then plated in 24-well plates, stimulated and stained for IFN-γ, and then analyzed using flow cytometry to determine the percentage of cells producing IFN-γ and the mean fluorescence intensity (MFI), or amount of production per cell, of IFN-γ. No differences due to treatment, covariate, or interactions were observed during P1. Percent cells producing IFN-γ and IFN-γ MFI decreased across P1 ($P < 0.02$). The E+ heifers had a lower ($P = 0.02$) percentage of cells producing IFN-γ during P2. Significant ($P \leq 0.02$) covariate effects were found for IFN-γ MFI (P2) and percentage of cells producing IFN-γ (P3), with higher baseline values associated with increased production for both. A treatment × covariate interaction occurred during P3 for IFN-γ MFI, with no treatment difference

with low baseline production and increased production for E+ heifers at higher covariate values ($P = 0.05$). Time effects ($P \leq 0.01$) were observed for IFN-γ MFI (P2) and percentage of cells producing IFN-γ (P3). Interferon-γ MFI increased over the first week and decreased during the second week of P2, whereas the percent of cells producing IFN-γ increased across P3. These data indicate that endophyte may have immunosuppressive effects during heat stress periods with evidence of an increase in IFN-γ MFI after removal of stressors.

**Key Words:** endophyte, heifer, peripheral blood mononuclear cells
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**316 Comparison of two alternate prostaglandin $F_{2\alpha}$ products in yearling beef heifers.** A. C. Lansford*, T. L. Meyer, R. N. Funston, *University of Nebraska, West Central Research and Extension Center, North Platte*.

Yearling Angus-based heifers managed at 2 locations were used to evaluate the efficacy of 2 alternate $PGF_{2\alpha}$ (Lutalyse vs. Lutalyse HighCon) products. Heifers at location 1 ($n = 100$; 340 ± 3 kg; L1) were managed at West Central Research and Extension Center near North Platte, NE. The second location was the Kelly Ranch, near Sutherland, NE ($n = 90$; 326 ± 4 kg; L2). All females were offered 0.5 mg/heifer melengestrol acetate for 14 d. On d 33, heifers received either 5 mL intramuscular Lutalyse (5 mg/mL dinoprost tromethamine; LL) or 2 mL *subcutaneous* Lutalyse HighCon (12.5 mg/mL dinoprost tromethamine; HC). Estrus detection aids, or patches, were applied at $PGF_{2\alpha}$ injection. Heifers were artificially inseminated 12 h after detection of estrus. Heifers not expressing estrus at L1 were given a second $PGF_{2\alpha}$ injection 6 d after initial injection and placed with bulls. At L2, heifers not expressing estrus were artificially inseminated at 96 h after $PGF_{2\alpha}$ injection and given 2 mL intramuscular Factrel (50 μg/mL gonadorelin hydrochloride). Bulls were placed with artificially inseminated heifers 10 d after last AI for 60 and 40 d for L1 and L2, respectively. Percentage of heifers exhibiting estrus during the estrus detection period was similar ($P = 0.40$) between treatments (82 vs. 87 ± 4% for LL and HC, respectively). Timing of estrus was also similar ($P \geq 0.15$), with the percentage of heifers exhibiting estrus ≤60 h after $PGF_{2\alpha}$ injection being 48 vs. 59 ± 5% for LL and HC, respectively, 22 vs. 16 ± 4% for LL and HC, respectively, at 72 h, and 70 vs. 75 ± 5% for LL and HC, respectively, at ≤72 h. Heifer BW at first pregnancy diagnosis was 386 and 397 ± 4 kg for L1 and, L2, respectively. Pregnancy was diagnosed via ultrasonography 51 and 57 d after initial $PGF_{2\alpha}$ injection for L1 and L2, respectively. Pregnancy by AI was similar ($P = 0.62$; 60 vs. 65 ± 5% for LL and HC, respectively), as was final pregnancy rate ($P = 0.11$; 93 vs. 98 ± 3% for LL and HC, respectively), which was determined 78 and 50 d after initial pregnancy diagnosis for L1 and, L2, respectively. Heifer BW at second pregnancy diagnosis was 421 and 427 ± 14 kg for L1 and L2, respectively. Treatment did not influence ($P > 0.33$) final BW or ADG. In summary, the 2 concentrations and corresponding administration routes of $PGF_{2\alpha}$ were similar in efficacy in synchronizing estrus in yearling beef heifers.

**Key Words:** beef heifer, estrus synchronization, prostaglandin $F_{2\alpha}$
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**317 Investigation of ovarian reserve parameters in *Bos indicus* cows.** A. L. Patterson[1,*], J. Beard[2], M. C. Herrington[3], S. L. Rosasco[3], E. M. Soares[4], E. J. Northrop[5], E. L. Larimore[6], J. J. J. Rich[5], O. L. Amundson[6], A. K. McNeel[1], C. C. Chase, Jr.[1], G. A. Perry[5], A. F. Summers[3], R. A. Cushman[1], *[1]USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, [2]New Mexico State University, Las Cruces, [3]Animal and Range Science Dep., New Mexico State University, Las Cruces, [4]Federal University of Santa Maria, Santa Maria, Brazil, [5]Department of Animal Science, South Dakota State University, Brookings, [6]South Dakota State University, Brookings*.

Beef heifers that give birth within the first 21 d of their first calving season have greater lifetime productivity and longevity. A favorable relationship exists between the number of antral follicles detectable by ultrasonography and calving date in beef heifers, indicating greater lifetime fertility in cows with more antral follicles. In contrast, *Bos indicus* cows have more surface antral follicles than *Bos taurus* cows but exhibit no advantage in fertility. Prior studies demonstrated that despite having more antral follicles, *Bos indicus* cows have equal numbers of primordial follicles per ovary as *Bos taurus* cows. *Bos indicus* cows do have heavier ovaries with more stromal tissue than *Bos taurus* cows. This study served to further compare preantral follicle populations between *Bos indicus* and *Bos taurus* cows to test the specific hypothesis that number of primordial follicles per gram of ovarian tissue are decreased in *Bos indicus* cows compared with *Bos taurus* cows. Ovaries were collected from *Bos indicus* cows ($n = 7$) and *Bos taurus* cows ($n = 42$), weighed, fixed, and sectioned for histological evaluation to determine the number of primordial, primary, and secondary follicles per ovary. The total number of follicles per ovary was divided by the weight of the ovary to determine the number of follicles per gram of ovarian tissue. Data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) with species as a class effect. Ovaries from *Bos indicus* cows were heavier than ovaries from *Bos taurus* cows (12.6 ± 1.1 vs. 7.0 ± 0.5 g, respectively; $P < 0.01$). No difference was found between *Bos indicus* and *Bos taurus* cows in the number of primordial follicles per ovary ($P = 0.64$); however, *Bos indicus* cows had a greater number of primary and secondary follicles per ovary ($P < 0.01$). Upon being adjusted for ovarian weight, *Bos indicus* cows tended to have fewer

primordial follicles per gram of ovary than *Bos taurus* cows ($P = 0.06$) but still had greater numbers of primary follicles per gram of ovary ($P < 0.01$). This suggests that the mechanisms controlling primordial follicle activation are different between *Bos indicus* and *Bos taurus* cows. From these results, we conclude that *Bos indicus* cows do not display enhanced fertility over *Bos taurus* cows because despite having more antral follicles, *Bos indicus* cows do not have larger ovarian reserves in comparison to the size of their ovaries. The USDA is an equal opportunity provider and employer.

**Key Words:** *Bos indicus*, folliculogenesis, ovarian reserves
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**318 Impact of dietary fatty acid source on ovarian phosphatidylinositol-3 kinase signaling.**

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The ovarian phosphatidylinositol-3 kinase (PI3K) pathway regulates follicle viability, entry of primordial follicles into the growing follicular pool, and steroidogenesis via phosphorylation of AKT (pAKT). Furthermore, ovarian intracellular signaling and function have been demonstrated to be altered by high-fat diet (HFD) feeding. High-fat diet feeding also alters gut microbiota populations in favor of an increase in Gram-negative strains, which are implicated in subsequent metabolic endotoxemia and PI3K signaling. Metabolic endotoxemia is characterized by increased circulating low levels of lipopolysaccharide (LPS), a component of Gram-negative bacterial cell walls. Lipopolysaccharide interacts with its receptor, toll-like receptor 4 (TLR4), at the cellular level, to initiate a signaling cascade that culminates in phosphorylation and activation of nuclear factor kappa B. Lipopolysaccharide and TLR4 can signal via the PI3K pathway; therefore, we hypothesized that HFD feeding could lead to alterations in basal ovarian intracellular signaling in swine. Using the pig as an agrimedical model, we sought to determine if HFD or dietary fatty acid composition would alter ovarian PI3K signaling. Thirty-six postpubertal gilts (56 ± 6.5 kg BW) were fed 1 of 3 diets for 9 wk. The diets consisted of 1) low fat (LF; $n = 12$; 20% calories coming from lard and soybean oil), 2) high fat (HF; $n = 12$; 40% calories coming from lard and soybean oil), or 3) *n*-3 high fat (n3HF; $n = 12$; 40% calories coming from menhaden fish oil, lard, and soybean oil). All diets were formulated to be isocaloric and isonitrogenous, and pigs were fed 2.8 times maintenance and this was adjusted weekly for 9 wk. At the end of the feeding period, all pigs were euthanized and ovaries were collected for quantification of proteins implicated in LPS signaling (TLR4) and follicle viability (AKT, pAKT, histone 4 lysine 5 acetylated [H4K5ac], and histone 4 lysine 20 methylated [H4K20me]) by Western blot. There was no treatment-induced difference in the abundance of H4K5ac, H4K20me, TLR4, or AKT. However, ovarian pAKT abundance tended to be reduced ($P < 0.1$) between the LF and n3HF groups compared with the HF diets. The n3HF diet also decreased ($P < 0.05$) the ratio of pAKT:AKT protein by 43% compared with the LF diet. These data support an influence of diet composition on ovarian PI3K that could translate to effects on follicle viability and growth activation, which could, in turn, have consequences for fertility in swine fed altered dietary fatty acid sources.

**Key Words:** dietary fatty acids, ovary signaling, phosphatidylinositol-3 kinase
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**319 Withdrawn**

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**320 The effect of vitamin A administration on testicular development in peripubertal bulls.**

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The establishment of the final number of Sertoli cells in the calf testicle determines daily sperm production in the bull. Retinoic acid (RA) has been described as one of many factors having an effect on Sertoli cell proliferation. Fourteen Angus and Shorthorn bulls (287 ± 3.3 d of age; 310 ± 10 kg) were randomly assigned to 1 of 2 treatments: 1) intramuscular injection of 1 million IU vitamin A (Vit A) or 2) no treatment (Control). Scrotal circumference (SC) was measured in all bulls at the time of the treatment application and 11 d later at castration. Weight of the testes and epididymis were obtained, and samples of parenchyma were collected from each testicle. Samples were fixed in formaldehyde, embedded in paraffin, and cut into 5-µm sections. Slides were deparaffinized with successive washes of xylene and alcohol. After antigen retrieval and blocking with 10% normal goat serum, sections were sequentially incubated with mouse monoclonal anti-androgen receptor antibody (AR441), ab9474 (Abcam, Cambridge, MA), and CF633 Goat Anti-Rabbit IgG (H+L) fluorescent stain (Biotium, Fremont, CA). Samples were examined under a fluorescent microscope, and the images were captured with a digital camera and processed using Image-Pro Plus software. Effects of Vit A treatment on SC, testicular weight, testicular parenchyma weight and epididymis weight, number of Sertoli cells, germ cell, and ratio of germ cells to Sertoli cells within the seminiferous tubule (ST) were analyzed using the ANOVA procedure of SAS (SAS Inst. Inc., Cary, NC). No differences were observed among treatments for SC (1.63 ± 0.26 vs. 2.17 ± 0.17 cm; $P = 0.135$), testicular weight (228.17 ± 17.00 vs. 221.79 ± 24.98 g; $P = 0.575$), testicular parenchyma weight (141.02 ± 11.82 vs. 131.46 ± 14.49 g; $P = 0.615$), epididymis weight (12.01 ± 1.10 vs. 9.43 ± 1.01 g; $P = 0.109$), number of Sertoli cells/ST (45.56 ± 3.14 vs. 48.04 ± 2.18; $P = 0.557$), number of germ cells/ST (217.29 ± 26.83 vs. 156.04 ± 16.75; $P = 0.100$), and the germ-to-Sertoli cell ratio (5.03 ± 0.93 vs. 3.30 ± 0.43; *P*

= 0.158) for vitamin A and control, respectively. Within the confines of the current experiment, vitamin A has no effect on fertility when administered in peripubertal bulls.

**Key Words:** bulls, retinoic acid, Sertoli
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**321 Effect of injectable trace mineral on reproductive performance in beef heifers.** S. A. Springman[1,*], J. G. Maddux[2], M. E. Drewnoski[3], R. N. Funston[1], *[1]University of Nebraska, North Platte, [2]Maddux Ranches, Wauneta, NE, [3]University of Nebraska-Lincoln, Lincoln*.

Red Angus–based, May-born heifers ($n$ = 799) at 2 locations were used to determine the effects of an injectable trace mineral on reproductive performance. Heifers were managed at the Maddux ranch near Wauneta, NE. Following weaning in October, heifers were backgrounded in a feedlot until a BW of 295 kg was reached and then moved to graze native range at location 1 (L1; $n$ = 125) or location 2 beginning in early March (L2; $n$ = 286). A subset of heifers ($n$ = 388) grazed corn residue with cows over winter, were weaned in April, and were backgrounded in a feedlot until target weight was attained and then transported to L1 and L2 finishing in early June. Heifers were offered free choice mineral at both locations. Initial mineral status was analyzed via liver biopsy prior to mineral treatment ($n$ = 22; 307 kg). Initial liver concentrations of copper (146 μg/g), manganese (9.22 μg/g), selenium (1.54 μg/g), and zinc (115 μg/g) were adequate and not different ($P$ > 0.26) among heifers managed at the 2 overwinter locations. Heifers were synchronized with a 14-d CIDR-prostaglandin $F_{2\alpha}$ protocol and either injected with a trace mineral (5 mL; MULTIMIN; $n$ = 399) or received no injection (CON; $n$ = 400) the day of CIDR insertion. Fertile bulls were placed with heifers on range for 60 d following AI. Pregnancy diagnosis was determined via transrectal ultrasonography 61 d after AI. Heifer BW at pregnancy diagnosis was 333 and 342 kg for L1 and L2, respectively. The proportion of heifers pregnant within the first 21 d of the breeding season was not different ($P$ = 0.32; 69 vs. 62 ± 3% for CON and MULTIMIN, respectively) nor was the proportion pregnant within the first 33 d ($P$ = 0.57; 86 vs. 77 ± 2% for CON and MULTIMIN, respectively). Bulls remained with heifers at initial ultrasound; therefore, a second pregnancy diagnosis was performed 30 d later. Overall pregnancy rates were also not different ($P$ = 0.38; 95 vs. 93 ± 1% for CON and MULTIMIN, respectively). In summary, injectable trace mineral at CIDR insertion did not influence heifer reproductive performance in heifers with adequate trace mineral status.

**Key Words:** beef heifers, injectable trace mineral, reproduction
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**322 Plasma acyl ghrelin and nonesterified fatty acids are the best indicators for hunger status in pregnant gilts.** P. Ren[*], X. Yang, J. Kim, D. Menon, D. Pangeni, H. Manu, A. Tekeste, S. K. Baidoo, *Southern Research and Outreach Center, University of Minnesota, Waseca*.

In the present study, 3 different feeding levels were used to create different hunger statuses in pregnant gilts. Plasma hormones related to energy homeostasis and NEFA were analyzed to quantify their response to different feeding levels. A total of 18 gilts fitted with permanent cephalic vein catheters were allotted to 1 of 3 dietary treatments using a completely randomized design. All gilts were fed one common corn–soybean meal–based diet, with the amount being 1.0 × maintenance energy intake (100 × BW $[BW]^{0.75}$ kcal ME/d) throughout gestation except 3 periods of 7 d when dietary treatments were imposed on d 27, 55, and 83 of gestation. During the 3 short periods, sows were fed 1 of 3 different feeding levels: 0.5, 1.0, and 2.0 × maintenance energy level (0.5M, 1.0M, and 2.0M, respectively). During period 1 (d 27–34), serial blood samples were collected at the last day after the 6-d adaptation. Results showed that during gestation period 1, BW and backfat (BF) changes were higher ($P$ < 0.01) for gilts on the 2.0M feeding level than for gilts on the 0.5M feeding level. Plasma ghrelin concentrations showed a relatively flat pattern during the 24-h period. Generally, plasma ghrelin and NEFA concentrations and the area under curves (AUC) were greater ($P$ < 0.05) in gilts on the 0.5M feeding level than in those on the 2.0M feeding level. Additionally, consumption time for 1.82 kg feed at d 35 of gestation was longer ($P$ < 0.01) in gilts fed the 2.0M feeding level during d 27 to 34 of gestation than in those on the 0.5M feeding level. Simple linear regression results showed that AUC of acyl ghrelin was the best predictor for prediction of consumption time, whereas AUC of NEFA was the best predictor for prediction of BW or BF change during d 27 to 34 of gestation. In conclusion, our data suggested that a relative flat pattern existed in pregnant gilts in terms of diurnal plasma profile of acyl ghrelin and that feed intake of pregnant gilts was negatively correlated with plasma concentrations of acyl ghrelin and NEFA, which, in turn, were negatively associated with feed consumption time. The AUC of acyl ghrelin and NEFA seemed to be the best predictors for hunger status of pregnant gilts. This study provided insight to evaluate the hunger status in pregnant sows, which could be used as a reference to improve the welfare of gestation sows.

**Key Words:** acyl ghrelin, hunger status, nonesterified fatty acids
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**323 Effects of supplemental citrulline on intestinal neutrophil infiltration during heat stress and nutrient restriction in growing pigs.** S. K. Kvidera[1,*], E. A. Horst[1], E. J. Mayorga Lozano[2], J. T. Seibert[1], M. A. Al-Qaisi[1], J. W. Ross[1], R. P. Rhoads[3], L. H. Baumgard[1], *[1]Iowa State University, Ames, [2]Department of Animal Science, Iowa State University, Ames, [3]Virginia Tech, Blacksburg*.

Heat stress (HS) and nutrient restriction impair intestinal barrier function and allow passage of endotoxin into portal and, ultimately, systemic circulation. Earlier data from the present study indicated citrulline supplementation improves intestinal morphology in the ileum during HS. Current objectives were to determine how citrulline supplement affects neutrophil infiltration in intestinal mucosa during HS. Supplements were fed twice daily at 0600 and 1800 h and consisted of 20 g of cookie dough without citrulline (CON) or with 0.13 g/kg BW L-citrulline (CIT; 99.3% purity; MP Biomedicals, Santa Ana, CA). Forty crossbred gilts (30 ± 2 kg) were assigned to 1 of 5 supplemental–environmental treatments: 1) thermoneutral (TN; 23.6 ± 0.1°C) ad libitum feed (AL) with CON (TNAL; $n$ = 8), 2) TN pair-fed (PF) with CON (PF-CON; $n$ = 8), 3) TN PF with CIT (PF-CIT; $n$ = 8), 4) HS AL with CON (HS-CON; $n$ = 8), and 5) HS AL with CIT (HS-CIT; $n$ = 8). Acclimation lasted 4 d, and all pigs received the CON supplement. During period 1 (P1; 7 d), pigs were kept in TN, fed AL, and fed their respective supplemental treatments. During period 2 (P2; 60 h), HS-CON and HS-CIT animals were fed AL and exposed to cyclical HS (33.6 to 38.3°C) whereas TNAL, PF-CON, and PF-CIT animals remained in TN and were fed either AL or PF to their HS counterparts to negate the effect of dissimilar nutrient intake. Animals were sacrificed following P2, and segments of the jejunum, ileum, and colon were collected and analyzed for morphology and were stained for myeloperoxidase (a measure of neutrophil infiltration). There were no treatment differences on neutrophil infiltration in the jejunum. Pigs exposed to HS tended to have increased ileum neutrophil infiltration relative to TNAL controls (30%; $P = 0.09$) but did not differ from PF animals. Interestingly, PF-CON pigs had increased ileum neutrophil infiltration relative to TNAL and PF-CIT pigs (49 and 63%, respectively; $P \leq 0.02$). In the colon, HS increased neutrophil infiltration 62% ($P = 0.02$) relative to TNAL controls, but this did not differ from PF-CON pigs, as colon neutrophil infiltration was also increased in PF-CON relative to TNAL and PF-CIT pigs (64 and 108%, respectively; $P \leq 0.03$). There was no effect of citrulline supplementation in HS animals in any intestinal segment measured. In summary, HS and nutrient restriction increase neutrophil infiltration in the distal gastrointestinal tract. Supplemental citrulline does not diminish this immune response during HS but does ameliorate it under nutrient-restriction conditions.

**Key Words:** citrulline, heat stress, nutrient restriction
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**324 Diurnal ambient temperature variations in warm climate regions affect the serum concentrations of free amino acids in growing pigs.** A. Morales, N. Ibarra, S. Espinoza, F. Reyes, E. Avelar, R. L. Camacho, M. Cervantes Ramírez*, *ICA-Universidad Autónoma de Baja California, Mexicali, Mexico*.

Ambient temperature (AT) changes dramatically within a 24-h period in areas where it is above the thermoneutral (TN) zone of pigs. Usually, morning AT is close to the pig TN zone but afternoon AT causes heat stress (HS). These changes may affect the absorption and metabolism of AA. The serum concentration (SC) of free AA during the absorptive and postabsorptive phases reflects their absorption and cellular metabolism, respectively. Therefore, an experiment was conducted to analyze the SC of free AA in pigs exposed to the morning comfort-like AT or the afternoon HS conditions. Six pigs (Landrace–Hampshire–Duroc; 27.1 ± 1.3 kg initial BW) were used. A thermometer was subcutaneously implanted to register body temperature (BT) at 15-min intervals; AT was also recorded during the 14-d study. Blood samples were collected on the last 3 d of the experiment, at 0600 (preprandial and lowest AT), 1200 (5 h postprandial and mild HS), and 1600 h (9 h postprandial and severe HS). The pigs received the same amount (1.2 kg/d) of an AA-supplemented, wheat–soybean meal diet, in 2 equal meals (0700 and 1900 h). The temperatures registered at 0600, 1200, and 1600 h were 30.6, 39.0, and 41.1°C, respectively, for AT and 38.3, 39.8, and 40.3°C, respectively, for BT. The BT was highly ($r = 0.92$) and significantly ($P < 0.001$) correlated with AT. The SC ($\mu M$/mL) at 0600, 1200, and 1600 h were 0.179, 0.208, and 0.174, respectively, for Arg; 0.065, 0.068, and 0.063, respectively, for His; 0.090, 0.116, and 0.101, respectively, for Ile; 0.135, 0.138, and 0.125, respectively, for Leu; 0.052, 0.129, and 0.096, respectively, for Lys; 0.025, 0.029, and 0.026, respectively, for Met; 0.078, 0.092, and 0.074, respectively, for Phe; 0.116, 0.142, and 0.114, respectively, for Thr; 0.028, 0.027, and 0.026, respectively, for Trp; and 0.205, 0.245, and 0.224, respectively, for Val. Serum Ile, Lys, Met, Val, Ala, Asn, and Pro were higher ($P \leq 0.01$) and Arg, Phe, Glu, and Tyr tended to be higher ($P \leq 0.10$) but Cys was lower ($P < 0.05$) at 1200 h than at 0600 h. Lysine was higher, Cys and Tyr were lower ($P < 0.05$), and Ile and Val tended to be higher ($P \leq 0.10$) at 1600 h than at 0600 h. Serum Arg, Ile, Phe, Ala, Asn, Gln, Pro, Ser, and Tyr were lower ($P < 0.05$) and Leu and Val tended to be lower at 1600 h than at 1200 h. These data indicate that AT directly modifies the BT and that diurnal variations in AT differently affect the daily absorption and utilization of AA in pigs exposed to comfort-like AT and HS conditions.

**Key Words:** amino acids, heat stress, pigs
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**325 Effects of zinc amino acid complex on biomarkers of gut integrity and metabolism during heat stress and a following recovery period in growing pigs.**

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Study objectives were to determine the effects of zinc AA complex (ZnAA; Zinpro Corporation, Eden Prairie, MN) on metabolism, biomarkers of leaky gut, and inflammation in heat-stressed and nutrient-restricted pigs. Crossbred gilts ($n$ = 50; 50 ± 2 kg BW) were blocked by initial BW and randomly assigned to 1 of 5 treatments: 1) thermoneutral (TN) ad libitum control diet (TNCtl), 2) TN pair-fed control diet (PFCtl), 3) TN pair-fed zinc diet (PFZn), 4) heat-stress (HS) ad libitum control diet (HSCtl), and 5) HS ad libitum zinc diet (HSZn). The study consisted of 3 experimental periods (P): during P1 (7 d), all pigs were fed their respective diets ad libitum and housed in TN conditions (20.84 ± 0.03°C and 47.11 ± 0.42% RH). During P2 (7 d), HSCtl and HSZn pigs were exposed to progressive cyclical HS conditions (27 to 30°C and 41.9 ± 0.5% RH), whereas the TNCtl, PFCtl, and PFZn pigs remained in TN conditions and were fed ad libitum or pair fed to their HSCtl and HSZn counterparts. During P3 (7 d), all pigs were kept in TN conditions and fed ad libitum. Pigs exposed to HS had an overall increased rectal temperature, skin temperature, and respiration rate (0.33°C, 3.76°C, and 27 bpm, respectively; $P < 0.01$). Heat stress decreased ADFI and ADG relative to TN controls (1.79 vs. 2.48 kg/d and 0.60 vs. 0.92 kg, respectively; $P < 0.05$), but these variables were unaffected by dietary treatment. Circulating insulin levels were decreased in the PF pigs relative to TN and HS pigs ($P = 0.03$), and plasma NEFA levels were increased in Zn-fed pigs relative to Ctl-fed pigs ($P = 0.03$). During recovery, no differences were observed in rectal temperature or respiration rate across treatments, but HSZn pigs had decreased skin temperature relative to TN, PF, and HSCtl pigs ($P < 0.01$). During P3, no effects of ZnAA were observed in production parameters; however, PF pigs had increased ADFI and ADG relative to TN and HS treatments ($P < 0.01$). During P3, circulating insulin levels were increased in pigs that were in HS relative to TN and PF pigs (75%; $P < 0.05$); furthermore, blood glucose tended to be increased in Zn-fed pigs relative to Ctl-fed pigs ($P = 0.07$). Interestingly, plasma TNFα levels tended to be decreased during P1 ($P = 0.08$) and were decreased during P3 ($P = 0.04$) in Zn-fed pigs relative to Ctl-fed pigs. Circulating lipopolysaccharide binding protein was not different among periods ($P > 0.10$). In summary, ZnAA appeared to reduce TNFα (regardless of HS) and the stimulatory effect of HS on insulin secretion is amplified during HS recovery.

**Key Words:** heat stress, inflammatory biomarkers, intestinal integrity

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**326 Evaluation of a quantitative trait loci for porcine circovirus type 2b viral load on long-term growth performance and nutrient digestibility in inoculated or vaccinated pigs for porcine circovirus type 2b.**

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A previous experiment evaluated pigs selected for a porcine circovirus type 2b (PCV2)-susceptibility marker QTL (C, resistant, and T, susceptible) and were inoculated (PCV) with or vaccinated (VAC) against PCV2 in the nursery phase. Pigs genotyped for the C allele had reduced viremia and IgG production compared with the T allele when infected with PCV. Two experiments were conducted to evaluate growth performance through the finishing phase. A model was used to assess the residual between final and predicted BW on pigs from the previous trial. Pigs with a low or high net residual were used for Exp. 1 or Exp. 2, respectively. In Exp. 1, a total of 40 pigs (38.5 kg; 8 pigs/treatment) were selected from (genotype-PCV status) CC-PCV, CT-PCV, TT-PCV, CT-VAC, and TT-VAC. Pigs were housed by treatment, with 2 pigs per pen and 4 pens per treatment. In Exp. 2, 4 pigs from each residual, high (41.9 kg BW) and low (30.2 kg BW), were selected from the following (genotype-PCV status): CT-PCV, TT-PCV, CT-VAC, and TT-VAC, for a total of 32 pigs, individually housed. All pigs had ad libitum access to a 4-phase grow–finish corn–soybean meal diet that met or exceeded the NRC (2012) requirements, with titanium dioxide as an indigestible marker. Growth performance was measured every 14 d, whereas blood and fecal samples were collected at the end of each phase. Loin eye area and backfat were determined via ultrasound at the end of phase 4, and HCW was determined at harvest. For Exp. 2, data was analyzed using initial BW as a covariate. In Exp. 1, ADFI in phase 1 was reduced in the CC-PCV group compared with the TT-PCV group ($P < 0.05$). In phase 3, ADFI was reduced in the VAC group compared with the PCV group ($P < 0.05$). In phase 1 thru 3, digestibility of GE and DM were greater in the CC-PCV group compared with the TT-PCV group ($P < 0.05$). In Exp. 2, low residual pigs had greater G:F during the phases 2 and 3 ($P < 0.05$). No differences were found for GE and DM digestibility between groups ($P > 0.10$). Pigs with the CT genotype were found to have less backfat ($P < 0.10$) and greater lean ($P < 0.05$) and percent lean ($P < 0.05$) than those with TT genotype with no difference in BW. Together, these data suggest that the PCV2-susceptibility marker genotype may affect ADFI, nutrient digestibility, and carcass traits during the growing–finishing period.

**Key Words:** digestibility, pig, porcine circovirus type 2b

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**327 A humanized gnotobiotic piglet model to study host–microbiota interactions.** N. D. Aluthge*, W. Tom, T. E. Burkey, P. S. Miller, D. E. Hostetler, K. D. Heath, C. Kreikemeier, S. C. Fernando, *University of Nebraska-Lincoln, Lincoln*.

During the past decade, studies using culture-independent DNA sequencing–based approaches have found associations between the gut microbiota and several human disease conditions such as obesity, diabetes, allergies, etc. Many of these studies have used mouse models as surrogates for humans; however, there are marked differences between humans and mice in terms of anatomy, physiology, and immune system, which may confound the translation of these findings to humans. The domestic pig (*Sus scrofa*) shares a high degree of anatomical, physiological, and immunological similarities with humans; therefore, the pig is a valuable model for human gut microbiota studies. This study was conducted with the objective of establishing human gut–associated microbial communities in gnotobiotic piglets to develop a new model to investigate how microbial gene expression influences host metabolism by continuous sampling of the microbiome. Twenty germ-free piglets derived using cesarean section were "humanized" by inoculation with human fecal matter obtained from "obese" (BMI > 30 kg/m$^2$) and "lean" (BMI < 25 kg/m$^2$) individuals and were maintained in germ-free isolators. At 7 to 8 wk of age, 5 of these piglets were cecum cannulated within sterile surgery bubbles. Fecal samples were collected weekly from all piglets throughout the study whereas cecal samples were collected through the cannulae of the cannulated piglets at weekly time intervals during the final 3 wk of the study. The study period was 8 wk for the noncannulated piglets, whereas the cannulated piglets were studied for 10 wk. All fecal and cecal samples were subjected to 16S rRNA gene-based amplicon sequencing using the Illumina MiSeq platform to characterize their bacterial community composition. Comparison of the fecal and cecal bacterial communities of the "humanized" piglets with those of conventional pigs revealed that the "humanized" piglet microbiota was more similar to a human microbiota than to a swine microbiota ($P < 0.001$). No adverse health effects were observed in the cannulated piglets as a result of the cannulation procedure. Currently, work is being performed to investigate the influence of the microbiota on host gene expression using a transcriptome-based approach, evaluating the interaction between the cecal microbiota and the host gut epithelium.

**Key Words:** gnotobiotic piglet model, microbiota, next-generation sequencing
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**328 Ex vivo translocation of *Escherichia coli* F18 in the pig ileum that was challenged with norepinephrine or adrenocorticotropic hormone compared with controls.** S. M. Curry*, E. R. Burrough, N. K. Gabler, *Iowa State University, Ames, IA*.

Rearing stresses induced by pathogens, weaning, or out of feed events may make pigs more susceptible to bacterial infections. One proposed mechanism is through the increased activation of the hypothalamic–pituitary axis and the production of adrenocorticotropic hormone (ACTH) or norepinephrine (NorE). Previous studies have shown that luminal catecholamines have modulated bacterial growth and expression of virulence associated factors. To study the effect of ACTH and NorE, we used an F18 *Escherichia coli* transfected with a red florescent protein (RFP) plasmid, which carries ampicillin resistance, to assess bacterial growth in vitro and tissue translocation in an ex vivo intestinal model. We hypothesized that NorE or ACTH would increase pathogenic *E. coli* proliferation and translocation in the ileum of pigs. We evaluated *E. coli* translocation in ex vivo ileum explants when the tissue was incubated with Krebs buffer (Control), 10 μ*M* NorE, or 0.01 μ*M* ACTH in modified Ussing chambers. Prior to our ex vivo studies, 6-well plates containing MacConkey agar with ampicillin containing 0 and 0.01 μ*M* ACTH or 0 and 10 μ*M* NorE were each inoculated with 300 cfu of RFP-*E. coli.* After 24 h of incubation, cfu where assessed. There was an increase ($P < 0.01$) in cfu due to NorE (253 cfu)-treated wells compared with Control (227 cfu) but due to ACTH (233 cfu) treatment. Next, we studied the effect of 0.01 μ*M* ACTH and 10 μ*M* NorE in ex vivo conditions using 8 pigs at approximately 8 wk of age that were fed a common diet for 5 wk. Pigs were euthanized, and ileum sections were flushed and collected. Treatments were applied to serosal chamber in modified Ussing chambers: 1) Control, 2) 0.01 μ*M* ACTH, and 3) 10 μ*M* NorE. Each pig ileum section was represented in each of the 3 treatments. After a 20-min incubation period, $3 \times 10^8$ cfu/mL RFP-*E. coli* was administered to each mucosal chamber. After 60 min, aliquots were taken from serosal chamber and plated, and cfu were determined after 24 h. Ileum samples that were incubated with ACTH (7,012 cfu) or NorE (2,883 cfu) had greater ($P = 0.003$) translocation of RFP-*E. coli* compared with Controls (207 cfu) but were not different from each other. These data indicate that ACTH or NorE can increase ex vivo translocation of RFP-*E. coli* in the ileum and may partially explain the mechanism in which stress increases susceptibility to bacterial infections.

**Key Words:** bacterial translocation, catecholamines, pig
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**329 Characterizing the effects of acute and chronic heat stress on porcine ovarian function.** M. J. Dickson*, J. Nteeba, K. L. Bidne, B. J. Hale, C. L. Hager, S. K. Kvidera, J. T. Seibert, L. H. Baumgard, J. W. Ross, A. F. Keating, *Iowa State University, Ames, IA*.

Heat stress (HS) negatively impacts many aspects of animal health and productivity but is especially detrimental to reproductive parameters. Heat stress–induced seasonal infertility is phenotypically observed as increased spontaneous abortions, longer wean-to-estrus interval, decreased first service conception rate, reduced litter size, and fewer total number born. These physiological consequences have economic implications for the U.S. swine industry, amounting to approximately $450 million annually. Study objectives were to characterize the impacts of acute and chronic HS on porcine ovarian function. We hypothesized that alterations in ovarian physiology due to HS are contributory to infertility. In the acute study, 12 postpubertal gilts (126.0 ± 21.6 kg) were synchronized for 14 d by orally administering Matrix to ensure that gilts received treatment during the follicular phase of the estrous cycle. Immediately after Matrix withdrawal, gilts were split into 2 groups ($n = 6$) and exposed to HS or thermal neutral (TN) conditions for 5 d. Gilts were exposed to either constant TN conditions (20.3°C ± 0.5 and 33 ± 13% humidity) or cyclical HS (25.4– 31.9°C and 24 ± 6% humidity). In the chronic study, 6 prepubertal gilts (35 ± 4 kg) were split into 2 groups ($n = 3$) and exposed to either TN (20°C and 35–50% humidity) conditions or constant HS (35°C and 20–35% humidity) for 35 d. From both studies, gilts were euthanized, ovaries were collected, and protein was extracted for Western blotting. Superoxide dismutase 1 (SOD1), a marker of oxidative stress, and 5-methyl cytosine, an indicator of DNA damage, were used to assess cellular stress caused by HS. Superoxide dismutase 1 and 5-methyl cytosine abundance were unchanged in ovaries after acute HS, although there was a tendency for SOD1 to be increased via chronic HS ($P < 0.1$). Insulin receptor substrate 1 (IRS-1) protein abundance was not affected by either acute or chronic HS. Steroid acute regulatory protein (STAR), the enzyme catalyzing the first step in ovarian steroidogenesis, was increased by chronic HS ($P < 0.05$) whereas CYP19A1 protein, the enzyme that converts testosterone to estradiol, was not affected. Phosphorylated nuclear factor kappa B (pNFκB) and the ratio of phosphorylated AKT to total AKT were increased ($P < 0.05$) by chronic HS. This data suggests that different HS loads have differing effects on ovarian physiology and cellular response. This work was supported by Iowa Pork Producers Association and a Land O'Lakes fellowship to MJD.

**Key Words:** heat stress, ovary, seasonal infertility
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**330 Impact of *Lawsonia intracellularis–Mycoplasma hyopneumoniae* dual challenge on growth performance of pigs divergently selected for residual feed intake.** E. Helm[1,*], A. C. Outhouse[1], K. Schwartz[1], J. C. M. Dekkers[2], S. M. Lonergan[1], N. K. Gabler[1], [1]*Iowa State University, Ames,* [2]*Department of Animal Science, Iowa State University, Ames*.

The aim of this study was to compare the growth performance of pigs divergently selected for residual feed intake (RFI) when presented with a 21-d respiratory and enteric disease dual challenge. Using a 2 × 2 factorial design, 25 littermate pairs of barrows from the high-RFI ($n = 50$; low feed efficiency) and 25 from the low-RFI ($n = 50$; low feed efficiency) line from the RFI selection project at Iowa State University were selected. One pig from each pair was assigned to either challenge or nonchallenge (control) rooms ($n = 25$ barrows per line/treatment). Pigs were individually housed, fed a common corn–soybean diet, and allowed to acclimate for 3 wk prior to inoculation. On day after inoculation (dpi) 0, challenge pigs were inoculated intragastrically with *Lawsonia intracellularis* and intratracheally with *Mycoplasma hyopneumoniae*. Feed intake, BW, and fecal and serum samples were collected and recorded at dpi 0, 7, and 14. On dpi 7, challenge pigs were confirmed positive for *Lawsonia intracellularis* via qPCR on pooled fecal swabs and for *Mycoplasma hyopneumoniae* via serology. The 14-d challenge period data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) using line, challenge, and line × challenge interaction as fixed effects, with age as a covariate and litter as a random effect. Line × challenge interactions were observed, as low-RFI challenge pigs had a smaller reduction in ADFI ($P < 0.05$) and tended to have a smaller decrease in ADG ($P = 0.06$) from dpi 8 to 14 but not in overall performance. Irrespective of challenge, low-RFI pigs had lower ADFI compared with high-RFI pigs (2.4 vs. 2.8 kg/d; $P < 0.01$) but similar ADG, leading to greater G:F (0.35 vs. 0.30; $P < 0.05$). From dpi 0 to 7, a significant challenge effect was not detected. However, from dpi 8 to 14 and irrespective of line, challenge pigs had lower ADFI (2.4 vs. 2.8 kg/d; $P < 0.01$), ADG (0.62 vs. 0.89 kg/d; $P < 0.01$), and G:F (0.26 vs. 0.32; $P < 0.01$). Overall (dpi 0–14), the challenge pigs had an reduction in ADFI (2.5 vs. 2.7 kg/d; $P < 0.05$), ADG (0.75 vs. 0.89 kg/d; $P < 0.01$), and G:F (0.30 vs. 0.33; $P < 0.01$) compared with nonchallenged control pigs. These data show that pig performance can be reduced by 6 to 10% as a result of this dual enteric and respiratory pathogen challenge. Furthermore, these results also suggest that selection for lower RFI does decrease the impact of a disease challenge. This work was supported by AFRI-NIFA grants number 2011-68004-30336 and number 2016-67017-2474.

**Key Words:** health, pig, residual feed intake
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## RUMINANT NUTRITION SYMPOSIUM:

## GENETIC, DIETARY, AND MICROBIAL CONTRIBUTION TO FEED EFFICIENCY IN CATTLE

**331 The genetic improvement of feed efficiency in beef cattle.**

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Feed efficiency measured as residual feed intake (RFI) and its component traits, including average daily DMI, are highly variable and moderately heritable in the *Bos taurus* breeds of cattle that are predominantly raised in the United States. The limitation to the genetic improvement of RFI (which is not improved by simply selecting for growth and diluting maintenance requirements) has been the inability to routinely gather intake and growth phenotypes on sufficient numbers of animals to enable meaningful selection differentials to be achieved. Genomic selection (GS) was initially envisioned to be a solution to this problem via the development of equations to predict the genetic merit of animals for RFI based on their BovineSNP50 genotypes. Genomic selection has been shown to work very effectively within breeds, resulting in 2- to 4-fold increases in selection response. However, prediction equations developed in one breed perform very poorly in other breeds—evenly closely related breeds such as Angus and Red Angus. The reason for this is that the chromosomal architectures of breeds differ. The arrangement of allelic variants on chromosomes relative to the marker loci genotyped on the BovineSNP50 assay differs between breeds, so that the genetic merit of chromosomal segments tagged by marker alleles also differs. Two approaches seem warranted to address this problem. First, if we could identify the breed of origin of chromosomal segments, we could estimate the contribution of these segments (haplotypes) in multibreed analyses and built GS prediction equations that would first identify the breed of origin of chromosomal segments in tested animals and then estimate genetic merit for RFI based on the genotype × breed of origin of haplotypes. A second approach would be to base prediction equations of those variants that direct cause variation in RFI rather than those that simply tag chromosomal segments containing these variants. The difficulty with this approach is that the majority of causal variants have very small effects and are therefore very difficult to identify. However, using newly developed genotyping assays containing functional variants and the imputation of chip-based genotypes up to whole genome sequence provides an approach to simultaneously test tens of millions of variants for their effects on RFI. Meta-analyses performed across traits can then be used to identify loci for which the same alleles improve RFI in all (or the majority) of tested breeds to identify the variants most appropriate to use in cross-breed prediction of RFI.

**Key Words:** feed efficiency, genomic selection, residual feed intake

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**332 Challenges in measuring feed efficiency.**

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The term feed efficiency is vague and is defined differently by people. Historically, feed efficiency has been defined as the feed:gain ratio (F:G) or the inverse (G:F). Indexes have been developed to rank animals for feed efficiency. These indexes include residual feed intake (RFI) and residual gain (RG). The use of these measures of feed efficiency in genetic selection may be genetically correlated with other traits that are beneficial or antagonistic to beef production. Regardless of how feed efficiency is defined, an accurate measure of feed intake and growth is required for their calculation. Another potential approach toward genetic selection is to incorporate both feed intake and growth into a genetic selection index that weights the traits to match a production system. Most measures of feed efficiency have been made on growing animals. Limited information is available on the preferred time in the growth curve to measure intake and growth, and there is no good assessment of how repeatable these measures are across ages and diet. There is also limited information regarding selecting for growth efficiency and its impact on the production efficiency of the cow. The expense of collecting individual feed intake data has made it a candidate for developing genetic markers to estimate intake. The regulation of feed intake and rate of growth are both polygenic traits, making it difficult to determine the mechanism associated with variation in these traits across populations. Nongenetic factors such as diverse bacterial populations along the gastrointestinal tract may also contribute to differences in feed efficiency. The USDA is an equal opportunity provider and employer.

**Key Words:** beef cattle, feed efficiency, feed intake

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**333 Impact of diet type on repeatability of feed efficiency in beef cattle.** S. L. Hansen[1,*], M. S. Kerley[2], J. R. Russell[1], [1]*Iowa State University, Ames,* [2]*University of Missouri, Columbia*.

As the beef industry has pushed for improvements in feed efficiency (FE) over the last several years, our knowledge regarding factors that influence FE has evolved. Work from our multidisciplinary FE project has focused on the repeatability of FE across feeding phases. Briefly, this study used 985 steers (464 kg BW) fed across 6 replicated trials. Steers received roughage or whole shell corn–based growing diets for at least 69 d at the University of Missouri and were ranked for residual feed intake (RFI) within diet type. Steers were shipped to Iowa State University and blocked to pens based on growing diet and growing period RFI (classified as low, medium, or high) to receive either a dry-rolled corn– or byproduct-based (40% distiller's grains and 20% soyhulls) finishing diet. All steers received ractopamine hydrochloride at 200 mg/steer daily for the last 28 d on feed. Results from this project suggest that FE is repeatable across feeding phases (growing and finishing), regardless of diet type. However, growing phase diet type influenced the means by which steers achieved that efficiency ranking in the finishing period. Steers identified as highly efficient when grown on corn remained highly efficient in the finishing phase because they consumed approximately 6% less DM but gained similarly to steers ranked as lowly efficient during the growing phase. Interestingly, steers identified as highly efficient when grown on roughage diets remained highly efficient in the finishing phase not because they ate less DM but because they improved daily gains by more than 8.5% while maintaining DMI similar to those ranked as less efficient during the growing phase. This suggests that steers identified as highly efficient on a roughage-based growing diet may have the ability to extract more nutrients from the diet. Indeed, total tract fiber digestibility, estimated using titanium dioxide as an inert marker, was much greater for highly efficient steers vs. lowly efficient steers fed roughage-based diets. In contrast, nutrient digestibility was not different between FE classifications for corn-fed steers, suggesting that the ability to extract more nutrients from the diet may be more important in separation of FE classifications in high-roughage diets than in high-grain diets. Indeed, findings from others suggest that rumen microbe populations are less variable in cattle with superior FE, perhaps suggesting that differences among rumen microbe species may explain some of the differences among FE phenotypes of cattle.

**Key Words:** cattle, feed efficiency, roughage
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**334 Host specificity of the rumen microbial community and its relationship to feed efficiency.** P. J. Weimer[*], *USDA-ARS, Madison, WI*.

The microbial community of the rumen is diverse, containing perhaps thousands of individual species. These communities are highly individualized (i.e., vary among animals with respect to relative abundance of individual species) but display functional redundancy that allows conversion of feedstuffs to somewhat similar concentrations and proportions of fermentation end products (VFA and fermentation gases). The communities are also highly resilient (resistant to change), as evidenced by poor success in establishing exogenously inoculated strains, unless those strains fill an unoccupied niche in the community. Resilience is also demonstrated by reestablishment of the host bacterial community within a few weeks following near-total exchange of ruminal contents between cannulated cows. Contents exchange experiments have also revealed that restoration of an individual's ruminal chemistry (pH and VFA profile) occurs much more rapidly than does the reestablishment of the bacterial community, suggesting that the animal has substantial control over its own ruminal chemistry. Feed efficiency (FE) in both beef and dairy cattle is only moderately heritable, suggesting that other factors may contribute to FE, including interanimal differences in microbiome composition. Characterizing FE in individual animals needed for microbiome studies is complicated by changes in FE over the life of the animal (for example, compensatory growth in steers or varying metabolic demands over the lactation cycle in dairy cows). When such factors have been successfully controlled, several studies in both beef and dairy cattle have demonstrated significant associations between FE and the ruminal abundance of individual microbial taxa. However, the identities of these taxa have not been consistent across studies, and a causative role of the microbial community as a determinant of efficiency differences has resisted demonstration. Recently, near-total exchange of ruminal contents between dairy cows that differ in milk production efficiency (MPE; calculated as energy corrected milk per unit DMI) resulted in transient changes on MPE that disappeared as the ruminal community reestablished its original composition. These data suggest that MPE within individual animals might be improved by establishment of communities from high-MPE animals. Successful establishment of such communities in recipient animals will require novel strategies to overcome the high degree of resilience of the ruminal microbial community.

**Key Words:** feed efficiency, microbiome, rumen
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## RUMINANT NUTRITION

**335 Predicting feedlot growth performance over the feeding period using steer age and body weight.** C. J. Bittner*, A. K. Watson, J. C. MacDonald, G. E. Erickson, *University of Nebraska-Lincoln, Lincoln*.

Typically, mean growth performance is known for the entire feeding period and is used to formulate feedlot finishing diets. A more accurate way for formulating diets would be to know performance (DMI and ADG) at the beginning of the feeding period when requirements are greatest. The objective of this pooled analysis (2002–2015) of University of Nebraska-Lincoln research pen performance examined how steer age and feedlot entry BW affects growth performance over the finishing period. For data analysis, pens were divided into 3 subclasses when they started the finishing period, which included 1) calf fed (entering the feedlot at receiving), 2) short yearlings (grazed during winter and entering the feedlot in May), and 3) long yearlings (grazed during the winter and summer and entering the feedlot in September). Furthermore, within each steer age class, pen means were grouped based on initial BW (226.8 to 544.3 kg, in 45.4-kg increments) when starting the finishing diet. There were 1,002 pens of calf feds, 1,114 pens of short yearlings, and 435 pens of long yearlings. As initial BW increased, DMO (kg/d) for the whole feeding period quadratically increased ($P = 0.01$) in calf-fed steers and averaged 10.4 kg/d. However, in short (11.7 kg/d) and long yearlings (12.9 kg/d), DMO linearly increased ($P = 0.01$) as initial BW increased. For all age groups and initial weight class of steers, calculating DMO as a percent of current BW was relatively constant over the entire feeding period with a range of 2.2 to 2.6%. Intake as a percent of current BW was greatest early (2.7%) in the finishing period and linearly decreased ($P = 0.01$) as days on feed increased (2.3%). A quadratic increase ($P = 0.03$) in ADG was observed in calf feds as initial BW increased. No differences ($P \geq 0.60$) in ADG were observed for short yearlings due to initial BW. However, ADG linearly increased ($P = 0.01$) as initial BW increased for long yearlings. As heavier cattle were placed within each age group, G:F linearly decreased ($P = 0.01$). Evaluating intake as a percent of current BW reduces variation due to steer age and BW; however, as days on feed increases, intake as a percent of current BW decreases. Predicting intake and growth performance over the entire feeding period is dependent on steer age and initial weight when starting the finishing diet.

**Key Words:** cattle size, feedlot performance, intake
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**336 Evaluation of zero or three hundred milligrams of Optaflexx on growth performance and carcass characteristics of steers fed to different degrees of finish.** R. M. Jones[1,*], C. J. Bittner[1], F. H. Hilscher[1], M. F. Wilken[2], G. E. Erickson[1], [1]*University of Nebraska-Lincoln, Lincoln,* [2]*Elanco Animal Health, Greenfield, IN*.

The objective of this study was to test the effect of 0 or 300 mg of Optaflexx on growth and carcass performance of yearling steers fed to differing degrees of finish. Crossbred yearling steers ($n = 342$; 416 kg [SD 34] initial BW) were used in a generalized randomized block design (3 BW blocks) with a $2 \times 3 + 1$ factorial treatment design. Factors included Optaflexx dosage (0 or 300 mg/steer daily) and different days on feed (118, 139, or 160) plus cattle fed 2 wk longer (174 d) without Optaflexx to evaluate just feeding longer. Steers were fed Optaflexx for the last 35 d prior to harvest. No significant dose × days on feed interactions ($P > 0.40$) were observed for growth performance. Live final BW was 13 kg heavier ($P = 0.01$) for steers fed 300 mg of Optaflexx compared with steers fed 0 mg. Steers fed 300 mg of Optaflexx had greater ($P = 0.04$) carcass-adjusted ADG compared with steers fed 0 mg. Feeding 300 mg of Optaflexx resulted in an improvement ($P = 0.05$) in carcass-adjusted G:F. There were no differences ($P = 0.24$) in DMI between Optaflexx doses. Carcass weight and carcass-adjusted final BW were 6.9 and 10 kg greater ($P < 0.06$), respectively, for steers fed 300 mg of Optaflexx compared with steers fed 0 mg. As days on feed increased, final BW linearly increased ($P < 0.01$) whereas intake linearly decreased ($P < 0.01$). Carcass-adjusted ADG was constant ($P > 0.15$), which lead to a small linear improvement ($P = 0.02$) in G:F, due to the reduction in DMI. Cattle performance was negatively influenced by wet, cold, muddy conditions in January and February, which lowered ADG and HCW compared with targeted finish weights/HCW for the study. From d 90 to 97 of the trial, cattle on both Optaflexx treatments had a negative ADG response. During d 111 to 118, cattle performance suffered a reduction in live interim BW for steers fed 118 d for both Optaflexx and control treatments. During these time points, the weather was adverse, with low comprehensive climate index numbers, resulting a reduction in performance for cattle fed 118 or 139 d, as cattle fed longer than 139 d had time to recover in performance. Feeding Optaflexx at 300 mg improved ADG, G:F, and HCW regardless of days on feed (i.e., degree of finish).

**Key Words:** finishing, ractopamine, yearlings
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**337 The evaluation of brown midrib corn silage hybrids and silage inclusion for finishing beef cattle.**

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Crossbred steers ($n$ = 360; 334 ± 25 kg BW) were used to evaluate 3 corn silage hybrids at 2 inclusions in finishing diets with 20% modified distiller's grains with solubles. The 3 hybrids tested included a standard hybrid, which served as the control (CON; hybrid-TMR2R720), a hybrid containing the bm3 brown midrib (*bmr*) trait (BM3; hybrid-F15579S2), and an experimental bm3 *bmr* hybrid (BM3-EXP; hybrid-F15578XT) with floury endosperm. Treatments were designed as a 2 × 3 factorial arrangement that consisted of inclusion of corn silage in the finishing diet (15 or 45% of diet DM) and silage hybrid (CON, BM3, or BM3-EXP). Steers were blocked by BW and randomly assigned within block to pen ($n$ = 36; 10 steers/pen). Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen serving as the experimental unit and block as a fixed effect. There was a silage inclusion × hybrid interaction for ADG and G:F. Cattle fed 45% silage had greater DMI ($P < 0.01$) compared with steers fed 15% silage. Cattle fed BM3-EXP had greater ADG than cattle fed CON or BM3 when silage was included at 15% of the diet. When silage was fed at 45% of the diet DM, cattle fed BM3 and BM3-EXP gained similarly, but both were greater than cattle fed CON ($P < 0.05$). All treatments with 15% corn silage inclusion had greater ($P \leq 0.04$) G:F compared with 45% corn silage inclusion, but G:F response due to hybrid was different depending on inclusion. For steers fed 15% silage, G:F was greatest for cattle fed BM3-EXP (0.178), lowest for cattle fed BM3 (0.169), and intermediate for cattle fed CON (0.174; $P < 0.05$). For steers fed 45% silage, G:F was greatest for cattle fed BM3 (0.165; $P < 0.03$), whereas cattle fed CON and BM3-EXP had similar G:F (0.159 and 0.157; $P = 0.24$). At 15% corn silage inclusion, HCW was greater ($P < 0.01$) for cattle fed BM3-EXP compared with cattle fed CON and BM3 but similar between cattle fed BM3 and CON. At 45% corn silage inclusion, steers fed BM3-EXP and BM3 had similar HCW but were both heavier ($P < 0.01$) compared with cattle fed CON. Cattle fed 15% corn silage had greater ($P < 0.01$) fat thickness and marbling score compared with steers fed 45% corn silage in the finishing diet. The response to corn hybrid varied by inclusion, but the bm3 *bmr* trait improved ADG and G:F depending on inclusion.

**Key Words:** brown midrib, corn silage, finishing cattle
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**338 The evaluation of brown midrib corn silage hybrids in growing diets fed to beef steers.**

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A 76-d growing study was conducted using 216 crossbred steers (324 ± 10 kg initial BW) to evaluate the effects of 3 corn silage hybrids on performance when fed silage-based growing diets. The 3 hybrids were a standard corn silage hybrid, which served as the control (CON; hybrid-TMR2R720), a bm3 *bmr* hybrid (BM3; hybrid-F15579S2), and an experimental bm3 *bmr* hybrid (BM3-EXP; hybrid-F15578XT) with floury endosperm. Silage was harvested at similar DM content, packed, and stored in concrete bunkers for approximately 5 mo until the initiation of the trial. Silages were sampled weekly and composited by month for nutrient analysis at 28 d after harvesting. Steers were limit fed a common diet consisting of 50% alfalfa hay and 50% Sweet Bran at 2% of BW for 5 d prior to trial initiation to minimize gut fill. Following 5 d of limit feeding, steers were weighed for 2 consecutive days and averaged for initial BW. Cattle were stratified by BW and randomly assigned to pens with 12 steers/pen. Pens were randomly assigned to 1 of 3 treatments, with 6 replications/treatment. All diets included 15% modified distiller's grains plus solubles and 5% supplement. The remainder of the diet consisted of 80% corn silage fed as 1 of the 3 hybrids (CON, BM3, or BM3-EXP). Ending BW was collected similar to initial BW with steers limit fed at 2% of BW for 5 d and weighed for 2 consecutive days. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen serving as the experimental unit. Block was included in the model as a fixed effect. The 3 silages had similar DM, NDF, organic acids, and pH, whereas the bm3 *bmr* silages had numerically less lignin and ADF, as expected. Ending BW was greater ($P < 0.01$) for steers fed the BM3 and BM3-EXP compared with steers fed the CON but not different between steers fed the 2 BMR varieties. Steers fed both BM3 and BM3-EXP had greater ($P < 0.01$) DMI and ADG compared with the steers on the CON treatment, but DMI and ADG were not different between steers in the BM3 or BM3-EXP treatments. Although steers fed BM3 and BM3-EXP had greater DMI and ADG, there were no differences ($P = 0.26$) in G:F between the silage treatments. In silage-based growing diets, use of bm3 *bmr* silage increased DMI and, subsequently, ADG but did not affect G:F.

**Key Words:** brown midrib, corn silage, growing cattle
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**339 Effect of feeding brown midrib corn silage in growing diets for beef cattle on nutrient digestibility and ruminal fermentation characteristics.**

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Feeding corn silage in combination with distiller's grains has been shown as a potentially efficient way to grow steers prior to finishing. Our objective was to evaluate the effects of different silage hybrids on nutrient digestibility for growing beef cattle. Six ruminally fistulated steers (274 ± 27 kg BW) were used in a 126-d metabolism study with a replicated, 3 × 6 Latin rectangle experimental design. Three dietary treatments using 3 different silage hybrids were compared. The 3 hybrids were a standard corn silage hybrid, which served as the control (CON; hybrid-TMR2R720), a bm3 brown midrib (*bmr*) hybrid (BM3; hybrid-F15579S2), and an experimental bm3 *bmr* hybrid (BM3-EXP; hybrid-F15578XT) with a floury endosperm. All diets included 15% modified distiller's grains plus solubles and 5% supplement. The remainder of the diet consisted of 80% corn silage of 1 of the 3 hybrids (CON, BM3, or BM3-EXP). Period length was 21 d, which consisted of 16 d of adaptation and 5 d of fecal collection. Titanium dioxide was intraruminally dosed on d 10 to 20 as a marker to determine digestibility. Ruminal pH was continuously monitored with indwelling pH probes during each collection period. Corn bran and each silage were incubated for 30 h on d 21 to evaluate in situ NDF disappearance. Data were analyzed as a replicated Latin rectangle with steer as the experimental unit. Corn silage treatment tended ($P = 0.11$) to impact DMI and OM intake, with steers fed BM3 and BM3-EXP having greater intake than CON steers. Digestibility of OM was impacted by treatment ($P = 0.06$), with steers fed BM3-EXP (72.4%) having greater ($P < 0.05$) OM digestibility than steers fed CON (67.7%) and steers fed BM3 being intermediate but not different ($P > 0.11$) from steers fed either BM3-EXP or CON. Steers fed BM3 (58.4%) and BM3-EXP (58.2%) had greater ($P < 0.01$) NDF digestibility than steers fed the CON (46.5%). Similarly, there were no differences ($P = 0.29$) in ADF digestibility between BM3 (58.1%) and BM3-EXP (53.3%), but both were greater ($P < 0.01$) in ADF digestibility than CON (40.8%). Average ruminal pH for steers fed bm3 *bmr* hybrids (6.24) was lower ($P < 0.01$) compared with steers fed CON (6.50). In situ NDF disappearance was greater ($P < 0.01$) for samples incubated in steers fed bm3 *bmr* hybrids compared with samples incubated in steers fed CON. In silage-based growing diets, use of bm3 *bmr* silage increases fiber digestibility.

**Key Words:** brown midrib, corn silage, digestibility
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**340 Effects of using distiller's dried grains with solubles in postpartum diets of beef cows on heifer offspring reproductive performance.**

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Primiparous and multiparous Angus–Simmental cows were used in a complete randomized block design to evaluate the effects of feeding distiller's dried grains with solubles (DDGS) as a primary source of dietary energy, which resulted in varying levels of protein, during early lactation on heifer progeny composition and reproductive performance. Cows were blocked by calf birth weight, cow weight, BCS, and age and randomly assigned to 1 of 3 treatments: 1) a silage-based total mixed ration (TMR; CON), 2) TMR with 2.5 kg/d DM DDGS (MID), or 3) TMR with 4.7 kg/d DM DDGS (HIGH). All diets were formulated to be isocaloric and either meet or exceed all other nutrient requirements (NRC, 2000) for a postpartum targeted ADG of 0.22 kg. Nineteen days after timed AI (TAI) of the dams, cows and heifers were commingled and placed on pasture. Milk samples were collected from the dams at 65.5 ± 10.5 d postpartum (DPP) to determine composition. Following weaning, all heifer offspring were maintained as a group and fed a diet formulated to either meet or exceed all nutrient requirements (NRC, 2000). Blood samples were collected from the heifer offspring on 7-d intervals until estrous synchronization and evaluated for progesterone concentration as an indicator of puberty. Heifer offspring were started on a 5-d Co-Synch + CIDR protocol and were bred using TAI. Diameter of the largest antral follicle was determined at TAI via ultrasonography. Data were analyzed using the GLIMMIX and MIXED procedures of SAS (SAS Inst. Inc., Cary, NC). Planned orthogonal contrasts were used to test treatment effects. Milk fat increased as DDGS increased ($P \leq 0.03$) and lactose ($P \leq 0.03$) was increased in the MID treatment, with HIGH being intermediate and CON the lowest. Milk urea nitrogen (MUN) increased as DDGS increased within the diet ($P < 0.001$). Heifer offspring final BW ($P \geq 0.27$), ADG ($P \geq 0.22$), and days of age at puberty ($P \geq 0.39$) were not different between treatments. Total antral follicle count differed ($P = 0.027$) when CON was compared with the average of HIGH and MID, with HIGH highest, MID intermediate, and LOW lowest. Although not statistically different ($P \geq 0.30$), TAI conception rates had a 25% increase for the HIGH treatment when compared with the CON and MID treatments. In summary, feeding dams high levels of DDGS during early lactation resulted in variations in milk composition without a statistically significant impact on heifer offspring reproduction.

**Key Words:** corn coproducts, heifer development, lactational programing
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**341 Evaluation of corn distiller's solubles on finishing steer performance.** B. Hansen*, *University of Nebraska-Lincoln, Lincoln*.

Six hundred crossbred steers (435 kg [SD 41] BW) were used to evaluate the effects of corn distiller's solubles (CDS) on performance and carcass characteristics of finishing steers. Five treatments with 6 pens per treatment (20 steers/pen; $n$ = 6) were used in a generalized randomized block designed experiment with 3 BW blocks. Treatments consisted of a control diet (CON) containing 68% dry-rolled corn, 17% high-moisture corn, 10% alfalfa, and 5% supplement; CDS was included at 8, 16, or 20% of DM and replaced corn. An additional treatment combined 16% CDS with 20% wet distiller's grains plus solubles (WDGS). The treatment containing 16% CDS in combination with 20% WDGS was included to compare WDGS with corn in diets containing CDS. Steers were limit fed for 5 d at the beginning of the trial and weighed on d 0 and 1 to account for gut fill and were implanted on d 1 with Component TE-200. Steers were harvested at 110 (heaviest 2 blocks) or 117 d (lightest block) and carcass data were collected. Linear and quadratic effects of increasing CDS concentration were evaluated using orthogonal contrasts, and a pairwise comparison was used to compare 16% CDS with 16% CDS and 20% WDGS. Treatment × block interactions were tested but were not significant ($P > 0.08$). Final BW, ADG, G:F, fat thickness, and HCW linearly increased ($P < 0.01$) with increasing CDS concentration, whereas DMI tended to quadratically increase ($P = 0.06$) with CDS inclusion. Feed efficiency linearly increased from 0.136 in CON to 0.140 at 8% inclusion, 0.146 at 16% inclusion, and 0.149 at 20% inclusion of CDS. When comparing 16% CDS with 16% CDS and 20% WDGS, DMI decreased ($P = 0.04$) and G:F tended to increase ($P = 0.08$) when WDGS was included in the diet. No other differences for carcass characteristics were observed ($P > 0.12$). The feeding value of CDS when compared with corn was calculated at 139, 146, and 147% for 8, 16, and 20% CDS inclusion levels. When 16% CDS was compared with 16% CDS in combination with 20% WDGS, a feeding value of 115% was calculated for WDGS relative to corn. With recent changes in oil removal from CDS, the feeding value appears consistent with previous work and suggests CDS has more energy than corn for finishing cattle.

**Key Words:** corn distiller's solubles, finishing cattle, wet distiller's grains plus solubles

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**342 Evaluation of protein in distiller's grains on site and extent of digestion in finishing diets.** Z. E. Carlson[1,*], J. L. Gramkow[1], H. C. Hamilton[1], M. J. Jolly-Briethaupt[1], M. K. Luebbe[2], G. E. Erickson[1], J. C. MacDonald[1], *[1]University of Nebraska-Lincoln, Lincoln, [2]University of Nebraska, Scottsbluff*.

Six ruminally and duodenally fistulated steers were used in an unbalanced 6 × 6 Latin square with 6 periods and 4 treatments to evaluate the relative contribution of excess rumen undegradable protein from modified distiller's grains plus solubles (MDGS) on site and extent of nutrient digestion. The protein from MDGS was evaluated using corn gluten meal to provide similar protein as 40% MDGS. Treatments included 1) control diet (CON) containing 75.5% dry-rolled corn (DRC), 15% corn silage, 3.5% soybean meal, and 6% supplement; 2) modified distiller's grains plus solubles (MDGS40) with 40% MDGS, 39% DRC, 15% corn silage, and 6% supplement; 3) corn gluten meal (CGM) with 17.5% corn gluten meal, 61.5% DRC, 15% corn silage, and 6% supplement; and 4) corn gluten meal plus condensed distiller's solubles (CGM-CDS) with 17.5% corn gluten meal, 10% condensed distiller's solubles, 51.5% DRC, 15% corn silage, and 6% supplement. Condensed distiller's solubles was added to CGM to mimic the nutrient profile of distiller's grains from cellulosic ethanol production. Dry matter intake was greatest ($P \leq 0.08$) for MDGS40 and least ($P \leq 0.10$) for CON. Total tract digestibilities of DM and OM were lower ($P \leq 0.03$) for steers fed MDGS40 compared with steers fed CON, CGM, and CGM-CDS (OM digestibilities of 72.9, 84.7, 80.5, and 84.3%, respectively [SEM 3.1]). Intake of NDF ($P < 0.01$) for MDGS40 compared with CON, CGM, and CGM-CDS (2,015, 992, 973, and 1,001 g/d, respectively [SEM 88.9]). Total tract NDF digestibility was not different ($P = 0.64$) among treatments. No difference ($P \geq 0.55$) was observed in apparent or true OM ruminal digestibilities. Duodenal flow of NDF was greatest ($P \leq 0.01$) for MDGS40 compared with CON, CGM, CGM-CDS (977, 484, 541, 462 g/d, respectively [SEM 100.1]). Postruminal OM digestibility was not different ($P > 0.36$) among treatments. Ruminal pH had an hour × treatment interaction ($P < 0.01$) and suggests that the minimum ruminal pH of steers consuming CGM-CDS was greater 2 to 9 h after feeding compared with the other treatments. In conclusion, feeding MDGS at 40% (DM inclusion) increased DM and NDF intake with decreased total tract digestibility relative to diets containing corn or corn gluten meal. As expected, protein from distiller's grains is not the cause of lower digestibility.

**Key Words:** digestibility, distiller's grains plus solubles, protein

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**343 Effect of three initial implant programs with a common terminal Revalor-200 on feedlot performance and carcass traits of weaned steers.**
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A commercial feedlot study compared 3 implant strategies: Revalor-IS (d 1), Revalor-IS (d 1) and Revalor-200 (d 67), or Revalor-XS (d 1) for effects on performance and carcass traits. Each initial implant strategy was followed by a terminal Revalor-200 implant on d 133. Calf-fed steers ($n$ = 1,350; 283 kg [SD 10] initial BW) sourced in Nebraska, Iowa, Utah, South Dakota, Idaho, and California were used in a randomized block design trial. Steers were assigned to pens by sorting every 2 steers into 1 of 3 pens before processing. Pens were randomly assigned to 1 of 3 treatments (6 pens/treatment). Mean days on feed across blocks was 215 d. The finishing diet was identical across treatments and any diet changes that occurred across time were the same for all cattle. Live performance was calculated from pen BW shrunk 4%, and carcass-adjusted performance was based on HCW divided by a common dressing percentage of 64.25%. Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) and pen served as the experimental unit. There were no differences ($P$ = 0.19) in DMI due to treatment. Using carcass-adjusted performance, no differences in final BW or ADG were observed ($P \geq 0.38$). Therefore, G:F ($P$ = 0.55) also was unaffected by implant strategy. Similar results were observed when evaluating performance using final live BW. There were no differences in HCW ($P$ = 0.59), dressing percent ($P$ = 0.93), or USDA quality grade ($P$ = 0.90) and USDA yield grade ($P$ = 0.23) distributions among implant treatments. When evaluating interim performance, there were no differences in ADG ($P$ = 0.49) or G:F ($P$ = 0.87) from d 1 to 67, as expected, due to implant payout. From d 67 to 133, cattle initially implanted with Revalor-IS and given Revalor-200 on d 67 had significantly greater ADG ($P < 0.01$) and G:F ($P$ = 0.02) compared with the other 2 treatments. Gain ($P$ = 0.11) and G:F ($P$ = 0.21) for d 133 to 215 was not significantly different but numerically greater for the Revalor-IS treatment, suggesting some compensation. Implant strategy resulted in no overall differences, but the changes in ADG and G:F during different periods within the finishing period relate to different implant payout. Steers implanted with Revalor-IS, Revalor-IS/200, or Revalor-XS followed by a common terminal implant had similar overall performance, suggesting that more aggressive initial implant strategies have minimal impact on performance.

**Key Words:** carcass traits, implant strategy, performance
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**344 Impact of corn oil removal from modified distiller's grains plus solubles and supplemental corn oil on finishing cattle performance.**
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The effects of added corn oil in distiller's grains plus solubles on finishing cattle performance was evaluated using 320 steers (413 kg [SD 25] initial BW) fed in 32 pens (10 steers/pen) and 1 of 4 treatments ($n$ = 8 pens/treatment). Cattle were limit fed 5 d prior to starting and weighed on d 0 and 1 for initial BW. The 4 treatments consisted of a corn control diet (CON), 40% deoiled modified distiller's grains plus solubles (deoiled MDGS), 38% deoiled modified distiller's grains plus solubles plus 2% corn oil (MDGS+Oil), and 40% full-fat modified distiller's grains plus solubles (full-fat MDGS). The deoiled MDGS product contained 8.9% fat whereas the full-fat MDGS product contained 11.6% fat. All MDGS and corn oil were sourced from the same plant. Performance data were based on 134 d, and carcass data were collected at slaughter following a 48-h chill. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with pen as the experimental unit, and treatments were compared using a protected $F$-test. Intakes were impacted by treatment ($P < 0.01$), with steers fed deoiled MDGS having the greatest DMI ($P < 0.05$) and steers fed CON, MDGS+Oil, and full-fat MDGS having lower but similar DMI ($P > 0.15$). Dietary treatment had a tendency to impact ADG ($P$ = 0.06) and HCW, with the 3 modified distiller's treatments all having similar gains ($P > 0.23$) but deoiled MDGS and MDGS+Oil were greater than CON ($P < 0.04$) whereas full-fat MDGS was similar to CON ($P$ = 0.14). As a result of increased ADG, G:F was improved ($P < 0.03$) for cattle fed treatments containing MDGS compared with cattle fed CON. The greatest G:F was observed for cattle fed MDGS+Oil (0.165; $P < 0.05$) while cattle fed full-fat MDGS were similar to cattle fed MDGS+Oil (0.159 and 0.165, respectively; $P$ = 0.15) and deoiled MDGS (0.157; $P$ = 0.55). Marbling score ($P$ = 0.64) and LM area ($P$ = 0.52) were not impacted by dietary treatment. Fat thickness followed ADG, with the MDGS treatments having a greater fat thickness than CON ($P < 0.02$). Feeding MDGS improved G:F by 6 to 11% compared with feeding corn; however, G:F was increased 4.9% when 2% dietary oil was added back to deoiled MDGS whereas only a 1.2% increase in G:F was observed for full-fat MDGS compared with deoiled MDGS.

**Key Words:** distiller's grains plus solubles, finishing cattle, oil
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**345 Impact of feeding distiller's grains with or without oil removal as well as oil replenished on nutrient digestibility by finishing cattle.** J. E. Burhoop[1,*], M. L. Jolly-Breithaupt[1], J. L. Gramkow[1], M. K. Luebbe[2], J. C. MacDonald[1], G. E. Erickson[1], *[1]University of Nebraska-Lincoln, Lincoln, [2]University of Nebraska, Scottsbluff.*

A digestion experiment was conducted to determine the effect of adding corn oil to the diet on total tract digestibility of finishing cattle. The 70-d digestion trial was designed as a 5 × 4 unbalanced Latin rectangle with 4 diets, 5 ruminally cannulated steers, and 5 periods. The 4 treatments consisted of a corn control diet (CON), 40% deoiled MDGS (DOMDGS), 38% deoiled MDGS plus 2% corn oil (MDGS+Oil), and 40% full-fat MDGS (FFMDGS). The DOMDGS product contained 8.9% fat whereas the full-fat MDGS product contained 11.6% fat. Dietary fat was 4.2% for CON, 6.0% for DOMDGS, 7.9% for MDGS+Oil, and 7.1% for FFMDGS. All MDGS and corn oil were sourced from the same plant. Each period was 14 d, which consisted of 10 d of adaptation followed by 4 d of fecal collection, 4 times per day. Titanium dioxide was intraruminally dosed twice daily throughout the entire experiment as a marker to determine fecal output. Intake of DM, OM, and energy as well as total tract fat digestibility and DE (Mcal/d) were not impacted by dietary treatment ($P > 0.46$). Cattle fed all 3 treatments containing MDGS had similar ($P > 0.10$) DM excreted, OM excreted, NDF intake, NDF excreted, fat excreted, and fecal energy excretion but greater than steers fed CON ($P < 0.03$). Fat intake was greatest and similar for MDGS+Oil and FFMDGS ($P = 0.47$) and intermediate for DOMDGS ($P = 0.08$), whereas fat intake was least for CON ($P < 0.01$). Total tract OM digestibility was greatest for cattle fed CON (83.6%; $P < 0.01$), whereas DOMDGS and FFMDGS were intermediate and similar (79.1 and 78.1% for DOMDGS and FFMDGS, respectively; $P > 0.39$), and MDGS+Oil was lowest (75.6%) but similar to FFMDGS ($P = 0.10$). Total tract digestibility of NDF was greater for FFMDGS compared with CON and MDGS+Oil ($P < 0.04$) but not compared with DOMDGS. Feeding FFMDGS resulted in the greatest DE (Mcal/kg; $P < 0.04$), and DOMDGS was similar to both FFMDGS ($P = 0.40$) and CON ($P = 0.17$). However, feeding CON resulted in a lower DE compared with FFMDGS ($P = 0.04$). The MDGS+Oil diet had the lowest DE ($P < 0.01$). When corn oil was added back to MDGS, there was a negative impact on digestibility of OM and NDF as well as lower DE (Mcal/kg) compared with DOMDGS or FFMDGS.

**Key Words:** digestion, distiller's grains plus solubles, oil
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**346 Supplementing varying ratios of modified distiller's grains and corn to growing beef steers.** C. A. Welchons[1,*], V. B. Ferrari[1,2], R. G. Bondurant[1], F. H. Hilscher[1], G. E. Erickson[1], T. J. Klopfenstein[1], J. C. MacDonald[1], *[1]University of Nebraska-Lincoln, Lincoln, [2]University of Sao Paulo, Pirassununga, Brazil.*

An 84-d growing trial was conducted using 120 crossbred steers (281 kg [SD 15] initial BW) in a randomized complete block design ($n = 10$) to determine the effects of displacing modified distiller's grains plus solubles (MDGS) with dry-rolled corn (DRC) for steers consuming forage of differing quality on growing performance. Steers were limit fed 5 d and weighed on 2 consecutive days for beginning and ending BW. The experiment was arranged in a 4 × 3 factorial with ratio of MDGS to DRC as the first factor (100:0, 80:20, 60:40, and 40:60) and forage type as the second factor. The 40:60 ratio was designed to still meet the MP requirements of the animal while displacing as much MDGS with DRC as possible. Forage type consisted of either a high-quality (HQ; 70% brome hay and 30% sorghum silage) forage or 1 of 2 low-quality forages consisting of corn residue that was baled through a conventional rake and bale method (CB) or by disengaging the spreader on the combine and immediately baling the tailings (easy bale [EZB]). Diets consisted of 40% MDGS:DRC ratio energy supplement, 56% forage, and 4% supplement. Ad libitum feed was individually delivered daily via Calan gates. There was no interaction for MDGS:DRC ratio and forage type on ending BW, ADG, or G:F ($P > 0.32$). Steers consuming HQ forage had greater ADG (1.31 kg/d) than steers consuming either of the low-quality forages, which did not differ (0.76 and 0.81 kg/d for EZB and CB, respectively). Although HQ steers had increased ADG, DMI for HQ was also greater than for EZB and CB, leading to no difference in G:F among treatments ($P = 0.92$). As MDGS was replaced with DRC, there was a linear decrease in ending BW and ADG (1.03 to 0.88 kg/d; $P < 0.01$). Similarly, G:F linearly decreased ($P = 0.03$) as MDGS was replaced with corn due to the decline in ADG and no differences in DMI among treatments. As expected, steers fed high-quality forage had increased performance compared with steers fed low-quality forage. Even though all ratios of MDGS:DRC were designed to meet MP requirements, these data would suggest a greater energy value for MDGS compared with DRC, observed in the linear decrease in gain with increasing level of DRC.

**Key Words:** growing, distiller's grains, forage
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**347 Young Scholar Presentation: The impact of nutrition and reproductive stage on maternal and fetal pancreatic exocrine and endocrine function in ruminants.** F. E. Keomanivong*, P. P. Borowicz, J. S. Caton, K. A. Vonnahme, A. Grazul-Bilska, D. A. Redmer, K. C. Swanson, *Department of Animal Science, North Dakota State University, Fargo*.

The ruminant pancreas plays an essential role in digestion and metabolism; however, despite its extensive exocrine and endocrine functions, relatively little is known about how it is impacted by nutrition and physiological state. As feed quality and availability vary throughout the year, an increased likelihood for reduced nutrient intake develops. The secretion of pancreatic digestive enzymes and insulin has been closely linked to dietary intake, and alterations in maternal nutrient supply could result in modifications of the uterine environment and, consequently, fetal development. To evaluate the impact of various nutritional insults and dietary strategies on maternal and fetal pancreatic function, 3 experiments were conducted. The first of these explored various phases of the reproductive cycle and the impact of arginine infusion amid differing levels of feed intake. The second examined the influence of nutrient restriction and melatonin supplementation on maternal and fetal pancreatic development, whereas the third determined the effectiveness of realimentation during advancing stages of gestation. Not surprisingly, nutrient restriction caused reduced BW, pancreatic mass, and pancreatic enzyme activity in maternal tissues in all experiments. In Exp. 1 the infusion of arginine was unable to alter pancreatic exocrine or endocrine function during the various phases of the luteal stage. In Exp. 2, the addition of dietary melatonin seemingly diminished the impact of nutrient restriction on maternal pancreatic mass and α-amylase activity while decreasing the secretion of insulin and reducing the size of insulin-containing cell clusters. Although fetal pancreatic enzymes were unaffected by treatment, pancreatic morphology exhibited greater cluster size when carried by adequately fed dams. Implementing realimentation strategies during different stages of gestation proved to act as a rescue mechanism, causing a decrease in the impact of reduced feed intake and, in some cases, allowing for compensatory gain of the exocrine pancreas, although the endocrine pancreas was unaffected in both maternal and fetal tissue. Interestingly, dams had greater changes in exocrine secretions whereas fetuses differed mainly in endocrine function as a result of poor nutritional status. Additionally, comparison of pancreatic tissue revealed a greater quantity, along with larger sizes, of insulin-containing cell clusters in fetuses than in dams, which appear to separate as the animal matures. Pancreatic function is controlled by many complex mechanisms, and determining how these processes are regulated will provide opportunities for the beneficial manipulation of production in ruminants.

**Key Words:** endocrine, exocrine, pancreas
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**348 Young Scholar Presentation: Characterization and implications of novel rumen viral and methanogen diversity discovered through targeted genomic approaches.** C. L. Anderson*, S. C. Fernando, *University of Nebraska-Lincoln, Lincoln*.

Rumen microbes play a critical role in energy acquisition for the ruminant host. Consequently, an improved understanding of the composition, function, and interactions of rumen microbial populations would provide novel opportunities to enhance rumen fermentation, host efficiency, and health. However, our knowledge of the diversity and function of the complex rumen ecosystem has been stifled by the inability to culture the vast majority of microbial life. Using targeted culture-independent techniques, we explored rumen viral and methanogen diversity as well as interactions between these populations to better understand the rumen ecosystem. Viruses have been shown to influence ecosystem function through top-down and bottom-up effects resulting from cell lysis, horizontal gene transfer, active lysogeny, and metabolic reprogramming. For the first time, we investigated the response of rumen viruses to dietary modulation and demonstrated that dietary total digestible nutrient content best explains the variation in viral populations. Although rumen viruses were dynamic, core viral groups, mainly characterized by unknown viruses, suggest a potential role for viruses in structuring the rumen microbiome. Additionally, we identified glycosidic hydrolases among the virally encoded auxiliary metabolic genes, signifying that viruses augment the breakdown of carbohydrates to boost host microbe energy production and, in turn, viral replication. In addition to metagenomic approaches, in a separate study, we used microfluidic-enabled single cell genomics to describe novel methanogens not previously found in the rumen. These single cell genomics studies are ongoing and have implications for methane mitigation strategies as well as answering fundamental questions regarding the evolution of methanogenesis. Metabolic predictions indicate that the discovered methanogens use different substrates to produce methane, and this is reflected in their differential abundance on contrasting diets. Lastly, from these methanogen genomes, we were able to identify temperate viral signatures suggestive of a viral influence on methanogenesis. In summary, through targeted approaches, we were able to document novel features and dynamics of rumen viruses and methanogens in ways that would have not been possible through traditional approaches. This work builds foundational knowledge regarding the diversity and roles of viruses and methanogens in rumen ecosystem function necessary for future hypotheses. Furthermore, the methods used here can be adapted to study other populations and will help push us toward our goal of manipulating the rumen microbiome to favor certain phenotypes.

**Key Words:** methanogens, rumen microbiome, viral ecology
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**349 Effect of continuous or rotational grazing on growing steer performance and land production.** C. A. Welchons*, R. G. Bondurant, F. H. Hilscher, J. C. MacDonald, T. J. Klopfenstein, A. K. Watson, *University of Nebraska-Lincoln, Lincoln*.

A grazing trial using smooth bromegrass pastures was conducted from April to September (156 d) in 2 consecutive years to evaluate the effects of differing grazing strategies on growing steer performance and animal production per unit of land. In each year, 71 steers (313 kg [SD 6] initial BW) were assigned to 1 of 3 treatments with 3 replications per treatment. Treatments included 2 continuous grazing treatments (low grazing intensity [LO] or high grazing intensity [HI]) and a rotational grazing treatment (ROT). One HI replication was an outlier due to poor grass growth (62% of other HI replications) and was therefore removed from each year of the data set. Cattle on the HI and ROT treatments were initially stocked at 9.88 AUM (308 kg of forage)/ha whereas LO cattle were stocked at 6.82 AUM/ha. All pastures were fertilized with 89.75 kg N/ha prior to the grazing season. Sward heights and density were collected at the beginning and end of each grazing season to estimate available forage and determine changes in amount of available forage. Put and take steers were used to maintain similar grazing pressure among treatments. The grazing season was divided into 5 cycles, and steers in the rotationally grazed treatment were rotated every 4 d during the first and fifth cycle and every 6 d during the second, third, and fourth cycle. Ending BW (404, 401, and 404 kg for LO, HI, and ROT, respectively) and ADG (0.59, 0.56, and 0.58 kg/d for LO, HI, and ROT, respectively) did not differ among treatments ($P \geq 0.85$). However, calculated actual AUM per hectare was greater for HI (11.9 AUM/ha) and ROT (12.1 AUM/ha) treatments compared with the LO treatment (10.8 AUM/ha; $P \leq 0.01$). At the beginning of the grazing season, LO pastures had greater available forage than HI pastures (2,028 vs. 1,682 kg/ha; $P = 0.07$), whereas ROT pastures were intermediate (1,755 kg/ha) and did not differ from either LO or HI pastures. However, at the end of the grazing season, available forage did not differ among treatments ($P = 0.35$), suggesting that appropriate grazing pressure was applied. These data suggest that when intensively managed to maintain a constant grazing pressure, continuous grazing at a high stocking rate can yield similar individual animal performance and animal production per unit of land as similarly stocked rotational grazing, at least in the short term.

**Key Words:** bromegrass, cattle, rotational grazing
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**350 Corn silage rumen undegradable protein levels and extent of digestion.** C. R. Oney*, A. K. Watson, G. E. Erickson, J. C. MacDonald, J. L. Gramkow, *University of Nebraska-Lincoln, Lincoln*.

The amount of RUP in corn silage and the extent to which it is digested in the small intestine are uncertain. Moisture content and length of ensiling period both affect the digestibility of grain in corn silage. Three studies were conducted to assess the amount and extent of digestion of RUP in corn silage. In Exp. 1, 4 feeds (35 and 42% DM corn silage, soybean meal [SBM], and Soypass [enzymatically browned SBM; 50% CP and 75% RUP]) were used in an in vitro setting with 100-mL bottles incubated for 16 or 24 h (bottle was experimental unit). Purine analysis was done to correct for microbial N when calculating RUP content. Experiment 2 used in situ methods with 2 ruminally cannulated steers and 1 duodenally cannulated steer to compare RUP content and RUP digestibility of 2 corn silages (35 and 42% DM) along with Empyreal (wet corn milling byproduct; 75% CP and 65% RUP) and Soypass. Samples were ruminally incubated for 20 or 30 h and one-half of the samples were then duodenally incubated to determine RUP digestibility (each experimental unit consisted of 4 bags). In Exp. 3, dry-rolled corn (14% DM) was reconstituted to 25, 30, 35, and 50% moisture and ensiled in mini silos (2,265 $cm^3$) for 30 d (silo was experimental unit). After ensiling, samples were ruminally incubated for 20 or 30 h to determine RUP content. In Exp. 1, RUP as a percent of CP was greatest for Soypass ($P = 0.02$) with no differences between the 2 corn silages, averaging 23.2% (SEM 7.4), similar to SBM. As a percent of DM, RUP was also greatest for Soypass ($P < 0.01$), intermediate for SBM, and least for the corn silages, averaging 1.7% (SEM 1.6). In Exp. 2, RUP as a percent of DM was greatest for Soypass ($P < 0.01$) intermediate for Empyreal, and least for the corn silages, averaging 1.2% (SEM 0.28). As a percent of CP, RUP was greatest for Soypass ($P < 0.01$), intermediate for both corn silages averaging 14.7% (SEM 1.1), and least for Empyreal due to washout of bags. In Exp. 3, as moisture content of the corn grain increased, RUP as a percent of DM linearly decreased ($P < 0.01$). The RUP content and RUP digestibility of corn silage is low. Increased moisture content makes the grain portion of corn silage more digestible in the rumen, further decreasing total RUP levels.

**Key Words:** corn silage, crude protein, rumen undegradable protein
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**351 Effect of an injectable trace mineral at the initiation of a fourteen-day controlled internal drug release protocol on heifer performance and reproduction.**

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Three experiments were conducted at separate locations to determine the effects of a trace mineral injection (TMI), Multimin 90, on heifer performance and reproduction. In Exp. 1 (spring-born Angus; $n$ = 93; 428 ± 45.2 kg BW), Exp. 2 (spring-born Angus × Simmental; $n$ = 119; 426 ± 54.0 kg BW), and Exp. 3 (fall-born Angus × Simmental; $n$ = 199; 345 ± 39.7 kg BW), heifers were stratified by BW within experiment and assigned to 1 of 2 treatments: a control, saline injection, or TMI at a dose of 1 mL/68 kg BW. Heifers were also supplemented with free choice mineral containing Cu, Mn, Se, and Zn formulated to meet or exceed NRC recommendations. Injections were given 33 d prior to breeding at the initiation of a 14-d controlled internal drug release-PG protocol. Data concerning BW and BCS were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC) and AI and overall pregnancy rates were analyzed using the GLIMMIX procedure of SAS. There was no difference ($P \geq 0.37$) in BW during Exp. 1. Additionally, there was no difference ($P \geq 0.52$) in BCS at initiation or at AI and final pregnancy confirmation in Exp. 1; however, a greater ($P = 0.03$) BCS was noted for control heifers at breeding. During Exp. 2, BCS and BW did not differ ($P \geq 0.44$) across treatments. There was a tendency ($P = 0.07$) for TMI heifers to have an increased AI pregnancy rate (62 vs. 45%) compared with control heifers, despite no difference ($P = 0.51$) in overall pregnancy rate. In Exp. 3, no differences ($P \geq 0.39$) were noted in BW across all time points. Also, BCS did not differ ($P \geq 0.45$) at initiation, AI, or final pregnancy conformation. Interestingly, there was a tendency ($P = 0.10$) for TMI heifers to have an increased BCS at the time of breeding compared with control heifers. However, there were no differences ($P \geq 0.50$) in AI and overall pregnancy rates. In 1 of 3 experiments, an injectable trace mineral administered 33 d prior to the breeding season tended to result in increased AI conception rates of heifers even when adequate trace mineral supplement was provided. The variable response observed across experiments may be caused by differences in breed, calving season, mineral sources, and management strategies.

**Key Words:** beef heifer, injectable trace mineral, reproduction

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**352 Effect of late-gestation supplementation and postpartum progestin on probability of culling spring calving cows in the Nebraska Sandhills.**

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A 2-yr study evaluated effects of late-gestation supplementation and postpartum progestin administration on culling rate of March calving cows. In yr 1, 120 crossbred beef cows (479 ± 57 kg BW) were assigned to 1 of 4 levels of late-gestation supplementation and postpartum progestin or control in a 4 × 2 factorial arrangement of treatments in a completely random design. The 4 supplement (32% CP; DM) levels were 1) 0 kg/d December 1 to March 1, 2) 0.41 kg/d DM December 1 to March 1, 3) 0.41 kg/d DM January 15 to March 1, or 4) 0.82 kg/d DM January 15 to March 1 while cows grazed dormant upland Sandhills range. Approximately 3 mo postpartum, cows from each supplement treatment received either 1) a controlled internal drug release device for 7 d or 2) no progesterone administration. Cows were culled for 1 of 2 production reasons: 1) failure to produce a calf or 2) failure to become pregnant. Culled cows were not replaced, but stocking rate was maintained. Previous analysis of these data demonstrated that higher levels of late-gestation supplementation increased cow BW ($P < 0.05$) and cow BCS ($P < 0.05$) but did not affect ($P < 0.12$) reproductive measures or calf performance. Using a limited dependent variable methodology, it was determined that late-gestation supplementation decreased culling rate. Conversely, feeding no supplement from December 1 to March 1 significantly ($P < 0.02$) increased the probability of cows being culled. Feeding supplement from December 1 to March 1 decreased the probability of a cow being culled ($P < -0.01$; 7 vs. 20% for supplement vs. no supplement, respectively). Neither level of supplementation from January 15 to March 1 altered ($P < -0.19$) the number of cows culled compared with the December 1 to March 1 supplementation treatment. Postpartum exogenous progesterone administration did not ($P < 0.60$) influence the culling rate of beef cows. Supplementation for the duration of the winter grazing period decreased culling rate but did not influence pregnancy rate or calf performance.

**Key Words:** beef cow culling, progesterone, supplement

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**353 Effect of maternal nutrition on performance of Nellore cows and preweaning growth of their progeny.** L. M. Rodrigues[1,*], J. P. Schoonmaker[2], F. D. Resende[3], G. R. Siqueira[3], O. R. Machado Neto[4], T. R. Gionbelli[1], M. M. Ladeira[1], *[1]Federal University of Lavras, Lavras, Brazil, [2]Purdue University, West Lafayette, IN, [3]Agência Paulista de Tecnologia dos Agronegócios – APTA, Colina, Brazil, [4]Universidade Estadual Paulista, Botucatu, Brazil*.

The majority of developmental programming studies with beef cows have been conducted with *Bos taurus*. Little is known about developmental programming in *Bos indicus*, particularly the Nellore breed, which is the predominant beef breed in Brazil. The aim of the present study was to determine the effect of maternal nutrition on cow performance as well as the development of the calves until weaning. Ninety-two multiparous Nellore cows (387 ± 9.0 kg initial BW) were allotted to a completely randomized design with 2 treatments. Cows were inseminated with male semen from the same bull at 2 different time points. Forty-six cows were fed only mineral (control) and the other 46 were fed a protein supplement (33% CP, 1% BW) from Day 125 of gestation until calving. Cows were grazed on *Brachiaria brizantha* cv. Marandu pastures (8.2% CP and 68.5% NDF). At calving, cow–calf pairs were commingled and grazed on the same pasture until weaning. Least squares means for all data were computed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). Cow BW and BCS did not differ at any time point during the study ($P \geq 0.25$); however, cows that were supplemented with protein gained more BW ($P = 0.03$) and body condition ($P = 0.05$) during gestation. As a result, pregnancy rate in the subsequent breeding season tended ($P = 0.10$) to be greater for cows supplemented with protein. On the other hand, BW gain during lactation was greater for cows from the control group ($P = 0.05$). Calves from cows supplemented with protein had greater birth BW compared with calves from cows not supplemented ($P = 0.05$). Calf BW at 119 d or at weaning did not differ, nor did calf BW gain from birth to weaning ($P \geq 0.77$). In conclusion, supplementation of pregnant Nellore cows with protein during the dry season improves calf birth BW, cow BW gain, and body condition during gestation and can help cows recover sooner from calving.

**Key Words:** beef cattle, fetal programming, supplementation
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**354 Effects of a multielement trace mineral injection and dietary vitamin E supplementation on performance, carcass characteristics, and color stability of strip steaks from beef heifers.** B. N. Harsh*, A. C. Dilger, D. D. Boler, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana*.

The objective was to evaluate the interaction of a trace mineral injection (Multimin 90; TM) and a supranutritional level of dietary vitamin E (VITE) supplementation on performance, carcass characteristics, and color stability of strip steaks from beef heifers. Prior to trial initiation, Angus × Simmental crossbred heifers ($n = 48$) were managed on a common, trace mineral maintenance diet. Heifers were stratified by BW and allotted to 1 of 4 treatments in a 2 × 2 factorial arrangement: 1) saline injection and no additional vitamin E in the diet, 2) trace mineral injection and no additional vitamin E in the diet, 3) saline injection and 2,000 IU vitamin E heifer$^{-1}$ d$^{-1}$, or 4) trace mineral and 2,000 IU vitamin E heifer$^{-1}$ d$^{-1}$. Trace mineral injection (1 mL/68 kg BW) or saline injection was given once at the beginning of the 89-d finishing period. Diets contained 35% dry-rolled corn, 35% modified wet distiller's grains plus solubles, 20% corn silage, and 10% supplement. Cattle were slaughtered as one group, and strip loins were collected postmortem. Strip steaks were cut from each carcass and placed in overwrap trays for serial evaluation of color stability for 16 d. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) with fixed effects of VITE and TM and their interaction, and pen included as a random effect. Color stability data were analyzed as repeated measures. Trace mineral injection and VITE had no effect on final BW, DMI, or G:F ($P \geq 0.12$). Trace mineral injection and VITE had no effect on HCW, yield grade, 12th-rib backfat thickness, or rib eye area ($P \geq 0.34$). Marbling scores tended to increase ($P = 0.08$) in VITE heifers compared heifers not supplemented with VITE. Vitamin E supplementation reduced final lipid oxidation (1.00 vs. 1.97 μg MDA/g fat; $P = 0.03$) and total visual discoloration

**Table 353.** Performance of cow and calf until weaning

| Item | Control | Supplement | SE | *P*-value |
|---|---|---|---|---|
| Cow weight, kg | | | | |
| Day 0 | 390.2 | 384.6 | 9.03 | 0.69 |
| Before calving | 468.7 | 479.9 | 8.29 | 0.34 |
| After calving | 424.1 | 436.6 | 8.30 | 0.28 |
| Weaning | 479.0 | 465.6 | 15.53 | 0.54 |
| Weight gain, gestation | 79.2 | 95.3 | 5.27 | 0.03 |
| Weight gain, lactation | 59.1 | 26.4 | 11.78 | 0.05 |
| Day 0 BCS | 5.23 | 5.02 | 0.12 | 0.25 |
| Precalving BCS | 5.24 | 5.39 | 0.12 | 0.36 |
| Change in BCS | 0.01 | 0.36 | 0.13 | 0.04 |
| Pregnancy rate, % | 62.1 | 78.6 | – | 0.09 |
| Calf weight | | | | |
| Birth | 33.7 | 35.8 | 0.78 | 0.05 |
| Weaning | 205.5 | 207.3 | 4.42 | 0.77 |

(15.82 vs. 33.96%; $P = 0.04$) of steaks compared with steaks from nonsupplemented heifers. Heifers fed supranutritional levels of VITE produced steaks that maintained retail color longer, evidenced through lower hue angle values (38.17 vs. 38.66°; $P < 0.01$) than heifers not supplemented with VITE. Interestingly, steaks from heifers receiving TM had greater visual discoloration (27.68 vs. 22.09%; $P < 0.05$) at the end retail display compared with steaks from heifers receiving saline injection. Overall, VITE supplementation improved color stability and TM appeared to increase the rate of discoloration of strip steaks from beef heifers.

**Key Words:** beef heifers, color stability, vitamin E
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**355 Comparison of trace mineral repletion strategies to overcome a high antagonist diet.** S. J. Hartman*, O. N. Genther-Schroeder, S. L. Hansen, *Iowa State University, Ames*.

The objective was to compare trace mineral (TM) repletion strategies after depletion by S and Mo. Seventy-two Red Angus steers were blocked by BW (254 ± 14 kg) and assigned equally (6 steers per pen, fed via GrowSafe bunks) to corn silage–based depletion period diets either supplemented with Cu, Mn, Se, and Zn at NRC recommendations (CON) or supplemented with 0.3% S ($CaSO_4$), 5 mg of Mo/kg DM, and no added TM (DEP). Ending depletion liver Cu, Mn, and Se concentrations were lesser ($P < 0.0001$) for DEP vs. CON, whereas Zn was not different ($P = 0.28$). On d 89, steers were equally divided within diet to 1 of 3 TM repletion strategies: 1) Multimin90 injection (contained Cu, Mn, Se, and Zn) and 100% of NRC dietary TM supplementation from inorganic sources (ITM), 2) saline injection and 150% of NRC from inorganic sources (ING), or 3) saline injection and 150% of NRC recommendations provided as 25% organic and 75% inorganic sources (BLEND). Depletion steers received supplemental S and Mo throughout repletion. Liver TM was determined on d −9, 14, 28, and 42 of the repletion period and analyzed as repeated measures using PROC GLIMMIX ($n = 12$ per treatment). The interaction of depletion × repletion strategy × day was not significant for any variable ($P \geq 0.19$). Liver Se ($P < 0.0001$) and Zn ($P = 0.09$) concentrations were lesser in DEP vs. CON throughout repletion. Depletion diet by day ($P < 0.0001$) affected liver Cu, where CON did not differ across repletion (averaging 262 mg/kg DM) whereas DEP increased across all days, ending at 71 mg/kg DM. Repletion Cu and Se were affected by repletion strategy × day interactions ($P < 0.0001$), where d 0 and 42 values were similar across TM sources, d 14 ITM values were greater than other treatments, and d 28 ITM values were greater than ING, whereas BLEND tended to be (Cu) or was greater than (Se) than ING. At the start of repletion, liver Mn concentrations were lesser in steers assigned to ITM than ING and BLEND ($P \leq 0.004$); however, on d 14, ITM and ING steers had greater liver Mn than BLEND steers ($P \leq 0.04$), with no differences on d 28 and 42. These data suggest that regardless of dietary antagonists, ITM rapidly repleted Cu and Se, whereas similar repletion took 28 and 42 d for the BLEND and ING treatments, respectively.

**Key Words:** cattle, sulfur, trace minerals
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**356 The effects of supplementing eicosapentaenoic acid and docosahenaenoic acid during late gestation on lamb metabolism and performance.** D. N. Coleman[1,*], A. Relling[1], K. C. Rivera-Acevedo[2], *[1]Department of Animal Sciences, The Ohio State University, Wooster, [2]University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico*.

Fatty acids are involved in the regulation of many physiological pathways and can have lifelong impacts on offspring development and metabolism via maternal supplementation. Therefore, our objective was to investigate the impact of supplementing ewes with a diet enriched in omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahenaenoic acid (DHA) during late gestation on lamb metabolism and performance. Eighty-four gestating ewes were blocked by conception date into group pens with 3 animals per pen and randomly assigned to a diet enriched with MUFA (EnerG II) or the PUFA (STRATA G113) EPA and DHA during the last 50 d of gestation. With a biohydrogenation rate of 50%, the target dose of EPA and DHA supplemented was 18 mg/kg of metabolic BW ($BW^{0.75}$), with total fat supplementation on MUFA and PUFA being fed at the same percent of the diet. After lambing, ewes and lambs were placed on pasture until weaning at 60 d of age. Lambs born from these ewes were weighed and bled at Day 0, 30, and 60. Plasma glucose, NEFA, and insulin were measured using colorimetric assays, and ADG was calculated. An immunoassay was tested to measure the metabolic hormone adropin, measuring parallel displacement and recovery. For insulin and adropin, only the Day 60 plasma samples were used. Data were analyzed as a randomized complete block design with repeated measurements (SAS 9.4; SAS Inst. Inc., Cary, NC). Lambs born form ewes supplemented with MUFA or PUFA did not have different BW (15.8 kg for MUFA and 16.4 kg for PUFA; $P = 0.22$), ADG (0.32 kg/d for MUFA and 0.34 kg/d for PUFA; $P = 0.21$), or plasma glucose (93.68 mg/dL for MUFA and 96.47 mg/dL for PUFA; $P = 0.50$) and NEFA (514.68 mg/dL for MUFA and 493.39 mg/dL for PUFA; $P = 0.52$) and insulin (0.22 ng/mL for MUFA and 0.25 ng/mL for PUFA; $P = 0.59$) concentrations. Human adropin assays are a valid method to measure ovine adropin concentration. This study suggests that supplementation of ewes with EPA and DHA compared with MUFA during late gestation does not have any significant impact on their offspring up to weaning. Further laboratory analyses will confirm whether the dose of EPA and DHA was high enough to increase concentrations of these fatty acids in

ewe and lamb plasma. Future research should investigate the potential effects of supplementing higher doses of EPA and DHA to ewes during late gestation and effects on offspring.

**Key Words:** essential fatty acids, fetal programming, metabolism
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**357 Two-year study: Effect of backgrounding system on growing and finishing performance and carcass characteristics of beef steers.** J. L. Cox[1,*], K. Hales[2], K. M. Ulmer[1], R. J. Rasby[1], S. D. Shackelford[2], H. C. Freetly[2], M. E. Drewnoski[1], [1]*University of Nebraska-Lincoln, Lincoln,* [2]*USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE*.

A 2-yr study evaluated growing and finishing performance as well as carcass characteristics of spring-born calves backgrounded using 1 of 3 treatments: 1) corn residue grazing supplemented 6 d/wk with 2.77 kg DM/calf of distiller's (CRD), 2) oat–brassica forage grazing (OBF), or 3) drylotting on a grower ration (DGR). Steers ($n$ = 715) were stratified by BW (278 kg ± 1.2 in yr 1 and 291 kg ± 4.8 in yr 2) and assigned to treatment and replicate (4 replicates each year). Oat–brassica forage consisted of 27.9% turnip, 13.6% radish, and 58.5% oats (DM basis). The grower ration contained 51% corn silage, 25% alfalfa hay, 20% wet distiller's grains with solubles (WDGS), and 4% supplement (DM basis). The CRD and OBF calves grazed for 65 d and then were fed the grower ration for 27 d, whereas the DGR calves were fed the grower ration for 53 d. During backgrounding, the ADG of DGR calves (1.48 kg/d) was greater ($P < 0.01$) than that of both OBF calves (1.05 kg/d) and CRD calves (0.87 kg/d), and ADG of OBF calves was greater ($P < 0.01$) than that of CRD calves. At the start of finishing, BW of OBF calves (381 kg) was greater ($P < 0.01$) than that of DGR calves (361 kg) and CRD calves (366 kg). The finishing diet was fed for 160 d across all treatments and consisted of 55.8% dry-rolled corn, 32.3% WDGS, 8.7% corn silage, and 3.2% supplement. Finishing G:F was greater ($P < 0.01$) for DGR calves (0.167 and 0.156, respectively) than for OBF calves (0.156 and 0.149, respectively) in both years and greater ($P < 0.01$) than that of CRD calves in yr 1 (0.155) but was not different ($P = 0.13$) in yr 2 (0.151). At harvest, HCW of OBF calves (401 kg) was greatest ($P < 0.01$) whereas that of CRD calves (393 kg) was intermediate and that of DGR calves (391 kg) was least. Both 12th-rib fat ($P = 0.89$) and calculated YG ($P = 0.39$) did not differ among treatments. Marbling was greater ($P = 0.01$) for DGR calves (429) than for CRD calves (414), whereas that of OBF calves (424) was not different from that of DGR ($P = 0.30$) or CRD calves ($P = 0.10$). Although calves drylotted and fed a grower ration had greater ADG, the lower cost of gain associated with the grazing systems make these backgrounding methods economically competitive. Additionally, based on marbling, the quality of carcasses produced by grazing oat–brassica forage did not differ from calves fed a corn silage–based ration during the growing phase.

**Key Words:** backgrounding calves, brassicas, carcass quality
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**358 Identification of a novel rumen bacteria using starch as a selective nutrient in batch cultures.** V. Bandarupalli[*], B. St-Pierre, *South Dakota State University, Brookings*.

The bovine rumen is a complex and diverse microbial ecosystem composed of bacteria, protozoa, fungi, and bacteriophages. Among these diverse and complex microbes, bacteria are the predominant community, with a range of $10^{10}$ to $10^{13}$ cells per gram of ruminal contents that play a vital role in the fermentation process. However, the knowledge about the role of most bacteria in digestion of feedstuff is still in its infancy. The primary objective of this research was to identify uncharacterized bacteria that are involved in metabolizing starch. Our general approach involved collecting rumen fluid from cannulated cattle to culture under anaerobic conditions at a constant temperature in laboratory-scale bioreactors. More specifically, for this experiment, 3 treatment replicate cultures were supplemented with starch (ADM Corn processing, Clinton, IA) as substrate and 2 replicate cultures received no supplementation. To determine bacterial composition, microbial DNA was extracted from bioreactor samples collected on d 0, 7, and 14 followed by PCR amplification of the 16S rRNA gene (V1–V3 region), and amplicons were sequenced using the Illumina Miseq 2 × 300 platform. A combined total of 309,715 high-quality sequence reads were used to determine the bacterial composition in control and treatment groups. The number of reads per sample ranged between 49,517 and 131,704. Our results showed that 1 species-level operational taxonomic unit (OTU), corresponding to an uncultured species of *Prevotella*, was enriched on Day 7 (15.6 ± 3.22) and 14 (17.7 ± 5.02) in treatment groups when compared with control cultures (0.17 ± 0.08). Differences between starch and control were found to be statistically significant (ANOVA, $P < 0.05$). A better understanding of the role of novel bacteria in feed digestion will provide new avenues for developing supplements or feed additives that support animal health and increase production efficiency of the livestock industry.

**Key Words:** operational taxonomic unit, rumen bacteria, starch
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**359 In vitro apparent ruminal digestibility of diets containing corn distiller's grain with different quantities of crude fat.** D. E. Williams[1,*], R. L. Atkinson[1], P. M. Walker[2], [1]*Southern Illinois University Carbondale, Carbondale,* [2]*Illinois State University, Normal, IL*.

Four dual-flow continuous fermenters were used in a Latin square design to determine the apparent ruminal digestibility and ruminal characteristics of diets containing distiller's dried grains with solubles (DDGS) at different levels of fat content. Fermenters were randomly assigned to one of the following treatments: 1) 40% DDGS containing 4.82% fat content (40LOW), 2) 40% DDGS plus corn oil to obtain 7.5% fat (40MED), 3) 40% DDGS plus corn oil to obtain 10.5% fat (40HIGH), or 4) 70% DDGS plus corn oil to obtain 7.5% fat (70MED). Rumen fluid was collected at the beginning of each period from 2 ruminally cannulated Angus cows previously adapted to diets containing DDGS. Each period consisted of 10 d with a 7-d adaptation period followed by 3 d of sample collection. Calories per gram of diet increased as percent fat increased, and calories per gram was greater at the 70% inclusion of DDGS compared with 40% inclusion of DDGS at all levels of fat content. However, level of fat in the diet did not affect ($P \geq 0.35$) apparent ruminal digestibility of DM, NDF, ADF, of CP or total calories. Similarly, inclusion rate of DDGS had no effect ($P \geq 0.35$) on nutrient digestibility. Ammonia concentrations were greatest ($P = 0.0002$) for 70MED compared with the other treatments. However, treatment had no effect ($P \geq 0.16$) on VFA production with the exception of propionate, which increased ($P = 0.05$) as the level of DDGS increased from 40 to 70% inclusion rate. This data would suggest that level of fat content of DDGS has no negative effects on apparent ruminal digestibility and selected ruminal characteristics. From an economic perspective, higher fat DDGS should have a higher price differential, but lower fat DDGS can still be an effective protein and energy substitute.

**Key Words:** calories, corn distiller's grains, digestibility
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**360 Effects of feeding two levels of a pelleted thirty-percent pea starch and seventy-percent dry distiller's grain feed in feedlot finishing diets on animal performance and carcass characteristics.** C. L. Engel[*], *Carrington Research Extension Center, North Dakota State University, Carrington*.

One hundred seven Angus and Angus-cross steers were used in a feedlot finishing study to evaluate feeding 2 dietary levels of a combined pea starch (PS) and corn distiller's dried grains with solubles (DDGS) pelleted feedstuff. Steers were blocked by initial BW (average 456 ± 2.11 kg) and sorted into 4 weight blocks. Within block, cattle were randomly assigned and sorted into 1 of 12 pens. Pens were randomly assigned to 1 of 3 dietary treatments. Air-fractionated PS and DDGS were combined at a rate of 30% PS and 70% DDGS into a small diameter feed pellet (PS-DDGS). The 3 treatment diets were control (Con), 15% PS-DDGS pellet (15PS-DDGS), and 30% PS-DDGS pellet (30PS-DDGS). The Con diet included 64% dry-rolled corn, 14% straw, 20% DDGS (no PS), and 2% vitamin and mineral supplement (VMS). The DDGS was from the same source used in the PS-DDGS pellet. The 15PS-DDGS diet included 69% rolled corn, 15% PS-DDGS, 14% straw, and 2% VMS. The 30PS-DDGS diet included 54% rolled corn, 30% PS-DDGS, 14% straw, and 2% VMS. The 2 PS-DDGS diets contained no additional DDGS besides what was contained in the pellets. All diets were similar in energy at 1.30 Mcal/kg NEg. Crude protein was 13.7, 11.8, and 14.2% for Con, 15PS-DDGS, and 30PS-DDGS diets, respectively. Steers were weighed every 28 d and at the time of marketing. Steers were fed an average of 101 d. Hot carcass weights were recorded on the day of harvest. Carcass 12th-rib fat thickness (BF), LM area (LMA), and USDA marbling score and yield grades (YG) were recorded following a 24-h chill. Initial and final BW were similar ($P \geq 0.35$) for the Con, 15PS-DDGS, and 30PS-DDGS treatments. Although DMI was similar ($P = 0.33$) across all treatments, the 30PS-DDGS-fed cattle tended ($P = 0.10$) to have higher G:F than cattle fed the 15PS-DDGS and greater ADG than cattle on the 15PS-DDGS and Con treatments ($P = 0.10$). Hot carcass weight, YG, LMA, and marbling score were similar ($P \geq 0.23$) for the Con, 15PS-DDGS, and 30PS-DDGS treatments. Final BF was similar for 30PS-DDGS and Con but greater than 15PS-DDGS ($P = 0.02$). The PS-DDGS pellet effectively replaced DDGS and some corn in feedlot finishing diets. The 30PS-DDGS inclusion level improved animal performance and feed efficiency compared with the 15PS-DDGS inclusion level.

**Key Words:** beef cattle, distiller's dried grains with solubles, pea starch
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**361 Effects of whole or rolled corn diets on steer growing and finishing feedlot performance.** C. L. Engel[*], *Carrington Research Extension Center, North Dakota State University, Carrington*.

Crossbred steers ($n = 192$; 302 ± 0.52 kg average initial BW) were used in a 61-d growing and 79-d finishing study to evaluate feeding whole or rolled corn in growing and finishing diets. Steers were blocked by initial BW and randomly allotted to 16 pens (12 steers/pen). The pens were randomly assigned to 1 of 2 corn treatments: whole corn (WC) or dry-rolled corn (DRC). The backgrounding diets were 18% straw, 26% corn silage, 28% modified distiller's grain (MDGS), 26% corn, and 2% vitamin and mineral supplement (VMS). The finishing diets were 9% straw, 12% corn silage, 26% MDGS, 51% corn, and 2% VMS. Steers were individually weighed on d 0 and approximately every 28 d through the growing and finishing

phases. Steers were given an anabolic implant (36 mg estradiol from zeranol) prior to arrival at the feedlot. Steers were reimplanted with 120 mg TBA and 24 mg estradiol on d 61. Cattle were harvested at a commercial abattoir on d 140. Hot carcass weights were taken at harvest and the following carcass attributes were evaluated after a 24-h chill: 12th-rib fat depth, LM area, KPH, marbling, and USDA yield grade. Performance and carcass variables were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC), with pen serving as the experimental unit. Initial, 61 d, and final BW were similar for both the WC and DRC treatments ($P \geq 0.64$). There were no differences in growing and finishing period or overall ADG between treatments ($P \geq 0.22$). Additionally, DMI was similar ($P \geq 0.21$) among treatments overall and across both the growing and finishing phases. The G:F was also similar ($P \geq 0.23$) among corn treatments overall and across both the growing and finishing phases. All carcass characteristics were similar ($P \geq 0.71$) for WC and DRC treatments. These results indicate that feeding either whole or dry-rolled corn through the growing and finishing phases will result in similar animal performance and carcass characteristics.

**Key Words:** beef cattle, rolled corn, whole corn
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**362 Novel direct-fed microbials to control acidosis and liver abscesses in cattle.** S. K. Rohde*, *Department of Animal Science, University of Nebraska-Lincoln, Lincoln*.

In recent years, the use of antibiotics in food animals has come under great scrutiny. Studies have demonstrated that continuous use of antibiotics can result in collections of antibiotic resistance genes within bacteria. Such resistant microbes present in cattle and other livestock species can pose a threat to humans by contamination of food or during handling of animals. As such, developing novel strategies to reduce antimicrobial use while improving animal health and efficiency is critical. One such alternative strategy is the use of direct-fed microbials to replace antibiotics. In the current study, we isolated 2 species of bacteria from the rumen of animals fed a distiller's grain plus solubles diet where each could be used to control *Streptococcus bovis* and *Fusobacterium necrophorum* populations in cattle. The isolates were tested for their ability to inhibit *S. bovis* and *F. necrophorum* using the Kirby–Bauer disk diffusion susceptibility test using Mueller Hinton agar plates with 5% sheep blood. The resulting positive isolates were characterized by 16S rRNA sequencing. The sequence analysis revealed that the isolates belong to the genus *Aneurinibacillus* (*A. migulanus* and *A. aneurinilyticus*). The cell extracts of the isolates were used for disk diffusion assays and for growth curve experiments that revealed inhibition of both *S. bovis* and *F. necrophorum* by each isolate. Finally, in vitro acidosis induction experiments were performed using live cells and cell extracts of *A. aneurinilyticus* to evaluate the control of ruminal pH during acidosis induction. The in vitro induction experiments revealed that *A. aneurinilyticus* cell extract and live cells can protect ruminal pH (higher pH) better than the induced control. Currently the genome sequencing of the 2 strains is underway to identify the mode of inhibition. This study demonstrates the potential of direct-fed microbials as a viable strategy to control pathogenic and other inhibitory microbial populations in the rumen, decreasing the use of antibiotics.

**Key Words:** acidosis, direct-fed microbials, ruminal pH
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**363 Effects of foliar fungicide on whole plant brown midrib and floury corn varieties.** R. T. Pate[1,*], M. Weatherly[1], L. B. Hedges[2], S. Mideros[2], G. M. Fellows[3], F. Cardoso[1], *[1]Department of Animal Sciences, University of Illinois at Urbana-Champaign, Urbana, [2]Department of Crop Sciences, University of Illinois at Urbana-Champaign, Urbana, [3]BASF Corporation, Research Triangle Park, NC*.

Dairy producers rely on whole-plant corn silage (WPCS) as a main forage source for high-performance dairy cattle. However, fungal disease can have a negative impact on yield, health, and performance of corn plants for WPCS. The objective of this study was to determine the effect of foliar fungicide application on 2 corn varieties for WPCS. Brown midrib (BMR) and floury-leafy (FLY) varieties were planted in 6.76 ha (3.38 ha per variety). Treatments were BMR without fungicide (BMR/CON), FLY without fungicide (FLY/CON), BMR with fungicide (BMR/FUN), and FLY with fungicide (FLY/FUN). At vegetative tassel (VT) stage, fungicide was applied on both varieties (Headline AMP; BASF Corp.). Statistical analysis was conducted using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC). Disease evaluations were conducted on 10 random plants in each plot at VT and reproductive stage 5 (R5; kernel dent), and prevalence was measured as a percent of whole plant infected by gray leaf spot (GLS). The number of yellow leaves was counted at R5. Plant weight and height and cob weight measurements occurred at VT and R5 by measuring 12 random plants from each plot. All treatments were harvested at R5 with DM of 27, 31, 28, and 30% for BMR/FUN, BMR/CON, FLY/FUN, and FLY/CON, respectively. Dry matter was lower ($P < 0.001$) for corn treated with FUN than CON. Total yield (t/ha) tended to be higher ($P = 0.08$) for FUN (67.70 ± 1.53) than for CON (63.63 ± 1.53). However, DM yield (t/ha) tended to be lower ($P = 0.10$) for FUN (18.54 ± 0.53) than for CON (19.30 ± 0.53). The GLS prevalence was lower ($P < 0.001$) for plants treated with FUN (5.1 ± 0.2%) than for CON (19.5 ± 0.2%). Plants in FUN (737.89 ± 16.39 g) were heavier ($P < 0.001$) than plants in CON (671.60 ± 16.42 g). Plants in FUN were taller (270.79 ± 1.35 cm; $P < 0.001$) than plants in CON (265.56 ± 1.35 cm). There were fewer yellow leaves ($P < 0.001$) in FUN (0.09 ± 0.02) than in CON (0.26 ± 0.02) plants. Cob weight was higher

($P = 0.02$) for FUN (150.19 ± 2.38 g) than for CON (141.01 ± 2.42 g) plants. In conclusion, fungicide treatment increased total yield, health, and performance of corn plants and, thus, could have a positive impact on WPCS to be fed to cattle.

**Key Words:** corn plant, corn silage, foliar fungicide
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**364 Effects of excess dietary sulfur on mitochondrial complex IV activity in beef steers.** J. Hawley[1,*], E. B. Kegley[1], D. L. Galloway[1], W. G. Bottje[2], *[1]Department of Animal Science, Division of Agriculture, University of Arkansas, Fayetteville, [2]Department of Poultry Science, Division of Agriculture, University of Arkansas, Fayetteville*.

In ruminants, the ingestion of large amounts of dietary S can lead to acute S toxicosis. Sulfide is readily absorbed through the rumen wall into the bloodstream, and once absorbed, sulfide is thought to be involved in the competitive inhibition of mitochondrial complex IV, resulting in a shutdown of the mitochondrial electron transport chain and cellular ATP generation. Therefore, to test the effects of excess dietary S on mitochondrial complex IV activity in beef steers, 20 steers (283 ± 7.2 kg initial BW; 13 ± 0.6 mo of age) of predominantly Angus breeding were stratified by initial BW and randomly assigned to 1 of 6 pens (3 to 4 steers/pen). Pens were randomly assigned to 1) no additional S (approximately 0.15% S) or 2) high S (0.40% S; from $Na_2SO_4$). Steers grazed fall mixed-grass pastures and were offered corn and soybean meal supplements for a 114-d growing phase. When the average BW of the steers reached 373 ± 0.2 kg, steers were stratified within dietary treatment by BW and randomly assigned to 16 drylot pens (1 to 2 steers/pen; 8 pens/dietary treatment). Steers remained on the same dietary treatments and received corn and soybean meal concentrate diets for a 123-d finishing phase. Steers were slaughtered at an average BW of 565 ± 38.4 kg. Liver and LM samples were collected immediately postmortem and snap-frozen. Mitochondrial protein yield and complex IV activity obtained from liver and LM mitochondrial preparations were spectrophotometrically measured. Liver mitochondrial protein yield was 2.41 times greater ($P < 0.0001$) compared with the LM mitochondrial protein yield. There was no effect ($P \geq 0.66$) of dietary S on the extractable yield of mitochondrial protein per gram of liver or LM. Liver and LM mitochondrial complex IV activities were not ($P \geq 0.38$) influenced by dietary S. These results suggest that feeding beef steers 0.40% S in the total diet DM is insufficient to cause measureable mitochondrial complex IV activity inhibition. Understanding the role of mitochondrial complex IV activity inhibition in ruminants ingesting large amounts of dietary S will aid in understanding the cellular basis of S toxicosis.

**Key Words:** beef steers, mitochondrial complex IV activity, sulfur
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**365 Essential oils and prebiotics (Stay Strong and Start Strong) for newborn calves.** C. Louwagie[1,*], D. P. Casper[2], C. Chase[1], K. Abdelsalam[1], *[1]South Dakota State University, Brookings, [2]Formerly South Dakota State University, Brookings*.

Stay Strong (SS) is a blend of essential oils (EO) and prebiotic fiber technologies. Start Strong also contains a colostrum supplement. Both products (Ralco Inc., Marshall, MN) are designed to diminish health challenges and stresses experienced by newborn calves while aiding to establish a strong immune system and stimulate appetite. The study objectives were to determine the growth rate of calves receiving SS along or in combination with Start Strong (SSS) compared with a non-medicated milk replacer (MR). Sixty Holstein calves were blocked by birth date and randomly assigned to 1 of 3 treatments. Treatments were control (CON), a 24:20 all milk MR; SS mixed into the 24:20 MR at a rate of 0.05% (SS); and SS fed in combination with calves receiving 2 to 10 mL treatments of Start Strong at 12-h intervals after birth (SSS). Calves were sourced within 2 wk in June 2016 from a commercial dairy farm. The 24:20 MR was fed via bucket 2 times/d at a rate of 0.28 kg/calf per day for 14 d, which was increased to 0.43 kg/calf until 35 d and reduced to 1 time/d at 36 d to facilitate weaning at 42 d. Decoquinate was added to the MR at 41.6 mg/kg for coccidiosis control. Calves were housed in individual Calf-Tel hutches bedded with straw and had ad libitum access to a 20% CP calf starter (CS) and water. All data was analyzed using the PROC MIXED of SAS (SAS Inst. Inc., Cary, NC) as a completely random design. Calves were similar ($P > 0.10$) in ADG (0.52, 0.55, and 0.52 kg/d for CON, SS, and SSS, respectively) and BW gains (29.1, 30.9, and 29.3 kg) through 56 d. Frame size gains (final − initial) as measured via body length (33.5, 32.8, and 34.8 cm), heart girth (39.6, 38.4, and 37.8 cm), hip height (23.1 20.1, and 23.4 cm), wither height (25.7, 25.1, and 24.4 cm), and hip width (52.6, 56.9, and 53.1 cm) were similar for calves fed all treatments. Body temperatures measured via a thermal imaging camera (28.1, 28.2, and 27.6°C) were similar for calves fed all treatments. This study did not confirm our previous results of a growth response with SS; however, the feeding rate used in this study was one-half of the feeding rate in our previous work. Therefore, the feeding rates may be below an efficacious concentration of the technology to enhance growth performance.

**Key Words:** calf, essential oils, prebiotics
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**366 Preference of carinata meal compared with other oilseed meals and distiller's dried grains by dairy heifers.** K. Rodriguez-Hernandez[1,2,*], J. L. Anderson[1], M. A. Berhow[3], *[1]Dairy Science Department, South Dakota State University, Brookings, [2]CIRNOC-INIFAP, Matamoros, Mexico, [3]USDA, ARS, NCAUR, Peoria, IL*.

Different oilseed meals contain different types and amounts of glucosinolates, which may cause bitter tastes. Our objective was to determine if the type and content of glucosinolates in carinata meal affect dairy heifer preference and intake compared with other oilseed meals. Six Holstein heifers (7.2 ± 0.3 mo old; 234.7 ± 15.7 kg BW) were used in a sequential elimination preference study to compare 5 different grain mixes containing 27.4% (DM basis) of carinata meal (CRM), camelina meal (CAM), canola meal (CAN), linseed meal (LIN), and distiller's dried grains with solubles (DDGS). Glucosinolates concentrations were 6.09, 3.24, 0.23, 0, and 0 g/kg of DM for CRM, CAM, CAN, LIN, and DDGS grain mixes, respectively. Heifers were kept in individual pens (3.7 by 4.5 m) with a row of 7 feed containers. Grain mixes were offered for 30 min in the morning and evening. At each feeding, the positions of grain mixes were randomized and the 2 end containers were left empty to nullify effects of placement. Grass hay was fed at 1.6% of BW throughout the day in a separate tub. During phase 1, all 5 grain mixes were offered for 5 d and the most preferred by each heifer was removed at the end. In the subsequent phases, days and number of grain mixes were sequentially reduced until only 2 grain mixes were offered during 2 d. Preference ranking by heifer was based on intake amounts. Kendall's coefficient of concordance ($W$) was calculated to evaluate the agreement of preference among heifers. Total DMI were 3.90 ± 1.74, 5.91 ± 1.39, 6.60 ± 1.47, and 6.49 ± 1.16 kg/d for phases 1, 2, 3, and 4, respectively. During phase 1, when all grain mixes were offered, grain mix DMI per day were 1.58 ± 0.57, 0.20 ± 0.43, 0.16 ± 0.17, 0.14 ± 0.57, and 0.07 ± 0.13 kg/d for DDGS, LIN, CRM, CAN, and CAM, respectively. Heifers preferred DDGS first and LIN second, CRM and CAN were tied for third, and CAM was fourth with $W = 0.64$ and $P = 0.009$ indicating agreement in preference rankings among heifers. Despite greater glucosinolate content, CRM was comparable to CAN for taste preference, had greater preference compared with CAM, and had less preference compared with DDGS or LIN for dairy heifers.

**Key Words:** carinata meal, dairy heifer, taste preference
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**367 Effect of monensin and protein supplementation on intake and ruminal fermentation parameters in cattle consuming low-quality forage.** J. J. Martinez[1,*], C. A. Loest[2], K. C. McCuistion[1], N. L. Bell[1], L. P. Sastre[1], J. I. Solis[1], *[1]Texas A&M University Kingsville, Kingsville, [2]New Mexico State University, Las Cruces*.

The effect of monensin (Rumensin 90) and protein supplementation on intake, digestion, and ruminal fermentation parameters on cows consuming low-quality forage (LQF; 4.1% CP chopped bluestem hay) was evaluated. Four ruminally cannulated cows (637 ± 24 kg BW) were used in a 4 × 4 Latin square design (20-d periods). Treatments were arranged as a 2 × 2 factorial: the first factor was monensin (0 or 200 mg·cow$^{-1}$·d$^{-1}$) and the second factor was protein supplement (0 or 0.64 kg·cow$^{-1}$·d$^{-1}$ CP provided as cottonseed meal). A premix (0.23 kg·cow$^{-1}$·d$^{-1}$) consisting of ground hay, cracked corn, molasses, salt, dicalcium phosphate, and a commercial mineral premix was provided to all animals and allowed for inclusion of monensin. Animals were housed and individually fed at 0600 h daily. To prevent carryover effects from previous monensin feeding, 14 d were required before sampling. However, to obtain an optimal response from monensin, only 10 d were needed for treatment adaptation. Therefore, during d 1 to 4 of each period, all animals were fed LQF with no treatment. Day 5 through 14 allowed for treatment adaptation and Day 15 through 20 for sample collection. Intake measurements were taken d 15 to 19. Rumen fluid was collected h 0, 2, 4, 8, 12, 16, and 20 on d 20 to determine pH. Data were analyzed using the MIXED procedure in SAS 9.3 (SAS Inst. Inc., Cary, NC) with terms in the model including protein, monensin, and their interaction, with animal and period included as random effects. No protein × monensin interaction ($P = 0.37$) or effect of monensin ($P = 0.32$) was observed for any measure of intake. An effect of protein was observed for total OM intake (TOMI; $P < 0.01$), forage OM intake (FOMI; $P < 0.01$), total NDF intake (TNDFI; $P < 0.01$), and forage NDF intake (FNDFI; $P < 0.01$). Protein increased TOMI by 88.4%, FOMI by 86.8%, TNDFI by 61.6%, and FNDFI by 55.2%. A protein × monensin × hour interaction was observed ($P = 0.005$) for pH. This interaction was likely caused by the interaction of protein with hour after feeding and the interaction of protein and monensin at 0 h after feeding. Results suggest that adding monensin to a protein supplement for cattle consuming LQF will not provide an added improvement on intake compared with protein alone.

**Key Words:** low-quality forage, monensin, protein supplementation
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**368 Effects of balancing feedlot diets for amino acid requirements and effective energy using rumen-protected lysine on growing steer performance.**

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The objective of this study was to evaluate differences in growth characteristics and feed efficiency of feedlot steers consuming varying levels of rumen-protected lysine. We hypothesized that steers consuming a diet optimized for effective energy (EE) and containing a rumen-protected product meeting the predicted lysine requirement would have greater feed efficiency and gain and lesser intakes than steers consuming diets formulated below or above the requirement. After a 3-wk adaptation period, crossbred steers ($n$ = 120; 269 ± 23 kg) were stratified by BW and color, sorted into pens of 6, and fed for 75 d. Diets were balanced to meet EE requirements and not be limited by non-lysine AA. Treatments included a lysine-limiting control that contained no rumen protected products (NEGCON), a lysine-sufficient control that contained rumen-protected soybean meal (POSCON), a treatment that contained 50% of encapsulated lysine (Aji Pro 3G; Ajinomoto Heartland, Inc.) needed to meet the predicted lysine requirement (AJ50), a treatment that contained 100% of encapsulated lysine needed to meet the predicted lysine requirement (AJ100), and a treatment that contained 150% encapsulated lysine needed to meet the predicted lysine requirement (AJ150). The AJ50, AJ100, and AJ150 were predicted to provide 9.3, 18.6, and 37.3 g Aji Pro 3G/animal per day, respectively. Cattle were fed once daily and consumed feed ad libitum from GrowSafe feeders (GrowSafe Systems Ltd., Airdrie, AB, Canada), from which feed intake was measured daily. Data were analyzed using the PROC GLM procedure (SAS version 9.4; SAS Inst. Inc., Cary, NC). Initial BW (kg) did not differ across treatments ($P$ = 0.85). Final BW (396 ± 29 kg) was significantly greater for AJ100 (408 kg) than for NEGCON (392 kg; $P$ = 0.05) and AJ50 (392 kg; $P$ = 0.05) and tended to be greater than POSCON (394 kg; $P$ = 0.10) and AJ150 (393 kg; $P$ = 0.08). Animal DMI (kg/d) did not differ across treatments ($P$ = 0.57). However, DMI (% BW) was significantly lesser ($P$ = 0.05) for AJ100 (1.50% BW) than for AJ150 (1.63% BW). Differences in ADG (kg) were not observed between treatments (1.68 in NEGCON, 1.65 in POSCON, 1.70 in AJ50, 1.84 in AJ100, and 1.70 in AJ150; $P$ = 0.73.) No treatment differences in the F:G ratio ($P$ = 0.61) were observed for AJ100 (4.32) versus NEGCON (5.15), POSCON (5.05), AJ50 (5.06), and AJ150 (5.13). When optimized for AA and EE requirements, AJ100 steers had statistically greater FBW and statistically lesser DMI (% BW) than steers consuming other treatments.

**Key Words:** amino acids, lysine, rumen protected
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**369 Effects of winter grazing stockpiled cool-season grass pastures and method of initiating stockpiling on fall-calving cow production costs in comparison with winter drylot hay feeding systems.**

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To compare costs of grazing stockpiled forages, initiated by different methods, with winter hay feeding for fall-calving beef cows, nine 0.45-ha paddocks of cool-season grasses were blocked in triplicate and randomly assigned 1 of 3 treatments: spring strip grazing (SPG), summer strip grazing (SMR), or summer hay harvest (HAY). For SPG and SMR, live forage mass was estimated with a falling plate meter (4.8 kg/m$^2$), allocated in daily strips (2.4% of BW/d) to 10 fall-calving Angus cows. Hay from HAY paddocks was harvested as large round bales, weighed, core sampled, and stored outside. Paddocks were fertilized with 50.4 kg N/ha as urea. October through January, monthly forage samples were hand clipped to 2.54 cm from six 0.25-m$^2$ locations within each paddock. In November, bales were weighed, dissected, reweighed, and cored to measure nutritional value and recovery of unweathered hay. Forages were weighed, oven-dried for 48 h at 65°C, reweighed to determine DM content, and analyzed for IVDMD, NDF, ADF, ADL, and CP. The Cornell Net Carbohydrate and Protein System was used to meet ME requirements of lactating beef cows (523 kg SBW) using monthly nutritional values of forage or hay with distiller's dried grains with solubles (DDGS). Carrying capacity (CC) of stockpiled pastures was determined as total forage fed and initial stockpiled forage mass, adjusted for grazing efficiencies of 60% for SPG grazing and 70% for SMR and HAY. The CC of a drylot system (DRY), comparable to HAY but without stockpile grazing, was calculated from HAY forage mass in October and amount of hay produced, adjusted for harvest, storage, and feeding losses. Gross feed costs (GROSS; $/animal per day) were calculated as the costs of land rental, DDGS, fencing, harvest, fertilizers, and labor on a fixed land base, divided by winter CC. Net feed costs (NET; $/animal per day) were calculated as total costs on the fixed land base less summer grazing or hay harvest income, divided by winter CC. Carrying capacity was greater for DRY when compared with all other systems ($P$ < 0.05) but did not differ between stockpile systems ($P$ > 0.10). Neither GROSS nor NET costs differed between systems ($P$ > 0.10). The DRY system incurred greater ($P$ < 0.10) total costs per hectare than stockpile systems. There was no significant difference in total cost ($/ha) between SPG, HAY, and SMR ($P$ > 0.10). Although DRY systems had greater total costs, there were no differences in GROSS or NET with yields, costs, and returns used in this study.

**Key Words:** beef cow systems, stockpiled forage, winter grazing economics
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**370 Withdrawn**

**371 Rumen protein degradation characteristics among six protein feed sources using a batch culture system.** M. M. Masiero*, A. L. Landers, M. S. Kerley, *University of Missouri, Columbia*.

Soybean meal (SBM), distiller's dried grains with solubles (DDGS), porcine blood meal (BM), cottonseed meal (CSM), and fish meal (FM) were used to measure N degradation rate (Kd) in a batch culture system by different mathematical models. We hypothesized that protein Kd would differ among feeds when expressed as absolute rate (%/h) and would not differ among feeds when expressed as fractional rate (%/h on potentially digestible). Four experiments were conducted to estimate protein Kd (48-h incubation). Two degradation curves were generated for each feed, and SBM was used as a control for all 4 experiments. Ammonia release was used as an indicator of N degradation, which was measured at 0, 2, 4, 8, 16, 24, and 48 h after flask inoculation. Data were analyzed as a completely randomized design with flask as experimental unit using the GLM procedure of SAS (version 9.3; SAS Inst. Inc., Cary, NC). Absolute and fractional degradation rates were determined from linear and quadratic regressions. Coefficient of determination was greater for quadratic than for linear regression equations for SBM (quadratic $R^2 = 0.96$ and linear $R^2 = 0.88$, $P = 0.005$) and FM (quadratic $R^2 = 0.95$ and linear $R^2 = 0.85$, $P = 0.007$); however, CSM, DDGS, and BM did not differ ($P > 0.05$). Fractional degradation rate, estimated using quadratic regression, did not differ among feed sources ($P = 0.08$). Linear regression equations estimated similar protein degradation among feed sources except for DDGS, which had a faster degradation rate than other feed sources. In conclusion, using quadratic regression equations to estimate protein degradation better agrees with measured protein degradation data than linear regression equations.

**Key Words:** batch culture, nitrogen degradation rate, rumen fermentation
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**372 Young Scholar Presentation: Intestinal barrier function involvement in inefficient nutrient partitioning.** S. K. Kvidera*, L. H. Baumgard, *Iowa State University, Ames*.

The gastrointestinal tract (GIT) serves a dual purpose of nutrient absorption while preventing pathogen infiltration into portal and systemic circulation. The importance of both roles cannot be underestimated, as a variety of situations in animal agriculture reduce GIT barrier function, leading to immunoactivation and inflammation. Intentionally inducing GIT permeability in midlactation dairy cows leads to decreased feed intake and milk yield, increased markers of inflammation, and increased insulin relative to pair-fed controls. Furthermore, feed restriction detrimentally impacts GIT barrier function in cows, and this is accompanied by a linear increase in circulating acute phase proteins with increasing severity of feed restriction. Mild feed restriction decreases the insulin-to-DMI ratio; however, cows under severe feed restriction have a ratio similar to that of cows fed ad libitum, indicating insulin action is prioritized during severe feed restriction despite marked reductions in DMI. These insulin changes are interesting, as feed intake is reduced in both situations yet endotoxin infusion increases circulating insulin. Production, inflammatory, and metabolic patterns observed during intentionally induced GIT permeability and feed restriction mimic other inflammatory situations such as heat stress and ketosis, suggesting a common etiological origin of enhanced GIT permeability. Inflammation resulting from these GIT afflicted situations likely contributes to changes in whole-animal energetics, as an activated immune system demands a large amount of energy and nutrients. Interestingly, immune cells become more insulin sensitive and consume copious amounts of glucose on activation to support proliferation and function. In the acutely activated immune system of a midlactation dairy cow, glucose utilization by the immune system exceeds 1 kg in a 12-h period. Such a large demand for glucose certainly has detrimental effects on production, as the mammary gland requires glucose to synthesize and secrete lactose, the primary osmoregulator of milk yield. Immunoactivation increases immune system glucose utilization while simultaneously decreasing feed intake, therefore reprioritizing the hierarchy of glucose partitioning away from economically important phenotypes. In summary, GIT permeability appears to be the etiological origin of a variety of on-farm disorders (heat stress, ketosis, etc.) characterized by inadequate feed intake. Having a better understanding of the energetic and nutrient requirements of the immune response to GIT permeability is critical to develop strategies to minimize productivity losses when physiological states or environmental conditions activate the immune system.

**Key Words:** glucose homeostasis, inflammation, lipopolysaccharide
doi:10.2527/asasmw.2017.372

**373 Young Scholar Presentation: Making something out of nothing: The potential of calcium hydroxide–treated corn stover for dairy cows.** B. A. Casperson*, S. S. Donkin, *Purdue University, West Lafayette, IN*.

To provide food security as human demands for animal sourced foods increases with the rising global population, there is great need to improve the efficiency of livestock feed resources. Corn stover is an abundant crop residue typically left in the field and rarely used as a feedstuff for lactating dairy cows due to inherently low nutritional value. However, processing

strategies, such as those used in cellulosic ethanol production, that enhance nutrient digestibility of corn stover may enable use in lactating dairy cow diets. Chemical pretreatment of corn stover with 6.6% calcium hydroxide (TCS) improves the digestibility of the corn stover by breaking the lignin barrier and increasing the digestibility of hemicellulose and cellulose. We hypothesized that TCS could replace a portion of traditional forages in diets fed to lactating dairy cows without negatively impacting milk production or milk composition. In Study 1, midlactation Holstein cows ($n$ = 30) were assigned to either a control TMR (CON) or a TMR where TCS replaced alfalfa haylage (HYLGsub) or alfalfa haylage and a portion of the corn silage (HYLG+CSsub) at 15 or 30% of the diet DM, respectively. Dry matter intake was reduced ($P < 0.05$) when cows were fed the HYLGsub diet compared with CON-fed cows. Milk production, milk composition, and 4% ECM were not different ($P > 0.05$) between cows fed the CON, HYLGsub, and HYLG+CSsub diets. Study 2 examined maximal replacement of alfalfa haylage and corn silage with TCS using CON and HYLGsub diets with maximal corn silage replacement at 19% of the diet DM (CSsub) using lactating Holstein cows ($n$ = 6) in a 3 × 3 replicated Latin square. We confirmed that DMI is reduced with TCS inclusion ($P < 0.05$) but milk production and 4% ECM were not different among treatments ($P > 0.05$). Energy corrected milk per unit of DMI was greater ($P < 0.05$) for cows fed TCS even though apparent DM digestibility was reduced ($P < 0.05$) when cows were fed the CSsub diet, indicating an improved efficiency of feed resources with TCS inclusion. Cost–benefit analysis revealed that income over feed costs was improved with TCS inclusion. Taken together, these results demonstrate that TCS can serve as a valuable partial replacement for traditional forages while improving the efficiency of feed converted to milk. Feeding strategies incorporating TCS may allow efficient use of feed resources and help provide food security for the growing population.

**Key Words:** corn stover, feed efficiency, food security
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**374 Growth performance of dairy heifers fed carinata meal.**
K. Rodriguez-Hernandez[1,2,*], J. L. Anderson[1], *[1]Dairy Science Department, South Dakota State University, Brookings, [2]CIRNOC-INIFAP, Matamoros, Mexico*.

Carinata meal is an oilseed meal that is a quality protein source but contains high concentrations of glucosinolates, especially sinigrin. Glucosinolates limit dietary inclusion rates of the meal as they may cause issues with thyroid gland function, which consequently may cause growth issues. Our objective was to determine effects of feeding carinata meal compared with distiller's dried grains with solubles to peripubertal dairy heifers on growth performance. A 16-wk randomized block design experiment with 24 Holstein heifers (6.6 ± 0.7 mo and 218 ± 27 kg of BW) was conducted. Heifers were blocked by age. Treatments were 1) cold-pressed carinata meal (CRM; with glucosinolates at 2.06 g/kg of diet DM) and 2) distiller's dried grains with solubles (DDGS) at 10% of the diet on a DM basis. The remainder of the diets was composed of grass hay, ground corn, soybean meal, and mineral mix, with the inclusion amounts of the corn and soybean meal varied slightly to meet nutrient requirements and have diets be similar in CP and energy content. Heifers were individually fed using a Calan gate feeding system, and the rations were limit fed at 2.65% of BW on a DM basis. Frame sizes, BW, and BCS were measured at 4 h after feeding on 2 consecutive days during wk 0 and then every 2 wk thereafter throughout the feeding period. Data were analyzed using MIXED procedures with repeated measures in SAS 9.4 (SAS Inst. Inc., Cary, NC). Significance was declared at $P < 0.05$. There were no significant interactions of treatment × week. Heifer DMI (6.55 and 6.42 kg/d [SEM 0.16] for CRM and DDGS, respectively), BW (269.9 and 268.9 kg [SEM 1.47]), ADG (0.837 and 0.825 kg/d [SEM 0.029]), and G:F (0.131 and 0.130 kg/kg [SEM 0.004]) were similar ($P > 0.05$) between treatments. There were no differences ($P > 0.05$) in withers height (122.8 and 122.4 cm [SEM 0.53]), hip height (126.0 and 126.4 cm [SEM 0.27]), heart girth (145.6 and 145.2 cm [SEM 0.53]), hip width (37.98 and 38.26 cm [SEM 0.28]), and BCS (3.01 and 2.99 [SEM 0.01]). This research demonstrates that carinata meal, despite the glucosinolate content, can be fed at the inclusion rate of 10% diet DM to growing dairy heifers and maintain DMI, ADG, and frame growth compared with DDGS.

**Key Words:** carinata meal, dairy heifer, growth performance
doi:10.2527/asasmw.2017.374

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**375 Young Scholar Presentation: Effects of dietary factors and rumen pH on rumen biohydrogenation pathways and risk of milk fat depression.**
Y. Sun[*], M. Allen, A. Lock, *Michigan State University, East Lansing*.

Our overall objective was to determine the effects of dietary factors and rumen pH and their interactions on biohydrogenation pathways and the formation of biohydrogenation intermediates (e.g., *trans*-10, *cis*-12 18:2) that reduce fat synthesis in the mammary gland. By using an in vitro batch culture system in the first 3 experiments, we determined the effects of culture pH and common dietary factors (unsaturated fatty acid concentration, starch content, and starch fermentability) as well as *Saccharomyces cerevisiae* fermentation product on biohydrogenation pathways. In all 3 experiments, culture pH had the greatest influence on biohydrogenation pathways, with low culture pH increasing the formation of *trans*-10, *cis*-12 18:2 (all $P < 0.01$). In the first experiment, increasing unsaturated fatty acid concentration, provided by corn oil, at low culture pH resulted in a greater increase in *trans*-10, *cis*-12 18:2 concentration than at high culture pH (interaction,

$P < 0.05$). In the second experiment, starch content and fermentability interacted with pH to affect *trans*-10, *cis*-12 18:2 concentration; high-moisture corn at high starch content and low culture pH increased *trans*-10, *cis*-12 18:2 concentration (interaction, $P < 0.01$). In the third experiment, rumen fluid collected from cows supplemented with *Saccharomyces cerevisiae* fermentation product decreased *trans*-10, *cis*-12 18:2 concentration, especially in cultures containing high-moisture corn at low culture pH (interaction, $P < 0.01$). The fourth experiment was an in vivo study that determined the effect of production level on rumen biohydrogenation and risk of diet-induced milk fat depression. A milk fat depression–inducing diet decreased milk fat content ($P < 0.01$) and milk fat yield ($P = 0.05$) and increased *trans*-10, *cis*-12 18:2 concentration in milk ($P < 0.01$) and rumen pH range ($P = 0.01$). Rumen pH range was negatively correlated with milk fat concentration and positively correlated with *trans*-10, *cis*-12 18:2 concentration in milk (both $P < 0.01$). Higher producing cows were at higher risk for diet-induced milk fat depression, exhibiting greater reductions in milk fat content and yield and a greater increase in milk *trans*-10, *cis*-12 18:2 concentration than lower-producing cows (all interactions, $P < 0.10$). Our results indicate that dietary factors interacted with rumen pH to influence biohydrogenation pathways and *trans*-10, *cis*-12 18:2 concentration, rumen pH was the main driver of changes in biohydrogenation pathways, and production level also impacted cow response to diet-induced milk fat depression.

**Key Words:** biohydrogenation, milk fat depression, rumen pH
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**376 Young Scholar Presentation: Manipulating early lactation energy and protein balances using canola meal as a protein source.** S. A. E. Moore[1,*], K. F. Kalscheur[2], [1]*University of Wisconsin, Madison,* [2]*USDA-ARS, US Dairy Forage Research Center, Madison, WI.*

Negative energy and protein balances during the immediate postpartum period pose opportunities to improve dairy cow health and production. The inability of the cow to consume an adequate supply of nutrients leads to the mobilization of body reserves to serve as energy and protein supplies for milk production. Labile protein turnover can range from 8 to 21 kg in the first 5 to 6 wk of lactation. Turnover of protein stores can be used as AA for gluconeogenesis and synthesis of milk protein. Protein and specific AA requirements for dairy cows during the early lactation period are not well defined. The use of canola meal (CM) in dairy cow diets has recently shown favorable results in milk yield when compared with feeding soybean meal (SBM)–based diets. Midlactation feeding experiments and meta-analysis methods showed that cows produced 0.77 to 1.41 kg/d more milk when fed CM compared with SBM and other vegetable-based protein sources. The AA profile of CM has recently garnered attention due to an AA profile more similar to milk protein than that of SBM. In addition, the SBM AA profile is higher in the 2 nonglucogenic AA Leu and Lys. Therefore, it was hypothesized that CM may provide a protein source that is more efficiently utilized by the cow during a period of negative energy and protein balance. Our laboratory conducted a feeding experiment using a randomized complete block design with a 2 × 2 factorial arrangement of treatments. Cows were evaluated during the first 16 wk of lactation. High (18.1%) and Low (16.2%) concentrations of CP were fed, using CM or SBM as protein sources. Cows fed CM consumed 0.80 ± 0.34 kg/d ($P = 0.09$) more DM and yielded 4.45 ± 0.97 kg/d ($P < 0.01$) more milk than cows fed SBM. Milk component yield favored CM-based diets, and feed efficiency tended to be higher for cows fed CM (2.27 vs. 2.16 ± 0.38; $P = 0.06$). Another possible difference may be the impact of the protein source on fiber digestibility. In a recent study, total-tract NDF digestibility was 48.1 vs. 45.1% of NDF intake ($P < 0.01$) for CM- vs. SBM-fed dairy cows, respectively. This may be another avenue in which animals fed CM are outperforming their SBM-fed counterparts. The dramatic increase in production and underlying mechanism for CM-fed animals compared with SBM-fed animals warrants further investigation.

**Key Words:** canola meal, early lactation, protein metabolism
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**377 In vitro analysis of rumen microbial fermentation at different temperatures.** K. Linville[*], D. P. Casper, J. S. Osorio, *Dairy and Food Science Department, South Dakota State University, Brookings*.

Changes in ambient temperature can induce different responses in rumen temperature and consequently affect the optimal conditions for microbial fermentation. Besides rumen pH and anaerobic conditions, rumen temperature is another important factor that can compromise VFA production in the rumen of dairy cows. In vitro analysis of microbial fermentation can provide relevant information on how temperature can affect this fundamental biological process for ruminants. Ruminal fluid (approximately 1.5 L) was collected from 3 lactating cows with a ruminal cannula from the anterior, dorsal, and mid ventral region of the rumen and pooled. Then, this mixture was filtered through 4 layers of cheesecloth, and 50 mL of the final liquid was added to each digestion bottle. The Ankom RF gas production system was used to monitor the kinetics of microbial metabolism through measurement of cumulative pressure over 30 h of incubation at 36 (T36), 39 (T39), and 42°C (T42). At least 3 digestion bottles were used as replicates for each temperature treatment, and an empty bottle was used as a correction factor. A previously dried and ground TMR sample (approximately 1 g/bag) was used to determine NDF and ADF digestibility during the incubation period. Rumen fluids were

analyzed for ammonia N and VFA before and after the incubation period. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). An interaction ($P < 0.01$) of temperature × time was observed. This effect was mainly attributed to the lower ($P \leq 0.05$) cumulative pressure over time in the T42 treatment from 1 h incubation in comparison with T36 and T39. The cumulative pressure was, overall, similar ($P = 0.45$) between T36 and T39 treatments but lower ($P \leq 0.2$) for T42. Preliminary data suggest that rumen bacteria can sustain moderate increments in temperature; however, higher temperatures impaired rumen microbial fermentation. Further analysis of other parameters will provide a more comprehensive understanding of these results.

**Key Words:** in vitro gas production, rumen fermentation, rumen temperature
doi:10.2527/asasmw.2017.377

**378 Young Scholar Presentation: Feeding peripubertal dairy heifers diets high in distiller's grains with varying forage-to-concentrate ratios.**

A. K. Manthey[1,*], J. L. Anderson[2], *[1]Dairy Science Department, South Dakota State University, Brookings, [2]South Dakota State University, Brookings*.

Two studies were conducted to evaluate the effects of limit feeding peripubertal dairy heifers distiller's dried grains with solubles (DDGS) with varying forage-to-concentrate ratios. The first study determined the effects of increasing the inclusion amount of DDGS on growth, rumen fermentation, nutrient digestibility, metabolic profile, onset of puberty, and post-trial performance. The second study determined performance of heifers when fed DDGS or control grain mix with ad libitum grass hay. Both were 16-wk, randomized complete block design feeding studies with heifers individually fed using Calan gates. Data were analyzed using the MIXED procedures of SAS 9.4 (SAS Inst. Inc., Cary, NC) with repeated measures and significance declared at $P < 0.05$ and tendencies declared at $P < 0.10$. The first study had 48 Holstein heifers, and treatments were 1) 30% DDGS, with diet fed at 2.65% of BW (30DG); 2) 40% DDGS, with the diet fed at 2.50% of BW (40DG); and 3) 50% DDGS, with the diet fed at 2.35% of BW (50DG). The remainder of the diets was grass hay and 1.5% mineral mix. There were no differences in growth parameters; however, G:F and nutrient digestibility increased with increasing amounts of DDGS. Plasma total fatty acids and PUFA were linearly increased with a quadratic response, with 30DG and 50DG having the greatest concentrations. There was a quadratic response of plasma urea nitrogen and a quadratic tendency for cholesterol. Age and BW at puberty were similar among treatments, although there was treatment × age interaction. Post-trial data were collected on reproductive and lactation performance, which were comparable among treatments. The second study had 24 heifers (18 Holstein and 6 Brown Swiss) and treatments were 1) corn and soybean product concentrate mix (CON) and 2) DDGS concentrate mix (DDG). Both concentrate mixes were limit fed at 0.8% of BW and grass hay was fed ad libitum. Dry matter intake and growth parameters were similar; however, rumen fermentation and metabolic profile differed. Results from these studies demonstrated that DDGS can be included at 30, 40 or 50% in replacement of hay in limit-fed diets or can be fed in replacement of corn and soybean meal with ad libitum grass hay and maintain growth performance of peripubertal heifers with some shifts in metabolic profile without detriment to subsequent performance.

**Key Words:** dairy heifer, distiller's grains, growth performance
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## UNDERGRADUATE STUDENT ORAL COMPETITION

**379 Initial evaluation of floor cooling on lactating sows under acute heat stress.**

A. J. Smith[1,*], F. A. Cabezon[1], A. P. Schinckel[1], J. N. Marchant-Forde[2], J. S. Johnson[2], R. M. Stwalley[3], *[1]Department of Animal Sciences, Purdue University, West Lafayette, IN, [2]USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN, [3]Department of Agricultural Biological Engineering, Purdue University, West Lafayette, IN*.

The objective was to evaluate the effects of floor cooling on lactating sows under severe summer heat stress. Twelve multiparous sows were provided with a cooling pad built with an aluminum plate surface, high-density polyethylene base, and copper pipes. Treatments were randomly allotted to sows to receive a constant cool water flow of 0.00 (CONTROL; $n = 5$), 0.25 (LOW; $n = 3$), 0.55 (MEDIUM; $n = 2$), or 0.85 L/min (HIGH; $n = 2$) for 90 min. The cooling was initiated 1 h after the room reached 35°C. Respiration rates (RR), rectal temperature (RT), and skin temperature (ST; 15 cm posterior to the ear) were recorded before the trial, prior to cooling, and after 90 min of cooling. Water flow rates and inlet and outlet water temperatures were recorded 6 times (every 15 min) to calculate the heat removal (watts) after cooling initiation. In all 3 replications, treatments were randomly switched between sows. Data were analyzed using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC). Respiration rate, RT, ST, and heat removal were analyzed using repeated measures with compound symmetry covariance structure with sow as a repeated random effect. For RR, RT, and ST measurements, the model included treatment and phase (before trial, prior to cooling, and at the end of the trial) and their interactions as fixed effects and replication as a random block. For the cooling phase, heat removal model included treatment and cooling time and their interactions as fixed effects and replication as a random block.

The mean room temperature and relative humidity during the trial were 35.3 ± 0.7°C and 57.8 ± 3.1%, respectively. The treatments impacted RR, RT, and ST after 90 min of cooling. At the end, mean RR were 132, 89, 71, and 31 breaths/min for the CONTROL, LOW, MEDIUM, and HIGH treatments, respectively ($P < 0.001$). The mean RT and ST were 39.9 and 39.8°C, respectively, for the CONTROL; 39.5 and 39.1°C, respectively, for the LOW; 39.2 and 38.8°C, respectively, for the MEDIUM; and 39.1 and 39.2°C, respectively, for the HIGH treatments ($P < 0.001$ and $P = 0.079$, respectively). Overall heat removal during the trial was 196.2, 278.3, and 320.7 W for the LOW, MEDIUM, and HIGH treatments, respectively ($P < 0.001$). Cooling pads with MEDIUM and HIGH water flow rates reduced RR and RT in lactating sows.

**Key Words:** cooling pads, lactation, sow
doi:10.2527/asasmw.2017.379

**380 Effects of dietary zinc source and concentration on performance of growing–finishing pigs reared with reduced floor space.** J. P. Holen[1,*], Z. J. Rambo[2], A. M. Hilbrands[1], L. J. Johnston[1], *[1]West Central Research and Outreach Center, University of Minnesota, Morris, [2]Zinpro Corporation, Eden Prairie, MN*.

Reduced floor space allowance (crowding) depresses pig performance; however, evidence suggests that a highly available source of zinc may partially mitigate these negative effects of stress when supplemented at the appropriate concentration. Therefore, the objectives of this experiment were to evaluate effects of dietary zinc source (organic vs. inorganic) and increasing zinc concentration on growth performance and carcass composition of growing–finishing pigs housed in crowded conditions. Maternal-line barrows and gilts (636 pigs; 28.7 kg initial BW) were blocked by initial BW and randomly assigned within block to 1 of 5 treatments. Twelve pens were assigned to each treatment over 3 replicate trials. Treatments were 1) control (Con9), in which pigs were housed in an uncrowded environment (0.73 $m^2$/pig) and fed corn–soybean meal based diets containing 50 ppm Zn (Phases 1 and 2) and 60 ppm Zn (Phases 3 and 4); 2) crowded (Con11), in which pigs were housed at 0.60 $m^2$/pig and fed the same diets as Con9; 3) AvZn40, which was Con11 + 40 ppm Zn from AvailaZn; 4) AvZn80, which was Con11 + 80 ppm Zn from AvailaZn; and 5) inorganic zinc (ZnSO80), which was as Con11 + 80 ppm Zn from zinc sulfate monohydrate. Growth characteristics and feed intakes were determined at the end of each dietary phase (28 d). Upon completion of the trial, carcass composition and meat quality were recorded. Overall, crowding decreased ADG ($P < 0.05$) for Con11 pigs compared with Con9 pigs (Table 380). There were no differences in ADFI or G:F among treatments. Neither zinc source nor concentration affected fat-free lean percent (FFL), dressing percent, loin muscle area (LMA; $cm^2$), or backfat depth (BF; mm). Altogether, these data indicate that neither supplemental organic zinc nor supplemental inorganic zinc influenced growth performance or carcass composition of pigs under crowded conditions.

**Key Words:** growing–finishing pigs, growth performance, zinc
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**381 Effects of spring administration of extended-release eprinomectin (LongRange) on fescue toxicosis, performance, and reproduction of fall-born beef heifers.** J. M. Kordas*, F. A. Ireland, D. W. Shike, *University of Illinois at Urbana-Champaign, Urbana*.

The objective of this experiment was to assess the effects of eprinomectin (LongRange), an extended-release injectable parasiticide, on fescue toxicosis and its impacts on beef heifer performance and reproduction. Fall-born Angus × Simmental heifers (9 mo; 264.8 ± 21.1 kg BW) were randomly assigned 1 of 2 treatments: LongRange (LR; $n = 100$) or control (CR; saline; $n = 99$). Prior to trial initiation, heifers were dewormed with oral fenbendazole (SafeGuard) to minimize parasite load. At trial initiation (May 29, 2015), treatments were administered at a rate of 1 mL/50 kg BW. All heifers grazed endophyte-infected tall fescue as a single group and were offered a supplement (1.36 kg DM/heifer·$d^{-1}$) for the duration of the experiment. Body weights, BCS, hair coat score (HCS), blood, and fecal samples were collected 10, 10, 6, 4, and 3 times, respectively, throughout the trial. A subset of 40 heifers were randomly selected (20 from each treatment) to assess respiration rate (RR) on d 1, 54, and 110. On d 138, heifers began a 14-d controlled internal drug release-PG synchronization protocol. Following AI, heifers were exposed to 5 bulls for 71 d. On d 214 and 291, AI and overall pregnancy were determined. Body weight, ADG, BCS, HCS, RR, and fecal egg counts were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Reproductive data were analyzed using the GLIMMIX procedure of SAS. Heifer served as the experimental unit. Heifer ADG was greater ($P \leq 0.01$) for LR heifers throughout the study. From d 112 to 291, LR heifers had greater ($P \leq 0.01$) BCS than CR heifers. On d 83 and 112, LR heifers tended ($P \leq 0.10$) to have slicker hair coats than CR heifers; however, neither serum prolactin levels nor RR differed ($P \geq 0.58$) between treatments. Fecal egg counts did not differ ($P \geq 0.16$) on d −1 or 55; however, on d 111, LR heifers had decreased ($P < 0.01$) fecal egg counts compared with CR heifers (1.5 vs. 13.6 eggs/g). LongRange heifers tended ($P = 0.10$) to have greater AI pregnancy rates (69 vs. 58%) and had greater ($P = 0.01$) overall pregnancy rates (84 vs. 68%) than CR heifers. LongRange administered in the spring increased ADG, BCS, and AI and overall pregnancy in fall-born beef heifers. However, the underlying mechanism is still unclear, as there were minimal to no differences in HCS,

**Table 380.** Effect of zinc source and concentration on growth performance and carcass composition of growing–finishing pigs

| | Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| Trait | Con9 | Con11 | AvZn40 | AvZn80 | ZnSO80 | SE | *P*-value |
| ADG, kg | 0.97[a] | 0.91[b] | 0.93[ab] | 0.92[ab] | 0.93[ab] | 0.013 | 0.04 |
| ADFI, kg | 2.74 | 2.66 | 2.62 | 2.59 | 2.65 | 0.054 | 0.35 |
| BF, mm | 21.9 | 22.1 | 22.3 | 21.4 | 21.6 | 0.44 | 0.54 |
| LMA, $cm^2$ | 48.5 | 48.5 | 48.9 | 48.3 | 49.8 | 0.63 | 0.43 |
| FFL, % | 52.1 | 52.0 | 52.1 | 52.2 | 52.3 | 0.65 | 0.95 |
| Dressing percent | 75.9 | 76.0 | 75.7 | 76.2 | 76.4 | 0.84 | 0.98 |

[a,b]Means within a row with different subscripts differ ($P < 0.05$).

RR, serum prolactin, and fecal egg counts.

**Key Words:** beef heifer, extended release eprinomectin, fescue toxicosis
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**382 Relationship of proteolysis and superoxide dismutase activity to tenderness of prime and select grade beef.** N. J. Herrera[1,*], E. K. Kunze[1], K. Domenech-Pérez[1], F. A. Ribeiro[1], M. D. Chao[2], C. R. Calkins[1], *[1]University of Nebraska-Lincoln, Lincoln, [2]California State University-Chico, Chico*.

Excessive fat deposition in humans induces metabolic stress, increasing production of reactive oxygen species (ROS). Cattle that grade Prime may have more ROS than cattle that grade Select. Perhaps ROS alters the extent of muscle proteolysis and thereby influences tenderness between high and low marbled beef. Superoxide dismutase (SOD), an endogenous enzyme, helps combat ROS by converting superoxide, the most potent ROS, into less toxic forms of oxygen. Proteolysis can be measured by tracking degradation of troponin T, a protein subunit that helps regulate in muscle contraction. The objective was to investigate the relationship between quality grade, tenderness, troponin T degradation, and SOD activity. Beef strip loins (36 Prime and 36 Select) were cut into 5 pairs of steaks (one 2.54 cm thick and one 1.27 cm thick). Randomly, each pair was aged 2, 7, 14, 21, and 28 d. The 2.54-cm-thick steaks were cooked to 70°C, and six 1.27-cm-diameter cores were removed for Warner–Bratzler shear force determination. Samples from 1.27-cm steaks, 2 and 28 d aging, were analyzed for troponin T degradation. The remaining 3.23-cm (1.27-inch) samples were powdered and stored at −80°C for SOD analysis. Prime steaks were significantly more tender ($P < 0.0001$) than Select steaks. Select graded steaks had a greater response to aging effect (greater change in Warner–Bratzler shear force) than Prime graded steaks ($P = 0.03$). Samples aged 28 d showed significantly more troponin T degradation ($P < 0.0001$) than samples aged 2 d, but there was no significant difference between Select and Prime graded steaks ($P = 0.16$). No significant difference was observed between quality grades for SOD activity ($P = 0.69$). These results suggest that the differences in tenderness between quality grades cannot be explained by the changes in superoxide dismutase.

**Key Words:** marbling, reactive oxygen species, tenderness
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**383 Effect of increasing amount of Amaferm on animal performance in receiving feedlot cattle.** K. Nickles[1,*], A. Relling[2], *[1]The Ohio State University, Columbus, [2]Department of Animal Sciences, The Ohio State University, Wooster*.

The receiving period for feedlot cattle is crucial for the later performance of the animal. This phase is characterized by high stress in the animals due to the change of environment and diet. This has been associated with a decrease in feed intake and performance. Amaferm has been shown to increase the rate and extent of digestion as well as reduce the time that animals require to resume consumption during diet transition. Therefore, the objective of the present experiment was to determine the effect of 0, 1.5, or 3.0 g/d of Amaferm in feedlot receiving diets. The experiment was replicated in 2 yr, and in both years, 168 Angus crossbreed steers (240 ± 0.66 kg) were blocked by BW and allocated in 24 pens with 7 animals per pen. The 24 pens were equally distributed and assigned to 1 of the following 3 treatments, control (0A) that receive a diet with 0 g/d of Amaferm, 1.5 g/d of Amaferm (1.5A), or 3 g/d of Amaferm (3A). The diet containing 60% corn silage, 15% distiller's dried grains with solubles (DDGS), 15% whole shelled corn, and 10% protein/vitamin/mineral supplement. Animals were weighed at d 1 and 7, and DMI was measure daily. Data were analyzed as a complete block design with a mixed model (SAS 9.4; SAS Inst. Inc., Cary, NC). The model includes treatment as a fixed variable and pen, year, and BW block as random variables. Mean separation for animal performance on d 7 was evaluated using linear and quadratic polynomial contrast. Increasing the dose of Amaferm inclusion linearly improved ($P = 0.04$) BW, ADG, and G:F without changing DMI ($P > 0.1$) on the first week of feeding The improvement in performance may be due to the ability of Amaferm to reduce rumen lactic acid concentration by stimulating the development of *Megasphaera elsdenii*, decreasing the risk of a decrease in pH. We conclude that inclusion of increasing doses of Amaferm in the receiving diet may help improve

performance of calves during the feedlot receiving period.

**Key Words:** digestibility, prebiotic, receiving diet
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**384 Influence of seminal additives on sow fertility.**

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The objective of this study was to determine the effect of 4 different seminal additives on pregnancy and farrowing rates and litter size in primiparous and multiparous sows. The study was performed on a commercial facility in Spain during a 12-mo period. A total of 1,091 sows were randomly allotted by parity to receive 1 of 4 additives in seminal plasma or served as controls: 1) 87 µg of cloprostenol (Planate; Schering-Plough Animal Health; $n = 158$), 2) 5 IU oxytocin (Ovivex; S.P.Veterinaria; $n = 154$), 3) 0.2 µg buserelin acetate (Receptal; Merck; $n = 93$), 4) 5 IU oxytocin + 0.2 µg buserelin acetate ($n = 81$), and 5) control ($n = 605$). Additives were added to the semen dose 15 min prior to insemination. Sows had daily boar contact for 15 d after weaning for estrus detection. Sows were artificially inseminated at detection of estrus and at 24-h intervals if still exhibiting estrus. Additives were administered only during the first insemination. Pregnancy rates were assessed by real-time ultrasonography on d 28. Pregnancy and farrowing rates were analyzed by logistic regression using a generalized linear mixed model that included treatment as a fixed effect, group as a random effect, and parity as a covariate. Litter size was analyzed by ANOVA using a linear mixed model that included the same effects and covariates as above. Multiple comparisons were accounted for with a Tukey adjustment. Pregnancy and farrowing rates did not differ between groups ($P = 0.3$ and $P = 0.1$, respectively). Total born and born alive litter sizes increased in response to all seminal additives compared with the control ($P < 0.0001$). We conclude that addition of seminal plasma additives at first breeding will increase litter size in both primiparous and multiparous sows.

**Key Words:** additive, fertility, sow
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**Table 383.**

| | Treatments | | | | *P*-value | |
|---|---|---|---|---|---|---|
| Item | 0A | 1.5A | 3A | SEM | Linear | Quadratic |
| BW, kg | 241 | 242 | 244 | 0.7 | 0.04 | 0.69 |
| ADG, kg | 0.28 | 0.33 | 0.56 | 0.180 | 0.04 | 0.39 |
| DMI, kg | 4.5 | 4.5 | 4.5 | 0.02 | 0.64 | 0.98 |
| G:F | 0.030 | 0.033 | 0.061 | 0.019 | 0.04 | 0.93 |

**385 Neonatal pig supplement effects on mortality.**

D. B. Scales[1,*], M. Schwartz[2], *[1]Michigan State University, East Lansing, [2]Swartz Farms Inc., Sleepy Eye, MN*.

Preweaning pig mortality is approximately 12% (MetaFarms, 2015), with 40% of these losses occurring in pigs weighing <1 kg at birth. Small pigs (SP) have a lower BW and intestinal weight and size (Widdowson and Crabb, 1976). It has been hypothesized that absorption of energy at birth may improve survival. Therefore, the objective of this study was to determine the effectiveness of a pig supplement on preweaning piglet mortality and weaning weight. The oral supplement used contained glucose, a glutamate source, ascorbic acid, butyric acid, glycerol, dried milk, and flavorings. Pigs ($n = 577$) were from 2 farms with differing parity distributions. Within 6 h of birth and within litter, pigs were weighed, tagged, and given a 1.5-mL oral dose of the supplement treatment or only handled (control). At 14 d of age, pigs were reweighed and mortality was recorded. Birth weight did not differ between farms ($P = 0.7$) or treatments. Weight at 14 d was different between farms ($P = 0.004$) but not between treatments, and there was no treatment × farm interaction ($P = 0.5$). At both farms, approximately 10% of the pigs born were SP. On farm TR, 60% of control SP died and 67% of treated SP died. No control SP from farm PR died, and 13% SP receiving the oral supplement died. Although overall survivability was 81% for control pigs and 73% for treated pigs on farm TR, farm PR survival rates were 92% for controls and 91% for supplemented pigs. As expected, birth weight of pigs increased as the dam's parity advanced to parity 5 (1.86 kg) and then decreased through parity 9 to a birth weight similar to that of parity 1 sows (1.2 vs. 1.3 kg, respectively). Mean pig weights at 14 d were less for pigs from parity 9 sows than from parity 1 sows (3.8 vs. 4.0 kg, respectively). When sow parities were grouped (A = parity 1 and 2; B = parities 3, 4, 5, and 6; and C = parities 7, 8, and 9), survivability of SP and normal birth weight pigs was highest on farm PR for group A sows (75 and 90%, respectively) and the C sows on farm TR (75 and 85%, respectively). Due to the differences in parity distribution and management on the 2 farms, it is difficult to evaluate this neonatal supplement. However, under these commercial conditions, this oral supplement does not appear to benefit the newborn pig.

**Key Words:** energy supplement, mortality, neonatal pig
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**386 Validation of individual computerized sow feeding systems in lactation.** G. E. NIchols[1,*], K. M. Gourley[1], J. M. DeRouchey[1], J. C. Woodworth[1], S. S. Dritz[1], R. D. Goodband[1], H. L. Frobose[2], *[1]Kansas State University, Manhattan, [2]Jyga Technologies Inc., Quebec City, QC, Canada*.

Two experiments evaluated the accuracy of individual computerized feed delivery systems for lactating sows (GESTAL Solo; JYGA Technologies, Inc., Quebec City, Canada). The feeders volumetrically dispense feed based on rotations of a screw auger. In Exp. 1, 29 prototype feeders were used across 3 farrowing groups. On d 0, 4 feeders were selected to calibrate the computer system to the bulk density of the lactation diet. Feeders were programmed for 5 feeding periods per day with feeding period allowing 2 to 4 feed drops (depending on time of day) triggered by the sow at a minimum of 15-min intervals. Sows activate a trigger within the feed bowl to receive a targeted amount of feed (680 g), and the computerized feeder records the delivery amount based on calibration values. Total lactation feed intake was recorded by weighing the quantity of feed provided to the feeding system for each sow throughout lactation. Feed delivered by a single trigger activation on d 0 and 10 and day of weaning was collected and weighed with a scale and compared with the computer record. Also, total feed delivered over the lactation period was compared between the recorded computer measurement and scale weight. Average percentage difference between the 2 measurements ranged from 0.01 to 36.6% ($P < 0.001$, SEM 3.0) for a single trigger event. Computer recorded total lactation feed was marginally less ($P < 0.089$) than actual weight of feed delivered (102.8 vs. 107.1 kg [SEM 1.8]). Individual feeders had recorded total feed delivery ranging from 77 to 122% of actual weight delivered. Based on the variation observed, a new feeder design was evaluated (plastic hopper manufacturing was injection molded vs. rotational molded). In Exp. 2, 29 feeders were used in a single farrowing group to evaluate the variation of the new feeders. Feeders were calibrated and data was collected using the same procedures as Exp. 1, except individual feed drops were collected 8 times per feeder throughout lactation. Average percentage difference across all feeders ranged from 3.8 to 13.4% ($P < 0.001$, SEM 1.5). There was no evidence ($P < 0.542$) of difference between computer recorded total lactation feed and actual weight of feed delivered (124.8 vs. 121.8 kg [SEM 1.8]). Individual feeders had recorded total feed delivery ranging from 90.4 to 106.4% of actual weight delivered. Overall, this study shows that the new model was less variable in feed drops and total feed delivery.

**Key Words:** computerized feeder, lactation, validation
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**387 Cooking from a frozen state, endpoint temperature, and postcookery chilling affect internal and external color and cooking losses in ground beef patties.** Z. M. Hicks[*], J. W. S. Yancey, J. A. Apple, T. M. Johnson, *Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville*.

To determine the effects of cooking state (frozen vs. thawed), endpoint temperature (65.5 vs. 73.9°C), and postcookery chilling on color of ground beef patties, 85% coarse-ground beef was purchased and ground through a 9.5-mm plate, formed into 115-g patties ($n = 240$), and crust frozen before patties were vacuum packaged and stored at −10°C. Packages were either thawed in a water bath for 2 h prior to cooking or cooked directly from frozen. Within each package, patties were weighed before being cooked to their assigned temperature and either allowed to cool at room temperature on paper plates or placed in a plastic baggie and submerged in an ice water bath. Patty temperature was monitored at 0, 1, 5, 10, 15, and 30 min after cooking, and patties were reweighed to calculate cook loss percentage before external and internal instrumental color (L*, a*, and b*) was measured on each patty. Patties cooked from frozen, to 73.9°C, or cooled at room temperature had greater ($P < 0.05$) cooking losses than those cooked from a thawed state, to 65.5°C, or cooled in an ice bath, respectively. External color of patties cooked from a thawed state was lighter (greater L*; $P < 0.05$), more red (greater a*; $P < 0.05$), and more yellow (greater b*; $P < 0.05$) than those cooked from frozen. Moreover, L*, a*, and b* values were greater ($P < 0.05$) for the surface of patties cooked to 65.5°C than 73.9°C, whereas L*, a*, and b* values were greater ($P < 0.05$), externally, for patties cooled in an ice bath than those cooled at room temperature. Internally, patties cooked from frozen, cooked to 65.5°C, or cooled in an ice bath were lighter ($P < 0.05$) than those cooked from a thawed state, cooked to 73.9°C, or cooled at room temperature, respectively. Patties cooked to 65.5°C from a thawed state had the greatest ($P < 0.05$) internal a* and b* values, whereas frozen patties cooked to 73.9°C had the least red and yellow ($P < 0.05$) internal color. Moreover, thawed patties cooked and chilled in an ice bath were more red ($P < 0.05$), internally, than other cooking state × cooling method combinations. It was expected that cooking to 65.5°C would result in redder internal cooked color, but persistent redness was also observed when patties were cooked from a thawed, rather than frozen, state and when cooled in an ice bath.

**Key Words:** cooked color, ground beef, persistent pinking
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**388 Piglet creching decreases protein content in colostrum.** Y. A. Montano[1,*], R. Manjarin[1], K. Petrovski[2], R. N. Kirkwood[2], *[1]California Polytechnic State University, San Luis Obispo, [2]School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy, Australia*.

The structure of the porcine placenta precludes immunoglobulin transfer into the fetus. Therefore, newborn piglets must absorb large amounts of colostrum during the first 24 h of life, before gut epithelial closure takes place. It has been hypothesized that farrowing order may affect suckling, with those piglets born first likely ingesting more colostrum compared with those born in last place. The objective of this study was to assess whether creching (i.e., placing piglets into a warm box at birth to prevent suckling and returning all piglets to the sow at the end of farrowing) increases total plasma protein levels at 24 h after farrowing in the last 3 piglets born on each litter and whether this increase is associated with higher milk protein synthesis in the mammary gland. A total of 56 litters (511 piglets) were either withheld from suckling for 4 h after the first pig was born (i.e., Creched; $n = 28$ litters) or immediately allowed to suckle (i.e., Control; $n = 28$). Blood was taken by jugular venipuncture at 24 h after farrowing in the first and last 3 piglets per litter. Colostrum samples were taken from front (fg), middle (mg), and rear glands (rg) in all sows immediately after farrowing the first pig and 3 h later. Total protein content in milk and blood, as an indirect measurement of immunoglobulin content, was analyzed using a Brix refractometer. Data were analyzed by ANOVA using a mixed model that included farrowing order and treatment and their interaction as fixed effects, litter as a random effect, and birth weight as a covariate. Total plasma protein levels at 24 h did not differ between piglets born first and last ($P = 0.87$) and were significantly higher in control compared with creched piglets ($P = 0.0015$). Similarly, there were no differences in total protein content in colostrum between sows when sampled immediately after farrowing ($P = 0.18$, $P = 0.39$, and $P = 0.38$ for fg, mg, and rg, respectively), whereas it decreased in mg ($P = 0.05$) and tended to decrease in rg ($P = 0.06$) in sows with creched litters compared with those with controls. In conclusion, the lack of differences in plasma protein levels between first and last pigs born along with lower colostrum protein content in response to creching may militate against the use of this technique. Further studies are needed to directly explore the effect of creching on immunoglobulin levels and long-term pig survival.

**Key Words:** colostrum, creching, piglet
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**389 In vitro dry matter digestibility of multiple sources of microalgae and microalgae products for growing pigs.** B. W. Hanson[1,*], Z. K. Zeng[1], G. C. Shurson[1], R. Ruan[2], C. Chen[1], P. E. Urriola[1], *[1]Department of Animal Science, University of Minnesota, St. Paul, [2]Department of Biosystems and Bioproducts Engineering, University of Minnesota, St. Paul*.

Use of microalgae in agricultural application has substantially increased in recent years. To evaluate the relative nutritional value of microalgae products, it is necessary to have an estimate of the nutrient digestibility. In vitro procedures are a good alternative to model processes of nutrient digestion in the gastrointestinal tract of pigs. The objective of this project was to measure the nutrient composition and in vitro DM digestibility (IVDMD) of different microalgae sources. Four microalgae samples were obtained from multiple agricultural sources: 1) microalgae (*Chlorella* sp.) grown in waste water from a dairy processing plant, 2) microalgae (*Chlorella* sp.) grown in waste water from a meat processing plant, 3) protein and lipid extracted microalgae product grown for biofuels production, and 4) microalgae (*Pavlova* sp.) grown in microalgae-specific media. The IVDMD was measured using a 2-step technique. First, triplicate samples from each source (1 g) were incubated in a 7:1 mixture of potassium phosphate– and sodium phosphate–based buffer solutions (pH 2) with 2 mL (100 mg/mL) of fresh pepsin solution for 2 h at 39°C. Immediately after gastric hydrolysis, small intestinal hydrolysis was performed by adjusting solution pH to 6.8 by adding a 1:1 mixture of potassium phosphate– and sodium phosphate–based buffer solutions and adding 2 mL of pancreatin solution (100 mg/mL). After 4 h of hydrolysis at 39°C, all samples were centrifuged at 10,000 g for 10 min and supernatant was removed. The pellet after centrifugation was dried at 55°C for 48 h and the weight was recorded. The IVDMD was calculated as a ratio between DM before and after hydrolysis. The IVDMD of *Pavlova* sp. (50.7 ± 0.5%) was less ($P < 0.05$) than that of *Chlorella* sp. grown in dairy waste water (57.1 ± 0.1%), which was greater than that of *Chlorella* sp. grown in meat processing waste water (64.2 ± 0.9%). The greatest IVDMD was observed in the protein and lipid extracted microalgae product (80.2 ± 4.9%). Digestibility values of microalga grown in dairy waste water and grown in meat processing waste water were not different ($P > 0.05$) from ground corn (62.6 ± 2.7%) used as control. In conclusion, microalgae products from various industrial application may have significantly different nutritional values to growing pigs because they have different digestibility values.

**Key Words:** in vitro digestibility, microalgae, swine
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**390 Effects of postinsemination dam nutrition on longevity and calf performance.** C. L. Mogck*, J. A. Walker, G. A. Perry, *Department of Animal Science, South Dakota State University, Brookings*.

Our laboratory has reported that moving heifers from a drylot to pasture at AI can negatively impact pregnancy success, but what is not known is how this nutritional stress impacts the embryos that survive. Therefore, the objective of this study was to evaluate the impact of moving drylot-developed heifers to forage immediately following AI on their longevity and the performance and longevity of their calves. Longevity data and calving records were collected from 105 heifers that were allotted into 2 treatments prior to breeding: drylot or range. All heifers were fixed-time inseminated following the 7-d CO-Synch plus CIDR protocol to a single bull and were turned out to pasture together and managed as a single group. Pregnancy success to AI was determined by ultrasonography, and calving data (calving date, birth weight, sex, and weaning weight) were collected for the following 5 yr. Therefore, heifers were then divided into 4 groups 1) AI Range 2) AI Drylot 3) Bull-bred Range, and 4) Bull-bred Drylot. Among drylot and range heifers that conceived the first year, there was no difference in longevity ($P = 0.30$). There was also no difference in longevity for the heifer calves that were in utero during the first year following treatment ($P = 0.43$). However, among calves that were in utero during yr 1, bull calves were heavier at birth compared with heifer calves ($P = 0.03$; 36 ± 0.5 vs. 35 ± 0.59 kg, respectively) and AI Range calves were heavier at birth compared with AI Drylot calves ($P < 0.01$; 37 ± 0.68 vs. 34 ± 0.64 kg, respectively). Bull-bred calves did not differ in birth weight ($P = 0.44$; 35 ± 0.77 and 36 ± 0.95 kg). Furthermore, weaning weights and ADG were greater for AI Range calves (207 ± 4.6 and 0.8 ± 0.02 kg, respectively) compared with AI Drylot calves ($P = 0.02$; 191 ± 4.4 and 0.77 ± 0.02 kg, respectively), which was greater than that of Bull-bred Range (174 ± 6.0 and 0.8 ± 0.03 kg, respectively) and Bull-bred Drylot calves (171 ± 5.5 and 0.77 ± 0.02 kg, respectively), which were similar. Bulls tended ($P = 0.06$) to be heavier at weaning than heifers (191 ± 7.5 vs. 181 ± 3.9 kg, respectively). With calves born in yr 2 through 4, there was no difference between treatments in BW ($P > 0.33$), WW ($P > 0.24$), or ADG ($P > 0.31$). In conclusion, moving drylot-developed heifers to pasture immediately following AI had no impact on longevity but did result in the AI-sired embryos having a decrease in BW, WW, and ADG compared with AI-sired calves from the range-developed heifers.

**Key Words:** calf performance, longevity, post-artificial insemination nutrition
doi:10.2527/asasmw.2017.390

**391 The impact of oregano essential oil supplementation over two complete reproductive cycles in multiparous sows.** M. Renken*, B. C. Thaler, J. A. Clapper, C. L. Levesque, *South Dakota State University, Brookings*.

We previously reported that oregano essential oil (OEO) supplementation in a single gestation and lactation cycle shortened birthing interval in primparous and multiparous sows. The impact of OEO (0 or 2 g/d; By-O-Reg; Advanced Ag Products) supplementation in gestation and lactation over 2 reproductive cycles on sow and piglet performance was determined. A total of 32 sows (parity 2–6) completed 2 reproductive cycles. Experimental diets were offered once daily in gestation and twice daily in lactation (OEO was added as a top dress in the morning feeding). Diets were formulated to meet or exceed nutrient requirements for sows/gilts in gestation (0.6% SID lysine and 3,280 kcal ME/kg) and lactation (0.9% SID lysine and 3,280 kcal ME/kg). Assessment of sow performance included BW and backfat at breeding, d 110 of gestation, d 1 of lactation, and at weaning; farrowing duration; piglet birth interval; piglet birth and wean weight; sow lactation feed intake; and colostrum and milk protein. Farrowing duration was determined as the time between birth of the first and last piglet. Data were analyzed as a RCB design with sow as the experimental unit. There was a limited effect of OEO supplementation on sow reproductive performance in the second parity. Mean sow BW and backfat at breeding, d 110 of gestation, and weaning were 203 ± 10 kg and 11.3 ± 1.3 mm, 258 ± 7 kg and 15.7 ± 0.8 mm, and 225 ± 6 kg and 12.0 ± 1.2 mm, respectively. Mean gestation length, farrowing duration, birthing interval, and lactation feed intake were 115.8 ± 0.2 d, 5.5 ± 0.9 h, 18.8 ± 3.9 d, and 6.37 ± 0.42 kg/d, respectively. Oregano essential oil supplementation had limited impact on litter characteristics. Mean total born, born alive, stillborns, and piglet birth and wean weights were 15.8 ± 0.90, 14.7 ± 0.6, 0.87 ± 0.44, 1.40 ± 0.12 kg, and 6.67 ± 0.31 kg, respectively. Sows fed diet with OEO tended to have a lower ($P = 0.06$) number of mummies (0.16 vs. 0.71 ± 0.21). Colostrum protein content from sows fed diets with OEO tended to be greater (21.2 vs. 17.9 ± 0.9%; $P = 0.06$) than from control-fed sows, and there was no difference in milk protein content (mean 5.9 ± 0.1%; $P = 0.70$). Oregano essential oil supplementation through 2 parities had little additional benefit on sow and litter performance. The reduction in mummies may reflect an impact on embryo survival in subsequent parities.

**Key Words:** essential oil, piglet, sow performance
doi:10.2527/asasmw.2017.391

**392 Cognitive ability, activity, and metabolic rate in mice divergent for water consumption.**

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Physical activity is known to affect not only the physical health of the body but mental and cognitive health as well. Exercise is favorably correlated with cognition, improving memory, and delayed age-related memory decline. Furthermore, low water consumption has been associated with cognitive issues. Two inbred mouse strains divergent for water consumption, C57 Brown/cdj (BR) and C57 Black/10J (BL), were evaluated as a part of a larger study to identify genes associated with water consumption. Physical activity and cognition have not been studied in these strains; however, we have anecdotally observed greater activity and more elaborate nest building in BR mice. The objective of the present study was to investigate differences between the 2 strains in physical activity, metabolic rate, and cognition. Physical activity and metabolic rate ($n$ = 16), water consumption ($n$ = 76), and cognition ($n$ = 32) were measured in males and females of each line and fitted to a general linear model including the effects of mouse strain. Physical activity and metabolic rates were measured in males between 4 and 6 wk of age using Sable Promethion chambers. Energy expenditure ($P < 0.0001$), activity ($P < 0.10$), and metabolic rate measured as carbon dioxide expenditure ($P < 0.05$) were all higher in BR animals than in BL animals. Daily water consumption data were collected for 4 d during the fourth, fifth, and sixth weeks by using custom water bottles. Animals were weighed at the beginning of the fourth, fifth, and sixth weeks and at the end of the sixth week. Consumption data were corrected for metabolic BW ($wt^{0.67}$) prior to analysis, so units of water consumption are expressed in milliliters consumed per gram of metabolic BW per day. Animals from the BR strain consumed more water per day ($P < 0.001$) than BL animals (1.32 vs. 0.65 mL/g, respectively). Cognition was examined by evaluating the likelihood of an animal successfully entering the correct escape hole in a Barnes maze by using a generalized linear model including the effects of sex and strain. Females were more likely to complete the maze within 5 min ($P < 0.10$) than their male counterparts (82 vs. 69% success rate of completion, respectively). The completion rate for BR was higher ($P < 0.10$) than that for BL, 87 vs. 61%, respectively. These results support the hypothesis of favorable relationships between activity, water consumption, and cognition.

**Key Words:** cognition, mice, water consumption
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**393 A commercially available activity monitor attached to the ear tag detects swine oral–nasal–facial behaviors.**

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Automated behavior data collection may help swine producers make better management choices about their herds. The objective of the first experiment was to determine if a commercially available activity monitor (Fitbit Zip Wireless activity monitor; San Francisco, CA) attached to a pig's ear tag could measure duration of locomotion activity (LOCO; voluntary movements that displace the whole body) in 6-mo-old boars (Yucatan; Sinclair Bioresources). Two trained observers used specialized software (Observer 11.5 XT; Noldus, Leesburg, VA) to code for LOCO duration of 3 pigs wearing activity monitors for two 12-h daylight periods. Activity monitor data were summarized at 1- and 5-min intervals using an added software package (Small Steps Labs, LLC, San Diego, CA). In addition, automated and video data were converted to a binary system (0 = <1 s activity and 1 = >1 s activity). Pearson's correlation and $\chi^2$ were used for data analysis in SAS (SAS Inst. Inc., Cary, NC). Activity monitor data were not correlated with video data coded for LOCO duration ($R^2$ = 0.14, $P$ = 0.87). After data were converted to binary codes, there was an 80.23% agreement at 1-min intervals and 97.11% agreement at 5-min intervals between activity monitor and LOCO data ($P < 0.01$). The second objective was to determine if activity monitors would detect oral–nasal–facial (ONF) behaviors. Six 15-min videos were identified for high, medium, and low activity. One trained observer who was blinded to the activity data and the objective 1 findings coded for ONF duration and LOCO frequency (count of hind leg steps). The ONF duration and activity monitor data were correlated ($R^2$ = 0.60, $P < 0.01$). Although the activity monitor attached to the ear tag did not accurately detect LOCO duration, this study confirmed that it does detect movement (yes or no response) and ONF. Healthy pigs spend much of their active time performing ONF behaviors. If the animal is sick or stressed, the expression of ONF may change. Therefore, low-cost activity monitors placed on the ear tag may be used to automatically monitor ONF to determine the health and welfare of pigs.

**Key Words:** automated, ethology, porcine
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**394 Effects of maternal nutrition on fructose concentrations and expression of *GLUT5* in bovine uteroplacental fluids and tissues from days sixteen to fifty of gestation.** N. P. Greseth[1,*], M. S. Crouse[1], K. J. McLean[1], M. R. Crosswhite[1], N. Negrin Pereira[1], A. K. Ward[1], L. P. Reynolds[1], C. R. Dahlen[1], B. W. Neville[2], P. P. Borowicz[1], J. S. Caton[1], [1]*Department of Animal Sciences, North Dakota State University, Fargo,* [2]*Central Grasslands REC, North Dakota State University, Streeter*.

Fructose is the main hexose sugar found in fetal fluids of ungulates. Therefore, we tested the hypotheses that the concentration of fructose in maternal and fetal fluids and mRNA expression of fructose transporter *GLUT5* in utero-placental tissues would be influenced by day of gestation and maternal nutrition. Angus-cross heifers ($n$ = 49) were estrus synchronized, bred via AI, assigned to nutritional treatment (100% of requirements for 0.45 kg/d gain [CON] and 60% of CON [RES]), and ovariohysterectomized on d 16, 34, or 50 of gestation (6 to 9/d). Six heifers were not bred, to serve as nonbred nonpregnant (NB-NP) controls and were ovariohysterectomized on d 16 of the synchronized estrous cycle. Tissues collected include caruncules from the pregnant uterine horn (P-CAR) and nonpregnant uterine horn (NP-CAR), intercaruncular tissue from pregnant uterine horn (P-ICAR) and nonpregnant uterine horn (NP-ICAR), and chorioallantois (fetal membranes [FM]). Fluids collected include maternal serum, histotroph from the pregnant uterine horn (P-histotroph) and nonpregnant uterine horn (NP-histotroph), and allantoic and amniotic fluid. The resulting arrangement was a 2 × 3 + 1 factorial analyzing day, tissue, and day × tissue or day, fluid, and day × fluid. Fetal tissues and fluids were not collected in NB-NP heifers due to lack of FM and allantoic and amniotic fluids. Expression of *GLUT5* in P-CAR was greater ($P$ = 0.02) on d 34 compared with d 16 and 50. In NP-CAR, expression was greater ($P$ < 0.01) on d 34 and 50 compared with d 16. In FM, *GLUT5* expression was greater ($P$ = 0.04) on d 16 compared with d 34 and 50. Serum fructose concentrations were greater ($P$ < 0.01) in NB-NP heifers compared with pregnant heifers. Concentrations of fructose in P-histotroph and NP-histotroph were greater ($P$ < 0.01) on d 50 compared with d 16 and 34. Fructose in amniotic fluid was influenced by a day × treatment interaction ($P$ = 0.04), with d 34 RES being greater ($P \leq 0.05$) than d 50 CON, which was greater ($P \leq 0.05$) than d 50 RES. We interpret these data to imply that the expression of *GLUT5* and concentrations of fructose are more greatly influenced by day of gestation than maternal nutrition; however, potential partitioning of fructose between treatments in amniotic fluids on d 50 of gestation warrants further investigation.

**Key Words:** fructose, *GLUT5*, uteroplacenta
doi:10.2527/asasmw.2017.394

**395 Effects of dietary probiotics on cattle stress behavior.** A. J. Kelsey[*], K. W. Walter, J. D. Colpoys, *Truman State University, Kirksville, MO*.

The objective of this study was to evaluate if dietary probiotics alter stress behavior in cattle. Following a 1-wk acclimation to treatment pastures, 2 treatments were evaluated: 1) control, receiving feed without probiotics, and 2) probiotics, receiving feed containing 10 g per animal per day of probiotics (Probios feed granules; Chr. Hansen, Inc.). Treatments were applied for 6 wk to 33 female cattle ≥1 yr old using a randomized complete block design where cattle were blocked by age (control, $n$ = 16, and probiotics $n$ = 17). Cattle were housed in 4 pastures and allowed access to ad libitum fescue-based pasture and received a corn-based feed ration of 2.3 kg per animal per day. Each week, chute exit velocity was measured using an electric sports timing system. During wk 6, all cattle individually underwent a 5-min novel object test (NOT) where a green jolly ball was used as the novel object. Cattle were individually tested within a 3- by 4.7-m test arena within a barn, consisting of 4 zones. Behavior was evaluated using live observations by 2 trained observers between 0800 and 1200 h. Latency to first and frequency of novel object touches, duration of time within the zone containing the novel object, and frequency of zone line crossings, vocalizations, defecations, and urinations were recorded. Thermal images of the lacrimal region of the eye were taken before and after NOT, and arena exit speed was recorded using an electronic sports timing system. Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) including the fixed effects of treatment, herd (2 herds were used in this study), and NOT order and the covariate of age. Prior to starting treatments, cattle fed probiotics tended to exit the chute faster than control cattle ($P$ = 0.09). However, during wk 3 through 5, cattle fed probiotics exited the chute slower than control cattle ($P$ < 0.01). During NOT, cattle fed probiotics crossed zone lines more frequently ($P$ = 0.04), vocalized less often ($P$ = 0.002), and tended to take longer to first touch the novel object ($P$ = 0.06) compared with the control treatment. No treatment differences were observed in duration of time spent in the zone containing the novel object, frequency of novel object touches, defecations, urinations, or arena exit velocity ($P$ > 0.10). No treatment differences in eye temperature before or after NOT were observed ($P$ > 0.10). These results suggest that dietary probiotics may alter cattle stress behavior.

**Key Words:** behavior, cattle, probiotics
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**396 Dimensional measurements and visual appraisal as predictors of liveweight of finishing pigs.**

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The objective of the study was to determine the accuracy of dimensional measurements and visual appraisal as predictors of BW in finishing pigs. One day prior to marketing, 169 group-housed pigs ($n$ = 4 or 5 pigs per pen) were individually weighed and 3 dimensional measurements were recorded, including flank-to-flank distance measured with a measuring tape (FF) and heart girth circumference measured with a measuring tape (TAPE) and a 0.95-cm (3/8-inch) polyethylene tube (TUBE). A panel composed of 10 individuals with either less than (5 individuals) or greater than (5 individuals) 1 yr of swine experience was briefly trained before visually estimating BW on group-housed pigs. Finally, the length of time for a trained individual to perform FF, TAPE, and TUBE on finishing pigs in group pens was recorded. The accuracy of visual appraisal and dimensional measurements were defined as the correlation between predicted and actual BW. Regressions for visual and dimensional predictions were generated using PROC REG and time data were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary, NC). Fixed effects of models included experience level (Visual Panel), tool (Timing) with pen, panelist (Visual), and person (Timing) as random effects. There were no differences ($P > 0.10$) in accuracy of prediction between experience level of panelists. Visually predicted BW was moderately correlated ($R^2 = 0.42$) with actual BW. As the SD of BW within pen increased (3.3 to 12.2 kg), the accuracy of visual prediction decreased ($R^2 = 0.64$ to $R^2 = 0.02$). Heart girth measured with TAPE was highly correlated with BW ($R^2 = 0.66$) with the following regression equation: BW = −86.73618 × TAPE + 1.9249. Similarly, TUBE was highly correlated with BW ($R^2 = 0.61$) with the following regression equation: BW = −88.9183 × TUBE + 1.91752. However, FF was moderately correlated with BW ($R^2 = 0.38$) with the following regression equation: BW = −29.97947 + FF × 1.75463. There were no differences in the time needed for a trained individual to estimate FF or TUBE (11.5 vs. 14.2 s, respectively; $P > 0.05$), yet TAPE required greater time to measure compared with either FF or TUBE (18.7 s; $P < 0.05$). Results suggest that the high accuracy and low labor requirements of TUBE indicate this is a valid tool for commercial producers to predict the liveweight of finishing pigs prior to marketing.

**Key Words:** estimation, finishing pigs, heart girth
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## UNDERGRADUATE STUDENT POSTER COMPETITION

**397 Effects of vitamins E and D on performance and antioxidant enzymes in nursery pigs.**

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Pigs are stressed at weaning due to commingling, change of diet, environment, and perhaps disease. We hypothesized that adding vitamins E and D to the pig's intake at weaning would improve their antioxidant response to stress and thus improve overall health. The pig's cellular antioxidant system includes the enzymes superoxide dismutase (SOD) and glutathione peroxide (GPx), made endogenously, which can be up- or downregulated in response to need. Vitamins, however, must be supplied exogenously. We previously reported (Gebhardt et al., 2015) that injections of vitamin E, D, and A to sows increased red blood cell (RBC) GPx in their offspring. The present experiment was conducted to study the influence of vitamin E and D supplementation in water on growth, feed intake, and RBC SOD and GPx activities. At 23 ± 3 d of age, 150 PIC 327–sired pigs were weaned and allotted by sex, litter, and weight into 30 pens of 5 pigs each. Pens were randomized within a single nursery room. Pigs from both treatments were fed commercial nursery diets, which met or exceeded the NRC (2012) nutrient requirements for 35 d. Treatment pigs received Emcelle E-$D_3$ Liquid (Stuart Products, Inc., Bedford, TX) through the water system to provide 120 IU vitamin E and 7,200 IU vitamin D per 3.79 L (1 gallon) drinking water. Total daily water consumption was similar between the control and treatment groups. Control pigs received water with no added vitamins. Pigs were weighed and pen feed was intake calculated at 11, 20, and 31 d after weaning. Twelve randomly selected pigs from each treatment were bled at 31 d after weaning for determination of RBC SOD and GPx by commercially available kits. There was no treatment effect on overall ADG (0.46 vs. 0.45 kg/d; $P = 0.52$), ADFI (0.62 vs. 0.62 kg/d; $P = 0.98$), or G:F (0.75 vs. 0.73; $P = 0.16$) in control vs. vitamin-treated pigs, respectively. However, SOD (362.86 vs. 324.17 units/mL; $P = 0.005$) and GPx activities (10,525 vs. 8,105 nmol $min^{-1}$ $mL^{-1}$; $P = 0.0002$) in control vs. vitamin treated, respectively, were reduced in the pigs receiving the vitamins in their drinking water. In this study, although there was no improvement in production parameters, antioxidant enzyme activities were reduced, hypothetically due to decreased need because of elevated vitamins provided in the drinking water.

**Key Words:** antioxidant enzymes, nursery pigs, vitamins E and D
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**398 Effects of in utero heat stress on boar growth and reproduction prior to, during, and after puberty.**

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The objective of this study was to determine the effects of in utero heat stress (IUHS) on reproductive performance in boars. Confirmed pregnant gilts at the University of Missouri were subjected to either thermoneutral conditions (15 to 20°C and 60 to 50% relative humidity; TN) during gestation (IUTN) or were subjected to TN from d 1 to 30, heat stress conditions (27 to 37°C and approximately 55% relative humidity) from d 30 to 60, and TN from d 60 until farrowing. Intact males were weaned at 3 wk of age (WOA), and transported to Purdue University ($n$ = 5 per treatment). Anogenital distance was recorded at birth, and testicular measurements (digital calipers) and BW were taken on a monthly basis (3–42 WOA). Animals were trained for semen collection at 24 wk of age and libido scores were recorded. Semen was collected 1 time per week and evaluated for total sperm production per ejaculate (volume × concentration), morphological abnormalities, and motility and mobility estimations using computer assisted semen analysis (Ceros II; IMV Technologies). Statistical ANOVA was performed using the mixed procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). Anogenital distance at birth tended to be greater in IUHS boars compared with IUTN boars ($P$ = 0.065). Testicular growth rate was less during puberty (11–24 WOA; 4.61 vs. 7.04 $cm^2$/wk ± 0.58; $P$ = 0.015), greater after puberty (24–42 WOA; 3.51 vs. 2.37 $cm^2$/wk ± 0.34; $P$ = 0.031), and tended to be greater prior to puberty (3–11 WOA; 1.79 vs. 1.47 $cm^2$/wk ± 0.11; $P$ = 0.060) for IUHS boars compared with IUTN boars. Average weekly libido score and BW did not differ ($P$ = 0.841 and $P$ = 0.938, respectively). Total sperm production per ejaculate was lower in IUHS boars ($41.4 \times 10^9$ vs. $33.1 \times 10^9$ ± 1.3; $P < 0.001$) and tail abnormalities were higher in IUHS boars (5.47 vs. 3.45% ± 0.64; $P$ = 0.010) compared with IUTN boars. There tended to be an increased percentage of sperm with distal midpiece reflexes in IUHS boars compared with IUTN boars (2.12 vs. 1.27% ± 0.43, respectively; $P$ = 0.098). Amplitude of lateral head displacement was less for IUHS boars (3.9 vs. 4.9 μm ± 0.3; $P$ = 0.018) and curvilinear velocity was slower for IUHS boars (84 μm/s vs. 103 μm/s ± 5.7; $P$ = 0.045) compared with IUTN boars. Total motility did not differ ($P$ = 0.200). In summary, IUHS boars had decreased sperm production, diminished sperm quality, and delayed testicular growth during puberty, indicating the negative repercussions on boar reproduction.

**Key Words:** boar, in utero heat stress, total sperm
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**399 Comparison of Igenity Silver Profile and Zoetis PredicGEN DNA tests in crossbred beef cattle.**

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Recently, several standalone DNA tests for beef cattle have been introduced to the marketplace. Two of these tests are the Igenity Silver Profile (Neogen, Lincoln, NE) and Zoetis PredicGEN (Zoetis Animal Genetics, Kalamazoo, MI). The Igenity Silver Profile estimates genetic merit for calving ease maternal, stayability, residual feed intake, ADG, tenderness, and marbling. The Zoetis PredicGEN estimates genetic merit for tenderness, marbling, and yield grade. No data is available that directly compares DNA test results from these 2 panels on the same sample of crossbred cattle. Our objective was to estimate correlations between test results from these 2 DNA panels. Steers ($n$ = 160) were sampled from the South Dakota State University Calf Value Discovery (CVD) Program. The primary purpose of the CVD Program is to help producers make educated decisions about retaining ownership of calves through the feedlot. Nine producers shipped anywhere from 6 to 73 steers to the VanderWal Farms (Volga, SD) feedlot in December 2015. Hair follicles were collected from steers and shipped to Zoetis Animal Genetics and Neogen Corporation for DNA testing. The Igenity and PredicGEN panels successfully genotyped 159 and 103 steers, respectively. Pearson correlation coefficients were estimated between test results for each weight gain and carcass trait, both within each DNA panel and across the 2 panels. Within the PredicGEN DNA panel, tenderness was positively correlated with marbling ($r$ = +0.26, $P$ = 0.008) and negatively correlated with yield grade ($r$ = −0.31, $P$ = 0.001), whereas marbling was negatively correlated with yield grade ($r$ = −0.58, $P < 0.0001$). Within the Igenity Silver Profile, marbling was positively correlated with ADG ($r$ = +0.35, $P < 0.0001$). Across DNA panels, tenderness ($r$ = +0.76, $P < 0.0001$) and marbling ($r$ = +0.49, $P < 0.0001$) tests were positively correlated. The PredicGEN yield grade test was negatively correlated with Igenity tenderness ($r$ = −0.45, $P < 0.0001$) and marbling ($r$ = −0.35, $P$ = 0.0004). The PredicGEN marbling test was positively correlated with Igenity ADG ($r$ = +0.34, $P$ = 0.0004) and tenderness ($r$ = +0.24, $P$ = 0.017). PredicGEN tenderness was positively correlated with Igenity marbling ($r$ = +0.24, $P$ = 0.013). The tenderness DNA tests by PredicGEN and Igenity are highly correlated whereas the marbling DNA tests from both companies are only moderately correlated. Producers are therefore more likely to observe greater differences between PredicGEN and Igenity Silver DNA profiles for marbling than for tenderness.

**Key Words:** beef cattle, carcass, DNA testing
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## 400 The effects of different oocyte maturation media on the production of in vitro derived pig embryos.

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Polyspermic penetration in pig oocytes has been identified as a persistent problem during in vitro fertilization (IVF) within the swine industry. The composition of oocyte maturation media has an effect on successful cytoplasmic and nuclear maturation of the oocyte. The objective of this study was to determine the effects of the meiosis inhibitor dibutyryl-cAMP (dbcAMP) and media formulation on oocyte maturation and subsequent IVF and embryo culture success. Oocytes ($n$ = 656; $r$ = 3) were matured in either a modified Medium 199 (M199) or a porcine oocyte maturation media (POM) for 48 h and either with dbcAMP supplemented to the media for the first 24 h of maturation or not. Oocytes were evaluated for nuclear maturation ($n$ = 130). Oocytes ($n$ = 526) were fertilized using frozen-thawed semen and evaluated for fertilization characteristics and subsequent embryonic development at 48 and 144 h for cleavage and blastocyst formation, respectively. Oocytes matured in M199 and dbcAMP had a significantly higher ($P < 0.05$) percentage of oocytes reaching metaphase II (MII) by 48 h (83.33% ± 3.34) compared with those matured in POM and dbcAMP (66.67% ± 4.78). The addition of dbcAMP during the first 24 h caused a significantly higher ($P < 0.05$) percentage of oocytes to read MII by 48 h compared with no dbcAMP supplementation in both M199 (58.26% ± 5.23) and POM (32.26% ± 5.98). Oocytes matured in POM with dbcAMP had significantly fewer ($P < 0.05$) penetrated oocytes 12 h after IVF compared with all other treatment groups. Oocytes matured in M199 had significantly fewer ($P < 0.05$) polyspermic oocytes 12 h after IVF compared with those matured in POM. Oocytes matured with dbcAMP supplementation for the first 24 h of maturation had significantly higher ($P < 0.05$) male pronuclear formation compared with those not supplemented with dbcAMP. There were no significant differences between the treatment groups with respect to embryo cleavage 48 h after IVF. Oocytes maturated in M199 media had a significantly higher ($P < 0.05$) percentage of those reaching the blastocyst stage of development by 144 h after IVF compared with oocytes maturated in POM. The results indicate that oocytes matured in M199 and supplementation with dbcAMP during the first 24 h of maturation have the greatest success in developing in vitro derived embryos.

**Key Words:** maturation, ooctye, pigs
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## 401 Feeding liquid sweet whey to growing swine.

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Liquid sweet whey (LSW) is the byproduct resulting from the manufacture of hard cheeses. It is the liquid remaining after the cheese curds are removed. Entrepreneurial artisanal cheese plants located on the urban fringe or associated with the rural agrotourist areas of Michigan and other states are too small to gain the attention of whey processors, leaving swine farmers the opportunity to access a low-cost swine feedstuff. This work was conducted to study the effects of feeding liquid sweet whey to growing pigs on growth performance and pork eating attributes. A total of 72 barrows (Yorkshire × [PIC 327], weighing 9.63 and 8.33 kg BW at weaning for replicate 1 and 2, respectively) were used. Six pens and 6 pigs per pen were used in each replicate. When weaned, pigs were allotted based on BW and birth litter to 1 of 2 experimental treatments: 1) Control, provision of corn–soybean diets and water in a single-space wet–dry feeder, or 2) LSW, provision of corn–soybean diets and LSW in a single-spaced, wet–dry feeder. Each feeder was fitted with a nipple drinker. No other source of liquid was provided. Pigs were fed for 98 and 103 d in replicate 1 and 2, respectively. Average daily gain did not differ between the 2 treatments. Daily dry feed intake was less ($P < 0.01$) for pigs fed LSW but they consumed an average of 9.10 kg of LSW each day, resulting in those pigs have slightly greater ($P < 0.05$) average daily DMI. Feeding LSW resulted in slightly poorer ($P < 0.05$) efficiency of DM utilization. A triangle taste testing was completed using a sirloin chop, and results indicate that consumers detected a difference ($P < 0.05$) between pork harvested from whey-fed pigs and those fed commercially available grain-based feeds. Feeding LSW using wet–dry feeders in wean–finish production has potential to provide economic and environmental benefits for both cheese and pork production.

**Key Words:** growth, liquid sweet whey, pigs
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**Table 401.**

| | Control | LSW | SE or (SD) | *P*-value |
|---|---|---|---|---|
| ADG, kg | 0.88 | 0.86 | 0.019 | 0.50 |
| Average daily dry feed intake, kg | 1.95 | 1.37 | 0.046 | <0.01 |
| Average daily LSW intake, kg | – | 9.10 | (2.83) | – |
| Average daily DMI, kg | 1.72 | 1.85 | 0.022 | <0.05 |
| Efficiency (gain:DMI) | 0.515 | 0.471 | 0.0099 | <0.05 |

**402 Analysis of particle size and organic matter in recycled sand bedding.** L. R. Statz*, P. J. Lammers, K. A. L. Hardyman, *University of Wisconsin-Platteville, Platteville*.

Recycled sand bedding is widely used and can support dairy cow health and comfort if appropriately managed. Recycled sand, if free of OM, is an inhospitable environment for pathogen growth. Sand particle size influences hoof health and lameness and is another factor to evaluate in recycled sand. Particle size and OM content of recycled sand were analyzed at Lake Breeze Dairy, LLC in Malone, WI. During the month of July 2016, samples of recycled sand bedding were taken 2 times a week from the sand lane (86.9 m long) at 21.3, 42.7, 64.0, and 85.3 m from the wash out point. Particle size was analyzed using sieves with 4,750-, 2,000-, 600-, and 300-µm openings. For each location, a 250-g sample was dried in a microwave oven until reaching stable mass. The dry samples were sieved and percent composition was calculated for 3 groupings of particle size: <600 µm (small), 600 to 2,000 µm (medium), and >2,000 µm (large). Approximately 600 g of the unsieved sand was taken from each sampling location for analysis of OM content determined by ashing (Dairyland Laboratories, Arcadia, WI). The results are summarized in Table 402. Sampling location within sand lane affected particle size, with the 21.3 m location being significantly different than the other 3 locations ($P < 0.01$). Organic matter and sand volume decreased as distance within sand lane increased ($P = 0.01$). The highest concentration of quality sand was located at 21.3 m, with significant declines in sand particle size, cleanliness, and volume at greater distances.

**Key Words:** recycled sand, sand bedding, sand quality
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**403 Acceptance of a novel cheese byproduct powder by young ruminants.** S. L. Van Asten[1,*], E. N. Alava[2], E. I. Alava[3], P. J. Lammers[1], *[1]University of Wisconsin-Platteville, Platteville, [2]University of Findlay, Findlay, OH, [3]Escuela Superior Politecnica del Litoral, Guayaquil, Ecuador*.

Acceptance of a novel cheese byproduct powder was evaluated in yearling Holstein heifers through 2 feed preference trials performed at the University of Wisconsin–Platteville Pioneer Farm, Platteville, WI. The cheese byproduct was provided by Agri Processing Services, LLC (Carmel, IN). Each morning, heifers were attracted to headlocks and locked in place. Heifers were then offered 2 feeding trays (14 by 26 by 15 cm) of feedstuffs. Plywood dividers were positioned between heifers to ensure heifers had access to only the assigned dietary treatment. Heifers were allowed 15 min to consume the offered feed, after which feed trays were removed, orts were collected, and heifers were released. Heifers were offered hay ad libitum throughout the day and were fed a concentrate ration following the daily test period. During each 15-min test period, heifers were digitally recorded and their eating habits were observed. In both trials, heifers ($n = 12$) were used in a 2 × 2 Latin square design with 2 feedstuffs (trial 1: 500 g concentrate pellets vs. 450 g concentrate pellet + 50 g cheese byproduct powder; trial 2: 500 g corn silage vs. 450 g corn silage + 50 g cheese byproduct powder) offered in 2 locations (right or left side) over 4 d. Orts were dried in an oven at 75°C until stable DM mass was achieved and used to calculate DMI and feed preference ratio (DMI of test diet × total DMI$^{-1}$). Digital recordings were viewed by trained individuals to measure time spent consuming each diet. Dry matter intake, time spent eating, and feed preference were compared with significance being declared at $P \leq 0.05$. Dry matter intake of pellets was greater than that of pellets supplemented with cheese byproduct (341.6 vs. 27.3 g; $P < 0.01$). Dry matter intake of silage was also greater than that of silage supplemented with cheese byproduct (77.3 vs. 4.4 g; $P < 0.01$). Time spent eating pellets or silage was greater than time spent eating pellets or silage supplemented with cheese byproduct ($P < 0.01$) and there was a preference ($P < 0.01$) for feedstuffs without cheese byproduct supplementation. Regardless of feedstuff offered, heifers consumed unsupplemented feedstuff first (trial 1: 57.61 vs. 42.39% [$P < 0.01$]; trial 2: 57.29 vs.

**Table 402.** Characteristics of recycled sand bedding at different locations in sand lane

| | Sample location,[1] m | | | | | *P*-value | |
|---|---|---|---|---|---|---|---|
| | 21.3 | 42.7 | 64.0 | 85.3 | SEM | Location | Day |
| Small, % | 48.54[a] | 83.55[b] | 79.35[b] | 77.03[b] | 3.36 | <0.01 | 0.05 |
| Medium, % | 44.48[a] | 14.27[b] | 18.14[b] | 19.52[b] | 3.13 | <0.01 | 0.06 |
| Large, % | 7.09[a] | 2.33[b] | 2.21[b] | 2.78[b] | 0.60 | <0.01 | 0.02 |
| OM, % | 3.86[a] | 8.01[ab] | 8.77[b] | 9.50[b] | 1.17 | 0.01 | 0.96 |
| Sand volume, % | 64.00[a] | 27.00[b] | 7.00[c] | 2.50[c] | 1.65 | <0.01 | 0.89 |

[a,b,c]Superscripts reflect location differences ($P \leq 0.05$)
[1]Distance from washout point (m).

42.71% [$P < 0.01$]). In both trials, heifers would consume feed combined with cheese byproduct, but there was a preference for feed offered without cheese byproduct supplementation.

**Key Words:** byproduct feeds, feed acceptance, feed preference
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**404 Supplementation of fructose on porcine sperm improves characteristics on frozen–thawed sperm.**
B. D. Whitaker, E. Winn*, *University of Findlay, Findlay, OH*.

Using an alternative energy source for spermatozoa during in vitro fertilization could be responsible for the high incidence of polyspermic penetration in porcine oocytes. The objective of this study was to evaluate the effects of supplementing 11.0 m*M* D-(+)-glucose or 11.0 m*M* D-(−)-fructose as the energy source during the thawing and culture procedure of frozen-thawed semen. Sperm was evaluated for forward progressive motility, viability, and the ability to undergo the acrosome reaction (capacitation) at 0, 2, 4, and 6 h after thawing. The effects of supplementing 11.0 m*M* D-(+)-glucose or 11.0 m*M* D-(−)-fructose during the thawing and in vitro fertilization procedures were evaluated on fertilization, polyspermic penetration, male pronuclear (MPN) formation, and embryonic development. Sperm supplemented with fructose had significantly higher ($P < 0.05$) forward progressive motility and viability compared with sperm supplemented with glucose at 0, 2, and 4 h after thawing. Additionally, sperm supplemented with fructose had a significantly higher ability ($P < 0.05$) to undergo the acrosome reaction compared with sperm supplemented with glucose at each time measurement after thawing. There were no significant differences observed in fertilization, polyspermic penetration, or MPN formation rates between oocytes ($n = 41$) fertilized with either glucose- or fructose-supplemented sperm. Oocytes ($n = 478$) fertilized with sperm supplemented with fructose had a significantly higher ($P < 0.05$) percent of embryos cleaved by 48 h after IVF (80.00% ± 4.23) compared with those that were supplemented with fructose (69.76 ± 3.87). There was no difference in blastocyst formation rate at 144 h after IVF between the treatment groups. The results indicate that supplementing frozen-thawed boar semen with fructose rather than glucose improves spermatozoan characteristics but does not have an effect on the in vitro production of pig embryos.

**Key Words:** fructose, in vitro fertilization, sperm
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**405 Effects of nutrient supplementation on pig sickness behavior when infected with porcine reproductive and respiratory syndrome virus.**
N. R. Gordon[1,*], S. M. Curry[2], W. P. Schweer[2], N. K. Gabler[2], J. D. Colpoys[1], *[1]Truman State University, Kirksville, MO, [2]Iowa State University, Ames*.

Porcine reproductive and respiratory syndrome virus (PRRSV) is a significant respiratory pathogen in grow–finish pigs. The objective of this research was to investigate how nutrient supplements impact pig sickness behavior during a PRRSV infection. Sixty PRRSV-naïve pigs were allotted based on BW into 10 pens (6 pigs/pen) housed in a curtain-sided commercial barn during summer months. At 35 kg BW, all pigs were intranasally and intramuscularly inoculated with a field strain of PRRSV virus and began treatment supplements. Treatments included 1) control, receiving no nutrient supplement ($n = 3$ pens); 2) water nutrient supplement (modified Blue2; TechMix LLC; $n = 3$ pens); and 3) water + feed supplement (modified Blue2 + modified powdered form of Blue2; TechMix LLC; $n = 4$ pens). Pig home-pen behavior was recorded on 4 color cameras positioned above the pens. Video was collected on days after inoculation (dpi) −1, 3, 6, 9, 12, 15, and 18. Video observations were recorded using a 10-min scan sampling interval from 0700 to 1900 h daily by 1 trained observer. Percent of pigs standing, lying, sitting, eating, and drinking within each pen was recorded. Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) with a β distribution to evaluate treatment and day differences. Pigs given the water + feed supplement showed an increase in sitting behavior compared with the control and water supplement treatments ($P \leq 0.05$). No differences were observed between treatments for lying, standing, eating, or drinking behaviors ($P > 0.05$). On 6 and 9 dpi, an increase in lying behavior was observed compared with −1 dpi ($P \leq 0.05$). Compared with −1 dpi, a decrease in sitting behavior was observed 9 dpi whereas an increase in sitting behavior was observed 15 dpi ($P \leq 0.05$). Standing behavior decreased on 6 and 9 dpi compared with −1 dpi ($P \leq 0.05$). On 6 dpi, eating behavior decreased compared with −1 dpi, whereas on 15 and 18 dpi, eating behavior increased compared with −1 dpi ($P \leq 0.05$). Compared with −1 dpi, drinking behavior was reduced in pigs on 6 to 18 dpi ($P \leq 0.05$). In conclusion, no differences in sickness behavior were observed until 6 dpi. On 6 and 9 dpi, pigs were less active than on −1 dpi; however, activity was similar to −1 dpi on 3 dpi and 12 to 18 dpi. Eating behavior was decreased only on

6 dpi; however, drinking behavior decreased on 6 dpi and did not return to baseline by 18 dpi. Furthermore, the nutrient supplement treatments had minimal effect on sickness behaviors of PRRSV-infected pigs.

**Key Words:** pig, porcine reproductive and respiratory syndrome virus, sickness behavior
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**406 Oviductal fluid supplementation during maturation and fertilization improves in vitro embryonic development in pigs.** A. Goldacker*, E. Winn, J. Current, B. D. Whitaker, *University of Findlay, Findlay, OH*.

Oviductal fluid has a major role in the maturation of gametes and the process of fertilization. The objective of this study was to determine the effects of oviductal fluid supplementation in vitro, during oocyte maturation and in vitro fertilization (IVF). on oocyte maturation, spermatozoa and fertilization characteristics, and early embryonic development rates. During the last 24 h of maturation, oocytes ($n$ = 1,423) were placed into maturation media supplemented with either 1 (vol/vol) or 5% (vol/vol) thawed snap-frozen oviductal fluid. Fertilization was performed using pooled frozen-thawed semen from 3 different boars. During IVF, the fertilization media was supplemented with 1 (vol/vol) or 5% (vol/vol) oviductal fluid. At the end of maturation, oocytes ($n$ = 195) were evaluated for intracellular glutathione (GSH) levels, GSH peroxidase activity, and nuclear maturation. Fertilization characteristics were evaluated 12 h after IVF, and rates of embryonic cleavage and blastocyst development were observed at 48 and 144 h after IVF, respectively. Sperm were evaluated for forward progressive motility, viability, and the ability to undergo the acrosome reaction (capacitation) at 0, 2, 4, and 6 h after thawing. There were no significant differences in the percentages of oocytes that reached metaphase II by the end of maturation, GSH peroxidase activity, forward progressive motility, ability to undergo the acrosome reaction, or sperm penetration rates after IVF. Supplementation with 1% (vol/vol) oviductal fluid had significantly higher ($P < 0.05$) GSH concentration levels in oocytes and higher viable sperm at 2 h after thaw. Oocytes treated with 1% (vol/vol) oviductal fluid during the end of maturation and IVF (33.33 ± 2.61) and 5% (vol/vol) oviductal fluid during maturation (33.33 ± 2.66) or IVF (39.53 ± 3.78) had significantly less ($P < 0.05$) incidence of polyspermic penetrations and a significantly higher ($P < 0.05$) incidence of male pronuclear formation (87.50 ± 4.01, 86.67 ± 4.83, and 86.05 ± 3.19, respectively) compared with no oviductal fluid supplementation. Oocytes supplemented with 5% (vol/vol) oviductal fluid during maturation and IVF had significantly lower ($P < 0.05$) incidences of polyspermic penetration (27.91 ± 2.50) and significantly higher ($P < 0.05$) percentages of embryos reaching the 2-cell stage (81.76 ± 3.72) and blastocyst stage of development (37.74 ± 1.09) by 48 and 144 h, respectively, compared with all other groups. The results of this study suggest that supplementing 1 and 5% (vol/vol) oviductal fluid during maturation and IVF improves the success rates of in vitro embryo development in pigs.

**Key Words:** oviduct, pigs, polyspermy
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**407 Effects of dietary probiotics on cattle growth performance.** A. J. Kelsey*, J. D. Colpoys, *Truman State University, Kirksville, MO*.

As the livestock industry shifts away from performance-based antibiotics, probiotics may be a beneficial alternative for improving cattle growth and feed efficiency. Therefore, the objective of this study was to evaluate if dietary probiotics alter growth performance in cattle. Following a 1-wk acclimation to treatment pens, 2 treatments were evaluated: 1) control, receiving feed without probiotics, and 2) probiotics, receiving feed containing 10 g per animal per day of probiotic granules (Probios feed granules; Chr. Hansen, Inc.). Two groups of cattle were used for this experiment. Group 1 had treatments applied for 6 wk to 33 female cattle ≥1 yr old using a randomized complete block design where cattle were blocked by age (control, $n$ = 16, and probiotics, $n$ = 17). Group 2 had each treatment applied for 3 wk to 7 weaned calves 7 to 10 mo old (castrated males, $n$ = 4, and females, $n$ = 3) using a crossover experimental design. Group 1 cattle were housed in groups of 8 to 9 cows per pasture within 4 pastures; cows were allowed access to ad libitum fescue-based pasture and received a corn-based feed ration of 2.3 kg per animal per day. Group 2 cattle were housed in groups of 2 to 3 calves per pen within 3 drylots with access to a barn. Group 2 cattle were allowed access to ad libitum hay and received a corn-based feed ration of 4.5 kg per animal per day. Weekly BW and ADG were measured for groups 1 and 2 and the G:F ratio was calculated for group 2. Data were analyzed using a mixed model in SAS (SAS Inst. Inc., Cary, NC) including the fixed effects of treatment and herd (3 herds were used in this study) and covariate of age. No treatment differences were observed in group 1 on-test BW, off-test BW, or ADG ($P > 0.10$). In Group 2, on-test BW tended to be greater in the control treatment compared with the probiotic treatment ($P = 0.08$); however, off-test BW did not differ between treatments ($P = 0.85$). Group 2 calves fed the probiotics treatment had a greater ADG and G:F compared with the control treatment ($P = 0.04$). In conclusion, probiotics did not alter performance in female cattle ≥1 yr old. However, probiotics may improve growth performance in 7- to 10-mo-old calves.

**Key Words:** cattle, growth, probiotics
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**408 Bentley Abstract: Pain management in livestock: understanding the views of producers and veterinarians.** K. Rutherford[1,*], C. Thompson[1], S. Ison[2], *[1]SRUC, Edinburgh, United Kingdom, [2]Michigan State University, East Lansing.*

Treatment of pain is an important part of livestock management. In the UK, various pain management options are available. Yet, despite this and a historical emphasis on animal wellbeing, use of pain relief for livestock is perceived to be limited. This presentation will: i) assess the evidence regarding how much livestock producers actually use pain relief and ii) discuss the contributory factors which dictate whether pain relief is used or not. In recent survey studies of swine, cattle, and sheep farmers, we have gathered data on attitudes toward pain and its treatment as well as on how often pain relief is used in practice. The overall message from these studies is that provision of pain relief is often better than is appreciated. Producers may choose to use pain relief either because they feel it is the right thing to do (has ethical benefits) or because they feel it is the rational thing to do (has direct or indirect practical benefits). For instance, the statement that animals 'recover better when given pain relief' was agreed with by 72%, 82%, and 86% of pig, sheep, and cattle farmers, respectively. However, while attitudes are improving, routine pain relief is still not widespread. In relation to dystocia (rated as highly painful by all farmer groups), pain relief was always used by only 27% of cattle farmers and 19% of sheep and pig farmers. Efforts have been made to understand the factors that underlie such decisions. Cost is a commonly cited barrier to wider pain relief in livestock. However, analgesics were judged too expensive by only 14% of sheep, 10% of cattle, and 19% of pig producers. Alternatively, practical barriers, such as gathering or handling animals, are often mentioned. Farmers in all three groups showed a recognition/knowledge gap: more farmers reported an adequate ability to recognize pain than reported an adequate knowledge of how to mitigate it. Communication between farmers and vets is therefore critical. However, the survey data suggest that vets think they are discussing pain relief with farmers more often than farmers think they are discussing it with vets. Finally, it is encouraging that the surveys also showed that better pain management often associates with other progressive management practices, such as body condition and locomotion scoring, pregnancy diagnosis, and vaccination. Farmers who are proactive in their use of these practices are also more likely to treat livestock for pain.

**Key Words:** livestock, pain, welfare
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**409 DPP Abstract: Nutrient sensing and appetite in pigs.** E. Roura*, *CNAFS/QAAFI, The University of Queensland, Brisbane, Australia.*

Nutritional chemosensing has been defined as the science studying the perception of nutrients in animals. Dietary nutrients are perceived in the oral cavity mainly through the taste system, which involves a large set of taste receptors (TR) signaling the gustatory cortex of the brain through dedicated neuronal fibers. Our group has contributed to the discovery of the nutrient receptor repertoire (including carbohydrates, AA, and fatty acid receptors) in pigs and chickens. In recent years, the expression of TR outside the oral cavity has claimed the attention of the international scientific community. We have been studying nutritionally driven TR expression patterns with emphasis in pig and chicken extraoral tissues. In particular, our findings have uncovered some of the functional properties of a subset of bitter taste receptors (T2R) expressed in the stomach and small intestine. Behind an apparent simplicity, the functional implications of bitter taste has emerged as one of the most fascinating and complex biological discoveries over the last 15 yr relevant to nutrition and health. Although originally, bitter compounds were related to potential toxins (mostly of plant origin), in recent years, it has become apparent that most plant bitterants have little or no detrimental effects. Plants and plant-eaters seem to have coevolved partially based on bitter compounds and bitter perception. Therefore, the bitter sensory system seems to be a major player influencing adaptation of animals to ecological niches and a driver of nutritional evolution. In addition, some bitterants have been found to play a principal role in modulating gastric emptying and intestinal peristaltic movement and GIT peptide secretion, thus mediating appetition and satiation in pigs. However, the most compelling story about the function of bitter taste receptors is yet to be fully uncovered and will relate to bitter sensing of pathogenic bacteria and expression of T2R in internal organs such as the heart or the immune system.

**Key Words:** bitter taste, nutritional chemosensing, pig
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# AUTHOR INDEX

*Please note: numbers following author's name indicate abstract numbers.*


## A

Abdelsalam, K., 365
Abedal-Majed, M., 109
Acheson, R., 206
Acosta, J. A., 295, 306
Adams, A. A., 315
Adeola, O., 101, 182
Ader, P., 232, 244
Adeyosoye, O. I., 112
Al-Qaisi, M. A., 323, 325
Alava, E. I., 403
Alava, E. N., 403
Alegre, B., 384
Allee, G. L., 206
Allen, H. K., 305
Allen, M., 375
Allerson, M., 174
Almeida, F. N., 186
Almeida, L., 162
Altman, A. W., 315
Aluthge, N. D., 327
Amachawadi, R. G., 172
Amundson, O. L., 317
Anderson, C. L., 348
Anderson, J. N., 337, 338, 339
Anderson, J. L., 366, 374, 378
Apgar, G. A., 54, 89
Apple, J. A., 254, 283, 387
Arent, S., 252
Arentson, R. A., 287
Arkfeld, E. K., 135
Arruda, P. H., 100
Atkinson, R. L., 359
Aumiller, T., 180
Avaroma, C., 314
Avelar, E., 324
Ayers, P.,
Azain, M. J., 8, 229
Azarpajouh, S., 6, 7, 14, 75

## B

B. Menegat, M., 288
Babcock, J., 241
Baek, D. H., 224
Bai, J. F., 100, 196, 255
Baidoo, S. K., 18, 66, 93, 164, 223, 265, 322
Baker, J., 184
Baker, L., 197
Bandarupalli, V., 358
Bargo, F., 154
Barnett, S. M., 160, 166, 212, 289
Barroso, L. M., 32
Bass, B. E., 205, 295, 306
Baumert, D. A., 20
Baumgard, L. H., 9, 29, 38, 272, 323, 325, 329, 372
Baurhoo, B., 83, 120
Beard, J., 317
Becerra, R., 114
Becerra, R., 269
Beever, J. E., 331
Bell, N. L., 367
Beltranena, E., 190, 191
Bergman, J., 109
Bergstrom, J. R., 100, 254
Berhow, M. A., 281, 366
Bi, Z., 77
Bible, M. R., 220, 221, 231
Bidne, K. L., 38, 318, 329
Bienhoff, M., 294
Bionaz, M., 314
Bittner, C. J., 335, 336, 337, 338, 344
Blair, A. D., 98
Blavi, L., 178
Bloomer, S., 69
Bohrer, B. M., 133, 137
Bohrer, R. C., 120
Boler, D. D., 129, 133, 134, 135, 137, 354
Bondurant, R. G., 141, 346, 349
Bonet, J., 67
Bordignon, V., 120
Borowicz, P. P., 95, 347, 394
Bottje, W. G., 364
Bowman, R. L., 24
Boxler, D. J., 17
Boyd, R. D., 103
Boyer, V., 120
Bradford, B. J., 50
Bradley, C. L., 183
Brewer, G. J., 17
Broadhead, D. L., 352
Broomhead, J. N., 247
Brown, D. S., 25
Brown, M., 296
Brown, T., 384
Bruininx, E. M. A. M., 187, 188
Brummit, A. R., 401
Bruns, K. W., 141
Bruun, T. S., 150, 234, 235
Budiño, F. E. L., 217, 218
Burhoop, J. E., 344, 345
Burkey, T. E., 160, 166, 212, 289, 326, 327
Burnett, D. D., 85, 127, 131
Burrough, E. R., 143, 193, 226, 328
Busato, S., 314
Byrd, C. J., 272

## C

Cabezon, F. A., 63, 64, 70, 71, 117, 161, 243, 379
Caffe-Treml, M., 261
Calderon Diaz, J. A., 6, 7, 14, 75
Calkins, C. R., 126, 382
Callahan, Z. D., 132
Camacho, R. L., 324
Campbell, B. T., 90
Campler, M. R. B., 86
Cardoso, F. C., 19
Cardoso, F., 57, 363
Carlson, D., 307
Carlson, Z. E., 342
Carpenter, C. B., 10, 179, 181
Carr, S. N., 206
Carvalho, J. R. R., 128
Casas, G. A., 165, 304
Casper, D. P., 53, 62, 365, 377
Casperson, B. A., 373
Cassady, J. P., 42
Cast, W., 273
Caton, J. S., 95, 347, 394
Cave, V. M., 97
Cederberg, R. A., 308
Cervantes Ramírez, M., 324
Chamberlin, D., 241
Chang, J., 186
Chang, P. L., 103
Chao, M. D., 382
Chapel, N. M., 272
Chapple, W. P., 351
Chase, C., 365

Chase, Jr., C. C., 317
Chen, C., 77, 248, 249, 258, 389
Chen, H., 246
Chen, Q., 100, 196
Chen, Y., 136
Cheng, J., 71
Chewning, J. J., 247, 254, 283
Chi, F., 155
Ching, S., 155
Chizzotti, M. L., 128
Cho, S., 401
Choi, H. B., 102
Christenson, L. K., 309
Chung, W. L., 204
Ciobanu, D. C., 27, 160
Clapper, J. A., 391
Clark, A. B., 174, 222, 230
Clemente, H., 85
Clemmons, B. A., 112
Cline, P. M., 80
Cloutier, L., 271
Coble, K. F., 225
Coble, K. F., 127, 213, 237
Cochrane, R. A., 196, 255, 256
Coelho, M., 232, 244
Coetzee, H., 2
Coleman, D. N., 113, 356
Colpoys, J. D., 395, 405, 407
Coma, J., 67
Combs, D. K., 52
Connor, J., 239, 240, 280, 301
Cooper, N. C., 130, 268
Cooper, R. J., 343
Copeland, K. R., 397
Cordero, G., 183
Cornelison, A. S., 281
Courtney, L. S., 167
Couture, C., 271
Cox, J. L., 357
Craig, B. A., 161
Crenshaw, M. A., 85, 99, 155
Crenshaw, T. D., 184
Crooker, B. A., 18
Crosby, M. J., 110
Cross, A. J., 26, 42
Crosswhite, M. R., 95, 394
Crouse, M. S., 95, 394
Crowder, S. A., 177, 292
Cui, S., 18, 164
Culbertson, M., 273
Cupp, A. S., 109
Current, J., 400, 406
Curry, S. M., 143, 328, 405
Cushman, R. A., 109, 121, 311, 317

## D

Dahlen, C. R., 40, 95, 394
Davis, J. S., 109
de Jong, L., 187, 188
de Lange, C. F. M., 82, 84, 144, 148, 227, 257
De Mille, C. M., 229
de Nanclares, M. P., 258
De Rodas, B., 292
De Souza, A. L. P., 171, 173
de Tejerina, J. C. D., 384
De Vries, J. L., 241
DeChant, M. T., 54
Decker, J. E., 25, 331
Dekkers, J. C. M., 9, 29, 33, 34, 36, 44, 75, 330
DeRouchey, J. M., 10, 87, 100, 119, 122, 157, 158, 163, 168, 170, 172, 174, 175, 176, 179, 181, 196, 210, 222, 225, 230, 237, 238, 245, 275, 276, 277, 286, 288, 299, 302, 386
Derscheid, R. J., 100, 196
Desaulniers, A. T., 308
Deters, E. L., 107
Di Giminiani, P., 3
Dias, F. T. F., 217, 218
Dicke, B. D., 343
Dicks, N., 120
Dickson, M. J., 38, 325, 329
DiCostanzo, A., 105
Dieter, P. A., 113
Dilger, A. C., 129, 133, 134, 135, 137, 354
Dilger, R. N., 146
Dinh, T., 99, 131
DiPietre, D., 78
Do, S. H., 201, 202, 203
Domenech-Pérez, K., 126, 382
Donkin, S. S., 373
Dove, C. R., 8, 229
Drewnoski, M. E., 321
Drewnoski, M. E., 357
Dritz, S. S., 100, 119, 122, 157, 158, 168, 172, 174, 225, 230, 275, 286, 288, 299, 302
Dritz, S. S., 10, 170, 176, 179, 181, 196, 209, 210, 222
Dritz, S. S., 87, 163, 175, 237, 238, 245, 255, 256, 276, 277, 386
Drouillard, J. S., 138
Duarte, M. E., 159, 228, 297
Duffield, T. F., 4
Duggavathi, R., 83, 120
Duncan, N. B., 110
Dunkelberger, J. R., 34, 44
Durfey, C. L., 85
Dykstra, P. S., 140

## E

Eklund, M., 180
El-Kadi, S. W., 136
Ellersieck, M. R., 312
Ellis, M., 30, 130, 177, 195, 214, 216, 268
Engel, C. L., 360, 361
England, S. J., 220, 221, 231
Erceg, J. A., 94, 269, 396
Erickson, G. E., 335, 336, 337, 338, 339, 342, 343, 344, 345, 346, 350
Ernst, N., 401
Espinoza, S., 324
Estrada, J. E., 177, 195, 214, 268
Ewing, K., 30

## F

Fahrenkrug, S. C., 307
Fakler, T. M., 220, 221, 231
Fang, L. H., 102
Felix, T. L., 111
Fellows, G. M., 363
Feng, H., 171, 173
Fernando, S. C., 212, 289, 327, 348
Ferracioli, L. B., 217, 218
Ferrari, V. B., 346
Ferreira, G., 59
Ferring, C. L., 35
Feugang, J. M., 85, 155
Fields, B.,
Fievisohn, E. M., 393
Fike, K. E., 56
Fisher, R. E., 144
Fisker, B. N., 150
Fitzner, G. E., 210
Flowers, W. L., 45
Fogsgaard, K. K., 16
Fontoura, A. B. P., 116
Fortin, F., 36
Francis, J. M., 89
Franco, G. A., 112
Frank, J. W., 205, 295, 306
Freetly, H. C., 331, 332, 357
Frobose, H. L., 386
Fruge, E. D., 213
Fung, L., 197, 290
Funston, R. N., 321

Funston, R. N., 17, 141
Funston, R. N., 98, 316, 352
Fusconi, G., 123, 124, 125

## G

Gabler, N. K., 9, 29, 96, 143, 153, 193, 226, 295, 305, 306, 318, 328, 330, 405
Gaillard, C., 16
Gaines, A. M., 130, 177, 195, 214, 216, 268
Gall, T. J., 38
Galloway, D. L., 364
Gan, J., 77
Gandarillas, M., 64, 243
Gao, J., 190
Garcia, M., 50
Garcia-Guerra, A., 39
Gardine, S. E., 88
Gardiner, G. E., 250, 264
Garrick, D. J., 331
Garrison, C., 68, 236, 242
Garry, D., 127
Gasa, J., 67
Gauger, P. C., 100, 196, 255
Gebhardt, J. T., 100, 157, 158, 275
Geertsen, N., 235
Genther-Schroeder, O. N., 107, 355
Gerhart, A. J., 213
Gesing, L. M., 167
Gibbons, W. R., 115, 296
Gionbelli, T. R., 353
Goh, T. W., 201, 202
Goldacker, A., 406
Gomes Neto, J. C., 109
Gomez-Raya, L., 44
Goncalves, M. A. D., 119, 162, 239, 240, 273, 288, 301
Gonda, M. G., 98, 399
Gonzalez, J. M., 138
Goodband, R. D., 100, 119, 122, 157, 158, 168, 172, 225, 237, 275, 286, 288, 386
Goodband, R. D., 10, 87, 163, 170, 174, 175, 176, 179, 181, 196, 209, 210, 222, 230, 238, 245, 276, 277, 299
Gooding, J. P., 206
Gordon, N. R., 405
Gould, S. A., 167, 251
Gourley, K. M., 87, 170, 245, 386
Graeter, E., 180
Graham, A., 239, 240, 280, 294, 301
Gramkow, J. L., 339, 342, 345, 350
Gray, K. A., 35
Grazul-Bilska, A., 347
Greiner, K. F., 21
Greiner, L., 239, 240, 280, 294, 301
Greseth, N. P., 95, 394
Grez, M., 184
Grilli, E., 207
Grohmann, N. S., 30, 130
Guirado Dantas, F., 112
Gunn, P. J., 311, 369

## H

Haag, M. T., 104, 392
Haberl, B., 281
Haerr, K. J., 19
Hager, C. L., 329
Hale, B. J., 38, 329
Hales, K., 332, 357
Hall, J. B., 312
Hall, R. E., 233
Hall, T., 239
Hamilton, H. C., 342
Han, Y. G., 201
Handlos, G. C., 89
Hansen, B., 341
Hansen, C. F., 234, 235
Hansen, E. L., 213
Hansen, S. A., 213
Hansen, S. L., 107, 331, 333, 355
Hanson, B. W., 389
Harding, J. C. S., 36
Hardyman, K. A. L., 402
Harmon, J. D., 12
Harner, J. P., 51
Harrell, R. J., 294
Harsh, B. N., 135, 137, 354
Hart, K., 126
Hartman, S. J., 355
Hasan, M. S., 99, 155
Hastad, C. W., 225
Hastad, C. W., 127, 237
Hauschild, L., 279
Hawley, J., 364
Heath, K. D., 327
Hedges, L. B., 363
Helm, E., 330
Helmbrecht, A., 101
Hempstead, M. N., 97
Hendel, E., 303
Hendel, E. G., 76
Herkelman, K. L., 233
Hernandez, G., 384, 393
Hernandez, L. L., 60
Herrera, N. J., 126, 382
Herrington, M. C., 317
Herskin, M. S., 3, 16
Heyer, C. M. E., 180
Hicks, Z. M., 387
Hieber, J. K., 40
Higginson, V., 83, 120
Hilbrands, A. M., 380
Hill, G. M., 397
Hill, K. L., 56
Hilscher, F. H., 336, 337, 338, 339, 344, 346, 349
Hoelzle, L. E., 180
Hoff, S. J., 12
Hofman, J. C., 401
Hofmann, T., 180
Hogan, K., 302
Holder, C. J., 10
Holen, J. P., 380
Hollis, J. H., 318
Holtcamp, A. J., 131
Honeyman, M. S., 198
Hong, J. S., 102, 203
Horst, E. A., 323, 325
Hossain, M. M., 208
Hostetler, D. E., 327
Htoo, J. K., 101, 285
Hu, B., 77
Hu, J., 156
Huang, C., 304
Hulbert, L. E., 393
Hulsman Hanna, L. L., 40
Huntley, N. F., 145, 251
Huss, A. R., 196, 256

## I

Ibarra, N., 324
Ireland, F. A., 351, 381
Ison, S., 408

## J

Jacques, K. A., 123, 124, 125, 138
James, K., 400
Jang, Y. D., 186
Jayaraman, B., 208
Jenkins, T., 76
Jeong, J. H., 102
Ji, F., 185, 270
Johnson, A. K., 6, 7, 14, 75
Johnson, C., 81
Johnson, H. E., 105
Johnson, J. S., 13, 117, 243, 272, 379
Johnson, K. A., 331
Johnson, S. B., 392

Johnson, T. M., 387
Johnston, L. J., 15, 18, 73, 215, 380
Johnston, M. E., 22
Johnston, S. L., 155
Jolly-Breithaupt, M. L., 345
Jolly-Briethaupt, M. J., 339, 342
Jones, A. M., 176, 209, 210, 299
Jones, C. K., 100
Jones, C. K., 196, 255, 256, 263, 267
Jones, R. M., 336
Jordon, D. J., 343

## K

Kadas-Toth, E., 303
Kalbfleisch, T. S., 41
Kalscheur, K. F., 376
Karisch, B. B., 131
Karnezos, T. P., 177, 292
Karriker, L. A., 281
Karrow, N. A., 144
Kaushik, R., 296
Keating, A. F., 38, 318, 329
Keel, B. N., 37
Kegley, E. B., 364
Kellner, T. A., 167, 189, 278, 284
Kelsey, A. J., 395, 407
Keomanivong, F. E., 116, 347
Kerley, M. S., 331, 333, 368, 371
Kerr, B. J., 134
Kerr, B. J., 96
Kerrigan, M. A., 34
Kiarie, E., 82, 257
Kim, B. O., 201, 202
Kim, G. D., 134
Kim, H., 254, 283
Kim, H. S., 202
Kim, I. H., 151, 152, 156, 169, 208, 224, 259, 260, 274, 291
Kim, J. K., 169
Kim, J., 164, 265, 322
Kim, J. W., 106, 199
Kim, S. C., 208
Kim, S. W., 159, 228, 246, 297
Kim, Y. M., 259
Kim, Y. Y., 102, 201, 202, 203, 204
Kincheloe, J. J., 98
King, D. A., 41, 42, 135
King, M. E., 56
Kinghorn, B. P., 25
Kirkpatrick, B. W., 39
Kirkwood, R. N., 384, 388
Klein, D. M., 200
Klopfenstein, T. J., 346, 349
Knap, I., 150
Knauer, M. T., 31, 43, 45, 65, 68, 69, 74, 94, 236, 242, 269, 287, 396
Knopf, B., 280, 301
Knutson, E., 116
Koehler, D. D., 167
Koepke, J., 296
Koketsu, Y., 108
Koo, B., 84
Kordas, J. M., 381
Kovacs, A., 303
Kreikemeier, C., 327
Kremer, B., 294
Krom, W. A., 72
Kuehn, L. A., 332
Kunze, E. K., 126, 382
Kurtz, J. F., 258
Kurz, S. G., 109
Kvidera, S. K., 323, 325, 329, 372

## L

Lachmann Sevilla, M. B., 292
Ladeira, M. M., 128, 353
Lagos, L. V., 194
Lamberson, W. R., 104, 392
Lammers, P. J., 198, 402, 403
Lan, R. X., 169, 259
Lanahan, M. B., 247
Landers, A. L., 371
Lansford, A. C., 316
Larimore, E. L., 92, 317
Larsen, S. T.,
Lawlor, P. G., 250, 264
Lawrence, T. E., 142
Lay Jr., D. C., 13
Le Floc'h, N., 149
Le Thanh, B. V., 285
Lee, A., 144
Lee, J. K., 246, 297
Lee, J. H., 203, 204
Lee, J. W., 253, 261, 262
Lee, K. Y., 151, 208
Legako, J. F., 98
Lei, S., 9, 29, 325
Lei, X. J., 152, 224
Lemenager, R. P., 55, 340
Lemire, R. L., 127, 131
Lents, C. A., 26, 308
León, L. Y., 161
Less, J., 281
Lessard, P. A., 247
Létourneau Montminy, M. P., 271, 279
Levesque, C. L., 262, 296, 300, 391
Li, H., 77
Li, Q. Y., 153, 226
Li, T. S., 274
Li, Y. S., 212, 289
Li, Y., 15, 18, 73
Li, Z. C., 185, 270
Li, Z., 144
Liao, S. F., 85, 99, 155
Lindblom, S. C., 134
Lindblom, S. C., 96
Lindemann, M. D., 118, 186
Linhares, D., 305
Link, J. E., 397
Linville, K., 314, 377
Liu, W. C., 274
Liu, Y. H., 169
Lloyd, K. E., 103
Lock, A., 375
Locke, J. W. C., 312
Loest, C. A., 367
Lonergan, S. M., 9, 29, 143, 330
Long, C. J., 111
Loor, J. J., 19
Loor, J. J., 61
López-Vergé, S., 67
Loughmiller, J. A., 157, 158, 171, 173, 275, 294
Louwagie, C., 365
Loving, C. L., 143, 226, 305
Lowell, J. E., 137
Loy, D. D., 331
Lu, N., 118
Lucy, M. C., 272, 398
Luebbe, M. K., 342, 344, 345
Lugar, D. W., 72, 272, 398
Luna, G. C., 191
Lunney, J. K., 34, 44
Luo, Y., 393
Lutz, J. M., 401
Lyte, J., 318

## M

Ma, X. K., 185, 270
MacDonald, J. C., 342, 344, 345, 346, 349, 350
MacDonald, J. C., 141, 335
Machado Neto, O. R., 353
Mackay, T. F., 32
MacNeil, M. D., 25
Maddux, J. G., 321
Madogwe, E., 120
Magee, D., 392
Magstadt, D. R., 100

Main, R. G., 100, 196, 255
Maiorka, A., 162
Malakowsky, S., 79
Mandell, I. B., 227
Mani, V., 171, 173
Manjarin, R., 384, 388, 393
Mansilla, W. D., 227
Manthey, A. K., 378
Manu, H., 66, 93, 223
Manu, H., 164, 322
Manzanilla, E. G., 250, 264
Marchant-Forde, J. N., 117, 243, 379
Marcoux, M., 271
Marini, J. C., 298
Martel-Kennes, Y., 233
Martin, W., 15
Martinez, J. J., 367
Martins, C. C. S., 217, 218
Masiero, M. M., 371
Mathai, J. K., 282
Maxwell, C. V., 219, 254, 283
Mayorga, E. J., 9, 29, 325
Mayorga Lozano, E. J., 323
McCabe, E. D., 56
McCauley, S. R., 136
McCuistion, K. C., 367
McFee, R. M., 109
McGilvray, W. S., 148, 200
McGilvray, W. S., 91
McKenna, D. R., 206
McLean, K. J., 95, 394
McLeod, K. R., 315
McNeel, A. K., 317
Mejicanos, G. A., 199
Mendoza, O. F., 177, 195, 214, 216, 268
Mendoza, S. M., 76, 303
Menon, D., 164, 322
Mereu, A., 154
Merlot, E., 149
Meyer, A. M., 110, 132
Meyer, T. L., 316
Mickna, A. J., 351
Mideros, S., 363
Mielke, J. A., 215
Miles, J. R., 26
Miller, P. S., 160, 166, 212, 289, 326, 327
Mills, G. A., 308
Mings, P. D., 72
Minton, A. M., 24
Mogck, C. L., 390
Mohrhauser, D. A., 135
Mondadori, R., 120
Moniz, M. M., 222
Montano, Y. A., 388
Moore, K. C., 212, 289
Moore, S. A. E., 376
Moraes, J. E., 217, 218
Morales, A., 324
Moran, C. A., 123, 124, 125
Moran, K., 82
Moran, K., 94
Morgante, F., 32
Morlacchini, M., 123, 124, 125
Morris, A., 146
Morris, J. R., 214
Mosenthin, R., 180
Moughan, P. J., 48
Muckey, M. B., 255, 256, 263, 267
Mulberry, L., 78
Mullins, C. R., 86
Mumm, J. M., 6, 7, 14, 75
Murugesan, G. R., 76, 303
Murugesan, G. R., 175
Musser, R. E., 286
Mustafa, A., 83, 120
Mydland, L. T., 258
Myer, P. R., 112

## N

Nagaraja, T. G., 172
Nam, S. O., 204
Nankivil, J. J., 130
Nascimento, A. C. C., 32, 33
Nascimento, M., 32, 33
Navarro, D. M. D. L., 187, 188
Negrin Pereira, N., 95, 313, 320, 394
Neibergs, H. L., 28, 331
Neville, B. W., 95, 394
Ngula, J., 384
Nguyen, D. H., 151, 224
NIchols, G. E., 386
Nickles, K., 383
Niederecker, K. N., 132
Niederwerder, M. C., 34
Nonneman, D. J., 26, 37, 41, 42
Norman, M. M., 339
Northrop, E. J., 92, 121, 311, 317
Nteeba, J., 329
Nyachoti, C. M., 84, 106, 145, 199, 259
Nyachoti, C. M., 208
Nyachoti, M., 47

## O

O'Doherty, J. V., 250, 264
O'Quinn, T. G., 122
O'Quinn, T. G., 138
Ochoa, L., 239, 280, 294
Odde, K. G., 56
Oelschlager, M. L., 146
Oh, S. Y., 144
Oliveira, C. V. R., 128
Olson, K. C., 98
Oney, C. R., 343, 350
Orlando, U. A. D., 119, 162, 239, 240, 301
Orlando, U., 273
Ortman, J. L., 300
Osorio, J. S., 19, 377
Osorio, J. S., 314
Outhouse, A. C., 330
Overholt, M. F., 129, 134, 137
Overland, M., 258

## P

Pairis-Garcia, M., 86
Pan, L., 185, 270
Pangeni, D., 66, 93, 265
Pangeni, D., 164, 223, 322
Park, C. S., 101
Park, I., 159, 228, 246
Park, J. H., 152, 260
Park, J. W., 152, 224, 260
Parker, M., 65
Parr, E., 216
Parsley, M. A., 8
Pate, R. T., 363
Patience, J. F., 9, 29, 145, 153, 167, 189, 193, 226, 251, 278, 281, 284, 293, 295, 305, 306
Patterson, A. L., 317
Patterson, D. J., 25, 312
Patterson, R., 115, 253, 266
Payling, L., 252, 291
Pedersen, T. F., 150
Pendleton, A. R., 148
Pendleton, A. R., 91
Peralta, W. A., 64, 243
Pérez, J. F., 178
Perry, G. A., 92, 121, 311, 317, 390
Peterson, B. A., 130
Petrovski, K., 388
Petry, A. L., 91
Phelps, K. J., 138
Piao, X. S., 185, 270
Pineiro, C., 108
Piva, A., 207
Pizzolante, C. C., 217, 218
Plastow, G., 36
Pohler, K. G., 112

Pomar, C., 46, 271, 279
Poss, M. J., 171, 173
Poudel, P., 62
Powell, E., 54
Prestegaard, J. M., 368
Pritchard, R. H., 141
Proctor, J. A., 72, 398
Prunier, A., 149
Pukrop, J. R., 90
Putz, A. M., 36

## Q

Que, Y., 70, 71

## R

Raab, R. M., 247
Rademacher, C., 305
Rakhshandeh, A., 148, 200
Rakhshandeh, A., 91
Ralph, A. R., 351
Rambo, Z. J., 179, 325, 380
Ramirez, A., 14, 100
Ramirez, A., 305
Ramirez, B. C., 12
Rasby, R. J., 357
Rathert, A. R., 132
Rauw, W. M., 9, 29, 44
Redmer, D. A., 347
Reese, S. T., 112
Regmi, N., 241
Relling, A., 113, 356, 383
Rempel, L. A., 26
Remus, A., 279
Ren, P., 66, 93
Ren, P., 164, 223, 322
Renken, M., 391
Resende, F. D., 353
Reyes, F., 324
Reynolds, L. P., 95, 394
Rho, Y., 82, 257
Rhoads, R. P., 136, 323
Ribeiro, F. A., 126, 382
Rich, J. J. J., 92, 121, 317
Richert, B. T., 63, 64, 243
Rickard, J. W., 206
Riley, D. G., 40
Rincker, P. J., 206
Rivera-Acevedo, K. C., 356
Roche, J. R., 61
Rodehutscord, M., 180
Rodrigues, A. C., 128
Rodrigues, L. M., 353
Rodriguez-Hernandez, K., 366, 374
Rodriguez-Jimenez, S., 19
Rogers, G. M., 56
Rohde, S. K., 362
Rohrer, G. A., 26, 37, 41, 42
Rolf, M. M., 25
Romereim, S., 109
Romoser, M. R., 38
Rosa, F., 314
Rosasco, S. L., 317
Rosenfeld, C., 392
Rosero, D. S., 103
Ross, J. W., 38, 323, 329
Rossi, B., 207
Roura, E., 409
Rowland, R. R. R., 34, 44
Royal, S., 396
Rozeboom, C. J., 397
Rozeboom, D. W., 401
Ruan, R., 389
Rubach, J. K., 171, 173
Ruiz, U. S., 191, 217, 218
Rusche, W. C., 399
Russell, J. R., 369
Russell, J. R., 333
Rutherford, K., 408
Ryan, P. L., 85

## S

S. Cemin, H., 275
Saatchi, M., 331
Saensukjaroenphon, M., 196
Safranski, T. J., 272, 398
Sandberg, F. B., 220, 221, 231
Sanders, D., 171, 173
Santos, L. R., 128
Saqui-Salces, M., 215, 290
Saqui-Salces, M., 258
Sartini, B. L., 310
Sastre, L. P., 367
Scales, D. B., 397
Scales, D. B., 385
Schinckel, A. P., 63, 64, 70, 71, 117, 161, 243, 379
Schmitt, R. L., 177
Schmitt, R., 23
Schmitz, A. N., 393
Schmucker, S., 180
Schnabel, R. D., 25, 331
Scholtz, E. E., 211
Schoonmaker, J. P., 90, 128, 353
Schroeder, A. R., 351
Schuermann, Y., 83, 120
Schulz, L. L., 369
Schwab, C. R., 30, 129
Schwab, C. G., 58
Schwartz, K., 143, 305, 330
Schwartz, M., 385
Schweer, W. P., 143, 193, 305, 405
Schweihofer, J. P., 401
Seabury, C. M., 331
See, G. M., 31, 43, 45
Seibert, J. T., 38, 323, 325, 329
Seifert, J., 180
Serão, N. V., 32, 33, 34, 35, 43
Sexten, W. J., 140
Shackelford, S. D., 41, 42, 135, 357
Shah, S. B., 74
Shawk, D. J., 222
Shike, D. W., 139, 331, 351, 354, 381
Shircliff, K. E., 132
Shriver, A., 1
Shull, C. M., 30, 129, 130, 177, 214, 216, 268
Shurson, G. C., 197, 215, 248, 249, 290
Shurson, G. C., 258, 389
Shutter, J. A., 184
Silva Júnior, C. D., 217, 218
Sinn, S. M., 300
Siqueira, G. R., 353
Sitanaka, N. Y., 217, 218
Smith, A. J., 379
Smith, B. N., 146
Smith, M. F., 25, 312
Smith, S., 103
Smith, T. P., 112
Snelling, W. M., 332
Soares, E. M., 317
Solà-Oriol, D., 178
Solà-Oriol, D., 67
Solis, J. I., 367
Soltwedel, K. T., 220, 221, 231
Sonstegard, T. S., 307
Soto, J. A., 175, 276, 277
Spangler, H. L., 282
Spangler, M. L., 331
Sparks, C., 153
Springman, S. A., 321
Spuri Gomes, R., 109
St-Pierre, B., 62, 300
St-Yves, A., 83, 120
Stalder, K. J., 6, 7, 14, 75
Stalker, L. A., 352
Stark, C. R., 255
Stark, C. R., 192, 196, 267
Stas, N. M., 30, 268
Statz, L. R., 402
Steadman, C. S., 85

Stefanski, V., 180
Stein, H. H., 111, 137, 165, 178, 187, 188, 194, 267, 282, 291, 304
Stevenson, J. E., 220
Stewart, K. R., 55, 63, 72, 243, 272, 340, 398
Stewart, M., 97
Stock, J. D., 6, 7, 14, 75
Stockton, M., 352
Stokes, B. T., 369
Stokes, R. S., 107, 351
Strathe, A. V., 234, 235
Streeter, M. N., 343
Stuart, R. L., 114, 397
Stwalley, R. M., 117, 243, 379
Su Hyup, L., 66
Sukumaran, A. T., 99
Summers, A. F., 109, 317
Sun, Y., 375
Sutherland, M. A., 97
Swanson, K. C., 116, 347

## T

Taibi, M., 83, 120
Tan, F. P., 190
Tani, S., 108
Tauson, A. H., 234
Taylor, E. G., 55, 340
Taylor, J. F., 25, 331
Tedo, G., 154
Teixeira, P. D., 128
Tekeste, A., 66, 93, 265
Tekeste, A., 164, 223, 322
Tenley, S. C., 109
Terlouw, S. L., 22
Thaler, B. C., 391
Thallman, R. M., 332
Theil, P. K., 49, 150
Theradiyil Sukumaran, A., 131
Thodberg, K., 16
Thomas, J. M., 312
Thomas, L. L., 127, 163, 237, 238
Thompson, C., 408
Thomson, J. E., 283
Tinkle, A., 8
Tokach, M. D., 100, 119, 122, 157, 158, 168, 172, 196, 225, 275, 286, 288, 299, 302
Tokach, M. D., 10, 87, 163, 170, 174, 175, 176, 179, 181, 209, 210, 222, 230, 237, 238, 245, 276, 277
Tom, W., 327
Torrallardona, D., 250, 264
Torrallardona, D., 232, 244
Torres-Pitarch, A., 250, 264
Tostenson, B., 66, 93
Tostenson, B., 223
Totafurno, A. D., 227
Touchette, K. J., 282, 288
Touchette, K. J., 167, 174, 230, 240, 241, 276
Tran, H. N., 151
Trenhaile, M. D., 212, 289
Trenhaile-Grannemann, M. D., 160, 166, 326
Trevisi, E., 314
Trottier, N. L., 241, 298
Trudeau, M., 258
Tsai, T. C., 219, 254, 283
Tugnoli, B., 207
Turner, K. C., 397

## U

Ulmer, K. M., 357
Underwood, K. R., 98
Upadhaya, S. D., 156
Urriola, P. E., 248, 249, 290
Urriola, P. E., 197, 215, 258, 389
Usry, J. L., 181

## V

Vailati Riboni, M., 61
Valdez, F. R., 171, 173
Van Asten, S. L., 403
Van Dyke, K. L., 24
Van Eenennaam, A. L., 25
Van Genderen, C., 69
van Heugten, E., 82, 103, 114
van Heugten, E., 94, 236, 242, 269, 396
van Sambeek, D. M., 166, 212, 289, 326
Vande Pol, K. D., 216
Vanderhoof, J., 147
VandeVord, P. J., 393
Vanzant, E. S., 315
Vasanthan, T., 190
Venable, E. B., 54, 89
Vier, C. M., 119
Vierck, K. R., 122
Vishwanath, R., 312
Voegele, H. R., 126
Vonnahme, K. A., 347

## W

Waas, J. R., 97
Wagner, S. A., 40
Waide, E. H., 34
Walk, C. L., 219
Walker, J., 399
Walker, J. A., 390
Walker, P. M., 359
Walsh, M. C., 82, 252, 291
Walter, K. W., 395
Wang, H. L., 185, 270
Wang, L. F., 190, 191, 285
Wang, T., 99, 155
Wang, X., 219, 254, 283
Ward, A. K., 95, 116, 394
Ward, T. L., 185, 270
Watson, A. K., 343, 349, 350
Watson, A. K., 335
Waugh, T., 293
Weaber, R. L., 331
Weatherly, M., 363
Webb, M. J., 98
Webster, S. R., 302
Weeden, T. L., 292
Weiland, S. A., 293
Weimer, P. J., 334
Weiss, B., 59
Weiss, E., 180
Welchons, C. A., 346, 349
Wells, K. D., 104, 392
Weng, Z. Q., 34
Wey, D., 82, 227
Wheeler, T. L., 41, 42, 135
Whitaker, B. D., 400, 404, 406
White, B. R., 308
Wiegand, B. R., 132
Wiegert, J. G., 68, 69, 74, 236, 242, 269, 396
Wilcock, P., 183, 219
Wilken, M. F., 336
Willard, S. T., 85
Williams, D. E., 359
Williams, H. E., 172, 222, 286, 302
Williams, N. H., 281
Wilson, J. M., 192
Wilson, K. B., 129, 137
Wilson, M. E., 8, 325
Wilson, M. E., 184
Wilt, H. D., 221
Wiltbank, M. C., 39
Winn, E., 400, 404, 406
Wood, J. N., 103
Wood, J. R., 109
Woodworth, J. C., 100, 119, 122, 157, 158, 168, 172, 174, 225, 230, 275, 288, 302

Woodworth, J. C., 10, 87, 163, 170, 175, 176, 179, 181, 196, 209, 210, 222, 237, 238, 245, 255, 256, 276, 277, 286, 299, 386
Woyengo, T. A., 115, 253, 261, 262, 266
Wu, F., 119, 168, 225
Wu*, F., 122

## X

Xu, X., 185, 270
Xu, Y. T., 185, 270

## Y

Yancey, J. W. S., 387
Yang, X., 66, 93, 265
Yang, X., 18, 164, 223, 322
Yao, D., 258
Yin, A., 229
Yin, J., 274
Yoder, A. D., 192, 255, 256, 263, 267
Yoo, D. H., 202
Yoo, H. B., 203
You, L., 144
Yu, H., 40
Yun, H. M., 152, 169, 259, 260, 274

## Z

Zangaro, C. A., 115, 266
Zeng, Z. K., 248, 249, 389
Zhang, F., 182
Zhang, H., 15
Zhang, J., 100, 196, 255
Zhang, J. Y., 156, 260
Zhang, S., 241, 298
Zheng, L., 159, 228
Zhu, C., 82, 257
Zhu, J., 17
Zhu, J., 248
Zier-Rush, C. E., 103
Zijlstra, R. T., 180, 190, 191, 285
Zuidema, D. M., 399

# KEY WORD INDEX

*Please note: numbers following a key word indicate abstract numbers.*

3 cut marketing, 206

## A

AA ratios, 174
accuracy, 32
acidosis, 362
acyl ghrelin, 322
additive, 384
additivity, 182
ADG, 219
algae, 123, 124, 125
Ambitine, 177, 292
amino acid , 241
amino acid digestibility, 194, 265
amino acids, 48, 49, 58, 101, 200, 282, 324, 368
androgen receptors, 313
androgens, 109
antibiotic, 168, 217
antibiotic alternative, 305
antibiotic alternatives, 295
antibiotic-free, 137
antibiotic-free feeding program, 220
antibiotics, 13, 81, 130
antioxidant enzymes, 397
antioxidants, 107, 138
artificial insemination, 92
automated, 393
autozygosity, 44

## B

backgrounding, 105
backgrounding calves, 357
bacon, 137
bacterial, 112
bacterial translocation, 328
barley, 93
batch culture, 371
batch farrowing, 20, 21, 22, 23, 24
beef, 128, 138, 140, 142
beef calves, 56
beef cattle, 17, 98, 111, 133, 139, 141, 332, 353, 360, 361, 399
beef cow culling , 352
beef cow systems, 369
beef heifer, 316, 351, 381
beef heifers, 321, 354
beef quality, 131
beef steers, 364
behavior, 15, 19, 395
behaviour, 97
berberine, 211
betaine, 63, 72
bio-pesticide, 17
bioavailability, 186
biohydrogenation, 375
bitter taste, 409
blood draw, 40
blood lipid profiles, 274
blood metabolites, 234
blunt trimming, 8
boar, 45, 72, 398
boar semen, 85
boar stud, 24
body composition, 234
bone ash, 87, 232
Bos indicus, 317
Brahman breed, 56
brassicas, 357
broiler chickens, 159
broilers, 156, 259, 260
bromegrass, 349
brown midrib, 337, 338, 339
bull, 310
bulls, 320
butryic acid, 173
butyric acid, 170, 171
by-product feeds, 403
by-products, 198

## C

c-reactive protein, 251
caco-2 cells, 207
calcium, 239
calcium homeostasis, 60
calf, 365
calf performance, 390
calories, 359
canola co-products , 253
canola meal, 199, 376
carbadox, 303
carbohydrases, 249
carcass, 132, 142, 399
carcass iodine value, 284
carcass quality, 357
carcass traits, 93, 223, 343
carcass weight, 141
carinata meal, 366, 374
castration, 307
catecholamines, 328
cattle, 39, 40, 107, 333, 349, 355, 395, 407
cattle size, 335
cattle type, 139
cereal grain, 191
CGF, 55
chemical feed disinfection, 294
chemical mitigation, 100
chromium methionine, 185, 270
chromium propionate, 157, 158, 275
citrulline, 323
CLA, 128
clinical condition, 16
cognition, 392
color stability, 354
colostrum, 68, 236, 388
commercial health, 36
compensatory growth , 227
computed tomography, 184
computer training, 86
computerized feeder, 386
condition, 242
constraints, 23
cooked color, 387
cooked starch, 267
cooling, 74
cooling pads, 117, 379
copper, 118, 171, 173, 183, 186
copper source, 179, 181
core body temperature, 91
corn co-products , 55, 340
corn condensed distiller's solubles, 265
corn DDGS, 82
corn distillers grains, 359
corn distillers solubles, 341
corn germ meal, 195
corn plant, 363
corn silage, 337, 338, 339, 350, 363
corn stover, 373
corn whole stillage, 265
corn-expressed phytase, 246, 247, 297
cornstalk grazing, 88
cow time budget, 51
creching, 388
crude protein, 277, 350
cull sows, 16

## D

dairy, 59
dairy calves, 314
dairy cow, 60
dairy heifer, 366, 374, 378
dairy nutrition, 52
DDGS, 115, 192, 266, 360
death interval, 108
dehulling, 199
deoxynivalenol, 76
deoxyvinalenol, 233
deuterium oxide, 298
developmental programming, 132
DHA, 125
diarrhea, 47, 218
diet, 236
diet complexity, 84, 210
diet formulation, 80
dietary electrolyte balance, 299
dietary fat, 189, 278, 284
dietary fatty acids, 318
dietary fiber, 187, 188, 226
dietary phases, 268
dietary protein, 234, 235
digesta viscosity, 249
digestibility, 53, 94, 150, 151, 165, 189, 190, 193, 246, 249, 266, 285, 326, 339, 342, 359, 383
digestion, 345
digital imagery, 75
direct fed microbial, 293
direct fed microbials, 362
direct-fed microbial, 252, 291
disbudding, 97
disease, 34
disease genetics, 35
disease resilience, 36
distillers dried grains with solubles, 248
distillers grains, 126, 346, 378
distillers grains plus solubles, 342, 344, 345
DNA Testing, 399
dose-response, 154
dried active yeast, 62
duration, 157, 275
dynamic space, 14

## E

e. coli, 226
early gestation, 162
early lactation, 376
early life, 147
eating time, 116
economics, 78
efficiencies, 48
efficiency, 67
ejaculation, 311
electrolyte balance, 277
embryonic loss, 25
endocrine, 347
endophyte, 315
energy, 49, 165, 188, 190, 284
energy digestibility, 304
energy restriction, 160, 166
energy supplement, 385
enterococcus faecium, 169, 259
environment, 271
enzymatically fermented soybean meal, 209
enzyme matrix, 244
enzymes, 153, 226, 250
eosinophil, 219
epididymis, 311
epistasis, 32
equine, 54, 89
escherichia coli k88, 224
essential fatty acids, 113, 356
essential oil, 391
essential oils, 62, 90, 175, 365
estimation, 396
estrus, 92, 121
estrus synchronization, 21, 312, 316
ethanol co-products, 93
ethics, 1
ethology, 393
evaporative, 74
exocrine, 347
extended release eprinomectin, 381
extracellular vesicle, 309
extruded cold-pressed camelina cake, 262
extrusion, 267
eye temperature, 91

## F

facilities, 51
fasting heat production, 272
fat quality, 137
fat-soluble vitamins, 114
fatty acid composition, 126
fatty acids, 123, 124, 125
fava bean, 250
fecundity, 39
feed acceptance, 403
feed additive , 155, 286, 302
feed additives, 175, 285
feed blending, 225
feed efficiency, 155, 177, 238, 292, 331, 332, 333, 334, 373
feed grade antibiotics, 220
feed intake, 161, 162, 332
feed manufacturing surfaces, 255, 256
feed preference, 403
feed processing, 191
feeding frequency, 66
feeding levels, 164
feedlot, 88, 128
feedlot performance, 335
feet and leg conformation, 75
fermented rice bran extracts, 159, 228
fertility, 310, 384
fescue toxicosis, 381
fetal programming, 113, 353, 356
fiber, 52, 94, 269, 282
finishing, 105, 336
finishing cattle, 337, 341, 344
finishing pig, 10, 99, 179, 277
finishing pigs, 274, 275, 276, 396
fixed-time insemination, 22
foal, 110
foaming manure , 77
fodder, 89
foliar fungicide, 363
follicle , 39, 63, 309
folliculogenesis, 317
food security, 373
food waste, 197
forage, 52, 346
freestalls, 51
fructo-oligosaccharide, 152
fructose, 394, 404
fumonisin, 76
funtional trimming, 8

## G

gelatinized starch, 267
genetic, 31, 43, 65, 269
genetic parameters, 33
genetics, 26, 42, 94
genomic selection, 331
genotype-by-environment, 35
germ cell transplantation, 307
gestating sow, 204, 241
gestating sows , 18
gestation, 238, 242
gestation sows, 66
gilt, 164
gilt selection, 38
girth measurement, 116
gluco-oligosaccharide, 168
glucose, 121
glucose homeostasis, 372
GLUT5, 394
glutamine, 288
gnotobiotic piglet model, 327
GnRH2, 308
GnRH2 receptor, 308
goat kids, 97
gonadotropin releasing hormone , 92
GPR54, 307
ground beef, 387
grow-finish, 123, 124, 280
grow-finisher, 264
grower pig, 252, 291
grower/finisher pigs, 283
growing, 346
growing cattle, 338
growing pigs, 96, 208
growing-finishing pig, 203
growing-finishing pigs, 380
growth, 10, 85, 119, 130, 170, 179, 181, 216, 225, 268, 273, 287, 289, 401, 407
growth performance, 134, 151, 152, 156, 159, 169, 172, 176, 201, 202, 205, 215, 223, 224, 229, 247, 259, 260, 286, 296, 297, 299, 302, 374, 378, 380
gut, 212
gut health, 211, 218, 228, 314
GWAS, 34

## H

haptoglobin, 251
health, 85, 281, 330
health management, 81
health status, 231
heart girth, 396
heat production, 64, 145
heat stress, 9, 13, 29, 243, 323, 324, 325, 329
heavy finishing pig, 206
heavy pig, 122
heifer, 315
heifer development, 340
heifer fertility, 25
hemicell, 251
hemp hulls, 106
heterosis, 104
high protein DDGS, 257
high protein distillers dried grains, 290
HMB, 65
hot carcass weight, 135
housing, 12
humidity, 12
hunger status, 322
hydroponics, 89

## I

ideal protein concept, 279
immune activation, 143, 149
immune development, 147
immune status , 296
immune system, 180
immune system stimulation, 148
immunity, 50, 146, 289
implant strategy, 343
in utero heat stress, 272, 398
in vitro digestibility, 187, 389
in vitro fermentation, 253, 261
in vitro gas production, 377
in vitro hydrolysis and fermentation, 248
indirect calorimetry, 106
inflammation, 50, 61, 372
inflammatory biomarkers, 325
injectable trace mineral, 321, 351
intake, 335
intestinal barrier function, 153, 207
intestinal integrity, 325
intestinal microbiota, 180
intestinal morphology, 306
intramuscular fatty acid composition, 99
isoflavone, 146
isoleucine, 230
IVF, 404

## J

joint measurements, 75

## K

ketosis, 19

## L

lactating sows, 49
lactation, 64, 67, 117, 233, 237, 239, 240, 243, 379, 386
lactation crate size, 237
lactation performance, 62
lactational programing , 340
lactobacillus, 293, 300
lactobacillus acidophilus fermentation product, 205
lactobacillus plantarum, 176, 209
lactulose, 306
lameness, 6, 7
large farms, 23
lean color, 131
lethal variants, 25
lie-down stand-up sequence, 14
lifetime performance, 26
lipid, 103
lipid peroxidation, 96
lipidomics, 109
lipogenesis, 278
lipopolysaccharide, 118, 145, 372
liquid chromatography-mass spectrometry lc-ms, 258
liquid sweet whey, 401
litter gain, 235
liver, 120
liver abscesses, 90
liver and adipose transcriptome, 61
livestock, 5
longevity, 390
loss-of-function, 37
low birthweight , 136
low nutrient diets, 254
low-quality forage, 367
lying down sequence, 6
lys, 260
lysine, 99, 167, 174, 213, 273, 280, 294, 301, 368
lysine restriction , 227

## M

management, 149
marbling, 140, 382
marketing , 70, 71
marketing weight, 122
maternal lps, 144
maternal recognition of pregnancy, 121
maternal weight, 163
matrix, 21
matrix coated organic acid blends, 208
maturation, 400
meat characteristics, 98
meat quality, 122, 132
medium chain fatty acids, 196
medium-chain triglycerides, 156
meta-analysis, 105
metabolic cost, 143
metabolic modifier, 133
metabolic status, 83
metabolism, 48, 113, 356
metabolites, 110
metabolizable protein restriction, 98
metabolomic, 77, 258
methanogens, 348
mice, 104, 392
micro-aid, 158
microalgae, 215, 389
microbiome, 147, 300, 334
microbiota, 327
microrna, 309
milk, 166
milk by-product, 201, 202
milk composition, 235
milk fat depression, 375
milk intake, 298
milk production, 150
minerals, 178
mino acid digestibility, 304
mitochondrial complex iv activity, 364
monensin, 367
morphology, 212
mortality, 385
mortality incidence rate, 108
mRNA, 95
multi-enzyme, 248
multi-enzyme and probiotic blend, 221
multi-mycotoxin contamination, 76
multicarbohydrase, 84
muscle growth, 136
mycotoxins, 290
myoglobin, 42
myostatin, 136

## N

n-6:n-3 ratios, 274
Na, 222
NAFTA, 79
narasin, 287
NE, 106
NEFA, 322
neonatal pig, 385
neonate, 110
next-generation sequencing, 327
nitrogen balance, 145, 241, 295
nitrogen degradation rate, 371
non-infectious disease, 81
nonlinear models, 33
novel 6-phytase, 232, 244
nursery, 214, 301
nursery diet complexity, 223
nursery diet protein, 231
nursery pig, 87, 168, 172, 176, 181, 209, 210, 222, 225, 245, 247, 286, 288, 299, 302
nursery pigs, 118, 119, 167, 170, 171, 173, 174, 186, 215, 216, 221, 228, 229, 230, 246, 297, 397
nutrient digestibility, 164, 204, 262
nutrient requirements, 46
nutrient restriction, 323
nutrient variability, 197
nutrition, 57, 150
nutritional chemosensing, 409

## O

oat screening, 198
oats, 261
offspring health, 144
oil, 344, 345
omega-3, 138
ooctye, 400
optaflexx, 336
optimal nutrition, 80
organic acids, 303
organic acids and botanicals, 207
organic acids and medium chain fatty acids, 224
osteochondrosis, 184
OTU, 358
ovarian function, 120
ovarian reserves, 317
ovary, 329
ovary signaling, 318
oviduct, 406
OvuGel, 22
oxidative stress, 96

## P

packing, 78
pain, 1, 3, 5
palatability, 54
palm kernal meal, 203
pancreas, 347

Paylean, 206
PBMC, 315
pea-starch, 360
PEDV, 100, 196, 255
pellet, 192
pellet durability, 263
pellet durability index, 192
pellet mill, 263
pelleted diets, 184
percent fines, 263
performance, 66, 73, 208, 220, 221, 231, 343
peroxidation, 103
peroxidized oil, 134
persistent pinking, 387
philosophy, 1
phosphatidylinositol-3 kinase, 318
phosphorus, 111, 119, 180, 271
phosphorus digestibility, 199
physicochemical characteristics, 187, 188
phytase, 87, 111, 178, 183, 245
phytogenic additive, 217, 218
phytogenics, 175, 303
pig, 3, 26, 74, 91, 101, 103, 115, 148, 177, 195, 211, 212, 213, 250, 253, 261, 262, 264, 266, 268, 269, 273, 280, 287, 289, 292, 294, 301, 326, 328, 330, 405, 409
pig flow, 20
pig welfare, 86
piglet, 65, 68, 388, 391
piglets, 67, 227, 232, 244
pigs, 9, 15, 29, 30, 42, 47, 73, 82, 114, 130, 149, 157, 158, 178, 182, 185, 194, 198, 214, 257, 270, 271, 272, 324, 400, 401, 406
plasma, 200
polyspermy, 406
porcine, 393
porcine circovirus type 2b, 326
porcine reproductive and respiratory syndrome virus, 146
pork, 70, 71, 129, 135
pork export, 79
pork quality, 41
post weaning diarrhea, 285
post-ai nutrition, 390
post-farrow, 163
post-weaning, 88
poultry, 101
prebiotic, 383
prebiotics, 365
precision feeding, 46, 279
pretreatment, 115
probiotic, 172
probiotics, 395, 407
probiotics and xylanase, 151
production traits, 29
productive energy, 195
profitability, 141
progesterone , 352
prostaglandin f2α , 316
protease, 152, 252, 291
protease, carbohydrases, phytase, 254
protein, 58, 342
protein concentration, 47
protein metabolism, 376
protein source, 288
protein sources, 210
protein supplementation, 367
PRRSV, 193, 281, 405
puberty, 31, 43, 45
PUFA, 144
pulse grain, 191

## Q

quality, 53, 126, 135
quality grade, 140
quantile regression, 33

## R

ractopamine, 133
ractopamine HCl, 276
random regression, 35
rapeseed, 258
rapeseed meal, 102, 204
reactive oxygen species, 382
receiving diet, 383
recycled sand, 402
relative risk, 108
reproduction, 45, 57, 69, 321, 351
reproductive performance, 55
reproductive tract score, 38
requirement, 213
residual feed intake, 116, 330, 331
retinoic acid, 320
review, 305
risk mitigation, 100
rolled corn, 361
rotational grazing, 349
roughage, 333
rumen, 334
rumen bacteria, 358
rumen fermentation, 371, 377
rumen microbiome, 348
Rumen pH, 375
rumen protected, 368
rumen temperature, 377
rumen undegradable protein, 350
ruminal pH, 362
runs of homozygosity, 44

## S

saccharomyces cerevisiae fermentation product, 107
saliva cortisol, 18
salmonella, 256
salt , 222
sand bedding, 402
sand quality, 402
sanitation, 255, 256
seasonal infertility , 329
selection, 139
selection index category, 30
semen extender, 72
semen production, 24
sensory, 129
sensory additive, 154
serotonin, 60
sertoli, 313, 320
sex hormone binding globulin, 109
sexed semen, 312
shelf-life, 134
sickness behavior, 405
SID AA and DE, 257
single nucleotide polymorphism, 37
sire line, 30
skewness, 32
SNP association, 41
social network analysis, 15
sort loss, 70, 71
sow, 63, 64, 102, 117, 160, 161, 165, 236, 237, 238, 239, 240, 242, 243, 379, 384
sow lameness, 14
sow lifetime productivity, 38
sow performance, 391
sows, 6, 7, 8, 114, 163, 166, 233
soy protein concentrate, 304
soybean meal, 193, 194
space, 10
sperm, 311, 404
spermatozoa, 310
split-out, 127
stable fly, 17
stable isotope, 200
standing up sequence, 7
starch, 190, 358
stocking density, 127
stockpiled forage, 369
sulfur, 355, 364

superdose, 183, 245
supplement, 352
supplemental nutrition, 214, 216
supplementation, 353
survival, 68
swine, 31, 34, 41, 43, 44, 46, 69, 78, 80, 143, 153, 189, 196, 197, 230, 278, 281, 290, 293, 305, 389
swine barns, 77
swine diseases, 36
swine health, 20

## T

tail docking, 73
tall fescue, 131
taste preference, 366
techniques, 313
temperament, 40
temperature, 12
tenderness, 129, 382
testicular function, 308
threonine, 148, 279, 282
threonine ratio, 240
thyroid hormone, 102
timed artificial insemination, 312
timely euthanasia, 86
titration, 283
total sperm, 398
TPP, 79
trace minerals, 355
transcriptional changes, 314
transition, 59
transition cow, 19, 50, 83, 120
transition cow nutrition, 61
transition cows, 58
transition period, 57
transport, 13, 16
transporters, 95
treats, 54
troubleshooting, 69
true total tract digestibility of calcium, 182
tryptophan, 167, 276, 283
tylosin, 90

## U

umami, 154
uterine, 112
utero-placenta, 95, 394

## V

vaginal, 112
validation, 298, 386
vicia faba, 264
video auctions, 56
viral ecology, 348
vitamin E, 354
vitamins, 59
vitamins E and D, 397

## W

water, 53
water consumption, 104, 392
wean-finish, 127
wean-to-estrus, 162
weaned pig, 205, 296
weaned pigs, 295, 300, 306
weaner pig, 155
weaning, 160, 217
weaning pig, 201, 202
weanling pigs, 169
wean–to-finish pigs, 254
welfare, 3, 5, 9, 18
weaned pigs, 84
wet distillers grains plus solubles, 341
wheat gluten, 229
whole corn, 361
whole-genome sequence, 37
winter grazing economics, 369

## X

xylanase, β-glucanase, steeping, 82

## Y

yearlings, 336
yeast cell wall, 219
yeast-derived rumen escape microbial protein, 83
yield, 142

## Z

zinc, 185, 380
zinc amino acid complex, 270

## Characters

β-mannanase, 203

# YOUNG SCHOLAR PRESENTATION INDEX

*Please note: numbers indicate abstract numbers.*

039
061
133
138
243
284
312
347
348
372
373
375
376
378