Material and Methods

Female weaned piglets (n = 160, 29 ± 0.3 days, 9.1 ± 0.1kg) were fed a high (HiP) or low indigestible protein diet (LiP) and were housed under low (LSC) or high sanitary conditions (HSC) for 14 days. Piglets were housed in 4 climate-controlled respiration chambers, with 2 pens per chamber containing 4 piglets per pen, divided over 5 batches. For HSC, pens were disinfected before each batch and a strict hygiene protocol was adhered to. For LSC, there was no hygiene protocol and pooled faeces from commercial pig farms were spread twice a week in the pens. Diets included TiO_2. The HiP diet (207 g/kg crude protein) included sunflower seed meal and the LiP diet (191 g/kg crude protein) included casein as main protein source. Digestible crude protein (165 g/kg) and non-starch polysaccharide level (216 g/kg) were equal between diets. Piglets were fed ad-libitum the first 3 days followed by paired-feeding from day 4 onwards. Rectal temperature was measured daily. Rectal faeces were collected daily and scored on consistency ranging from 1 (liquid faeces) to 5 (hard faeces). From day 9 to 14, a complete energy and nitrogen balance was performed using half of the piglets. Feed intake and quantitative faeces plus urine excretion were recorded. Exchange of O_2, CO_2 and CH_4 was recorded every 12 min to calculate heat production. Effects of diet, sanitary conditions (SC), their interaction, batch, and batch-interactions were evaluated using the MIXED (continuous variables) or GLIMMIX procedure (Poisson distribution; faecal scores) of SAS.

Results and Discussion

Feeding HiP ($P < 0.001$) decreased faecal consistency from day 5-14 and LSC ($P < 0.001$) decreased it from day 4-6 and 12-13, but diet and SC did not interact (dietxSC, $P = 0.35$). Rectal temperature in week 2 tended to be higher for piglets housed under LSC ($P = 0.071$). This is in line with previous studies using this model to induce low-grade immune system stimulation, where LSC increased serum haptoglobin concentrations (van der Meer et al., 2020).

As anticipated, the apparent total tract digestibility (ATTD) of nitrogen was reduced by HiP (68.7 ± 1.5 vs. 78.5 ± 0.7%; $P < 0.001$) and by LSC (70.9 ± 2.1 vs. 76.3 ± 1.4%; $P = 0.034$), and the effect of LSC was largest when feeding the HiP diet (interaction $P = 0.028$). The ATTD of energy was reduced by LSC (66.2 ± 1.2 vs. 71.3 ± 1.5%; $P < 0.001$). Energy ATTD was higher when feeding the HiP diet (72.4 ± 1.2 vs. 65.1 ± 0.9%; $P < 0.001$), despite the lower nitrogen ATTD, likely because of a greater fibre fermentability when feeding HiP.

Energy retention averaged 296 ± 38 kJ/kg metabolic BW ($kg^{0.60}$) per day and was not affected by diet ($P = 0.95$) and SC ($P = 0.67$). Energy retention efficiency as percentage of gross energy and digestible energy intake was also not affected by diet or SC ($P > 0.05$ for all). Nitrogen retention was reduced by feeding HiP (1.59 ± 0.14 vs. 1.66 ± 0.14 g N/ $kg^{0.60}$ per day; $P = 0.034$) and by housing under LSC (1.46 ± 0.12 vs. 1.78 ± 0.10 g N/ $kg^{0.60}$ per day; $P = 0.005$), but there was no interaction ($P = 0.34$). Nitrogen retention efficiency as a percentage of ingested nitrogen was reduced by both HiP (53.7 ± 3.3 vs. 67.3 ± 2.4%; $P = 0.005$) and LSC (54.3 ± 3.9 vs. 66.7 ± 1.8%; $P = 0.002$), but nitrogen retention efficiency as a percentage of digested nitrogen was only reduced by LSC (76.3 ± 4.3 vs. 87.4 ± 1.5%; $P = 0.034$).

Conclusion and Implications

Protein fermentation increased PWD, irrespective of SC. Both protein fermentation and LSC reduced nitrogen retention and nitrogen efficiency. This was mainly caused by losses at the digestive level when feeding a diet inducing protein fermentation, but by losses at both digestive and post-absorptive level when housing piglets under LSC.

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References

J.K.Htoo, B.A.Araiza, W.C.Sauer, M.Rademacher, Y.Zhang, M.Cervantes, R.T.Zijlstra, 2007. Effect of dietary protein content on ileal amino acid digestibility, growth performance, and formation of microbial metabolites in ileal and cecal digesta of early-weaned pigs. Journal of Animal Science 85, 3303–3312.

Y.van der Meer, A.J.M.Jansman, W.J.J.Gerrits, 2020. Low sanitary conditions increase energy expenditure for maintenance and decrease incremental protein efficiency in growing pigs. Animal 14, 1811–1820.

R.Pieper, S.Kröger, J.F.Richter, J.Wang, L.Martin, J.Bindelle, J.K.Htoo, D.von Smolinski, W.Vahjen, J.Zentek, A.G.van Kessel, 2012. Fermentable fiber ameliorates fermentable protein-induced changes in microbial ecology, but not the mucosal response, in the colon of piglets. Journal of Nutrition 142, 661–667.

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O163 Effect of short-term events on the activity of gestating sows and their nutritional requirements

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Keywords: Precision feeding; Sow; Energy; Nutrition; Stress

Introduction

Various events, like a heatwave or a feeder dysfunction, can induce behavioural and physiological adaptations in gestating sows. Most often, these adaptations require energy and may deteriorate production performance (litter development and growth, sow body condition) if this extra energy is not provided. Previous studies mainly explored the effects of lasting events, while in practice most of the time these events occur only during few hours or few days. The aim of this study was therefore to evaluate the impact of various short-term events on the physical activity and the nutritional requirements of gestating sows.

Material and Methods

Two groups of approximately 18 sows each were continuously video recorded during two consecutive gestations. Individual behaviour (standing, lying, or in movement) was analysed manually from these videos as well as the number of posture changes. Different periods were considered regarding the event induced. Each test week, during which a specific event was induced, was always preceded by a control week without any induced event. A feeding competition event was induced by closing one of the two automated feeders available in each room. For this event, the behaviour of 31 sows was analysed during the first 36 hours of each week (test and control). Thermic stress events, cold and hot, were induced through fans and heaters, to reach a room temperature of 15°C and 32°C, respectively. For these thermic events, the behaviour of 37 sows was analysed during two periods (PM: 13:30 - 18:30 h for the resting period, and Night: 23:00 – 04:00 h for the feeding period). The effect of a pen enrichment (providing rope, bags and brush) on the behaviour of the 28 multiparous was also evaluated during the resting and feeding periods.

The statistical analysis was done using R studio software (version 4.0.3). A linear mixed-effects model was applied on the variable of interest integrating the period (PM, Night), week (test vs control), and their interactions as fixed factors, as well as the random effect of the sow. The daily individual energy requirement was calculated using the equations of Dourmad et al. (2008) including the effects of physical activity and ambient temperature.

Results and Discussion

During PM, the sows were on average more active during the cold week compared to hot week (103 vs 83 min standing/5 h, $P < 0.001$), and they spent less time lying laterally (125 vs 174 min/5 h, $P < 0.001$). Due to these changes in activity and thermoregulation, metabolisable energy (ME) requirement increased by 2.5% during the cold week ($P < 0.001$) and decreased by 3 % during the hot week (Figure 1). The coefficient of variation between sows of this change in ME requirement was 57 % for cold and 51 % for hot stress. The effect of temperature on the time spent lying laterally is a strategy to reduce or increase the thermic losses depending on temperature (Canaday et al., 2013).

The pen enrichment did not affect the time spent lying ($P = 0.80$), standing ($P = 0.68$), or in movement ($P = 0.83$), and thus did not affect the nutritional requirements (Figure 1).This result may be related to the presence of straw in the pen during the control and test weeks.

During the feeding competition, sows decreased their time spent lying by 97.7 min/36 h ($P < 0.001$) and increased their time spent waiting in front the feeder (147.3 vs 60.2 min/36 h, $P < 0.001$) which increased their energy requirements by 1 % (Figure 1). The coefficient of variation between sows of the change in ME requirement was 70 %. This increase of activity could be linked to the need of building a new hierarchy in the group to access the unique feeder.

Conclusion and Implications

The thermic stresses and the feeding competition significantly affected the sow's physical activity and thermoregulation, leading to a modification in ME requirement for maintenance. The enrichment setup was not stimulating enough to affect the physical activity or ME requirement, probably because the straw was also available in the control condition. This study indicates that the various short-term events tested impact differently the physical activity and the nutritional requirements. Integrating this data in real-time, into the nutri-

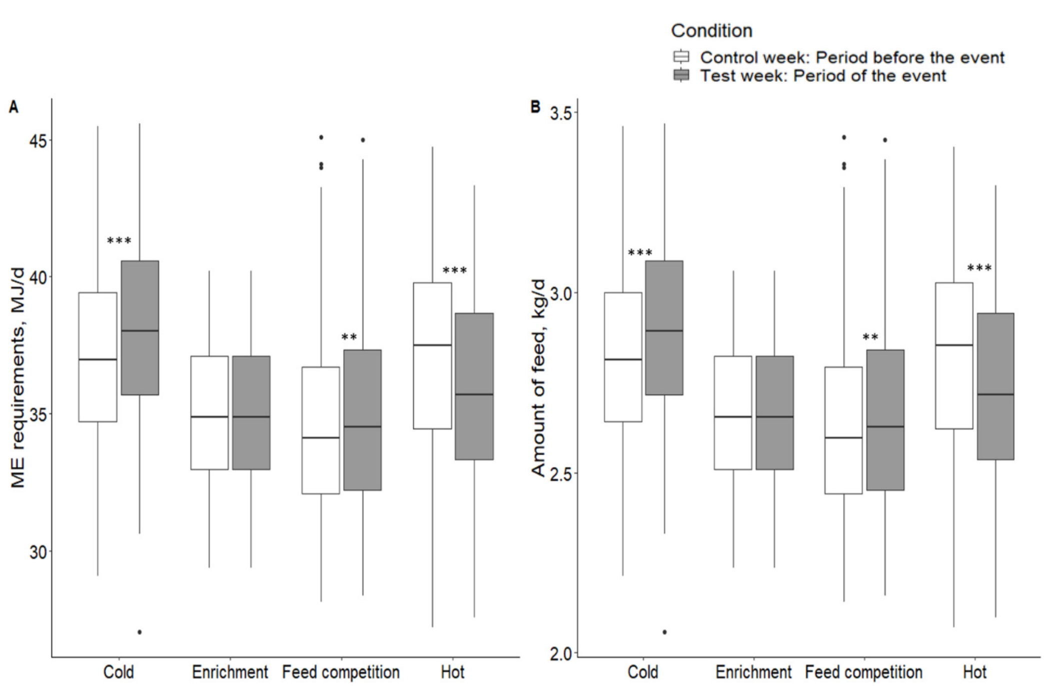

Figure 1. Effect of the various short-term events (cold and hot thermic stress, feed competition, and enrichment period) on the median and quantiles of metabolisable energy requirement (A) and the corresponding amount of feed (at 12.67 MJ/kg and 0.86 DM content kg/kg; B) for gestating sows.

tional model could be important for a better adjustment of the feed supply to the requirements of the sows all over their gestation period. Furthermore, the large variability of individual responses shows that an individual adjustment of the diet would be necessary to enhance the precision feeding model.

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References
D.C.Canaday, J.L.Salak-Johnson, A.M.Visconti, X.Wang, K.Bhalerao, R.V.Knox, 2013. Effect of variability in lighting and temperature environments for mature gilts housed in gestation crates on measures of reproduction and animal well-being. Journal of Animal Science 91, 1225–1236.
J.Y.Dourmad, M.Etienne, A.Valancogne, S.Dubois, J.van Milgen, J.Noblet, 2008. InraPorc: A model and decision support tool for the nutrition of sows. Animal Feed Science Technology 143, 372–386.

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O164 Effect of live yeast supplementation and feeding frequency in heat stressed pigs

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Keywords: Heat stress; Pigs; Live yeast; Energy metabolism; Feeding behaviour; Thermoregulation

Introduction
Under heat stress (HS), reduced growth performance is mainly related to decreased feed intake (FI). Live yeast (LY) supplementation was reported to improve HS response in pigs (higher FI and energy retention), possibly mediated by an increased number of meals (Labussière et al., 2021). The objective of the study was to determine (1) if the positive effects of LY-supplementation during HS is due to a modified feeding behaviour or energy metabolism, and (2) if these effects can be replicated by imposing an increased meal frequency.

Material and Methods
Thirty-six entire male pigs (62.2±1.0 kg) individually-housed in respiratory chambers were used to evaluate the effects of LY-supplementation and of increasing meal frequency during HS. There were 2 levels of LY-supplementation: 0 (N) vs. 100 g/ton of feed (Y; 1×10^6 CFU *Saccharomyces cerevisiae var. boulardii* CNCM I-1079/g of feed), and 3 feeding windows(FW): unlimited (Unli) from 0900h to 0700h, 2FW of 1 h each at 0900h and at 1500h, and 8FW of 15 min each (at every 90-min interval from 0900h to 1930h). Feeding behaviour, energy utilisation, nitrogen retention, and thermoregulation responses were measured. Ambient temperature was at 22°C during the first 5 days of measurement (Period 1; P1) and thereafter at 28°C for the last 5 days in HS conditions (Period 2; P2). Relative humidity was kept constant

Table 1
Effect of live yeast supplementation and feeding window on feeding behavior, energy metabolism, and nutrient deposition of heat-stressed pigs.

	N-Unli	Y-Unli	N-2FW	Y-2FW	N-8FW	Y-8FW	RSD	Statistics			
								D	FW	*P*	D × FW × *P*
Animals, n	5	5	6	5	4	6					
Meal (n/day)											
P1	5.6	7.1	2	2.4	5.1	4.2	0.8	-	**	*	-
P2	4.5	5.6	2.1	2.6	4.8	4					
Water intake (g/day)											
P1	7,045^{ab}	6,013^{ab}	5,200^{b}	5,242^{b}	5,126^{b}	5,149^{b}	3498	-	-	**	**
P2	8,637^{ab}	7,723^{ab}	7,075^{ab}	14,161^{a}	13,251^{ab}	6,015^{ab}					
Energy balance (kJ/kg BW$^{0.60}$/day)											
ME intake											
P1	2,765	2,727	2,398	2,568	2,524	2,588	243	T	-	**	-
P2	1890	2,136	1,658	2,228	2,027	1,870					
RE											
P1	1265	1239	988	1122	1088	1126	182	*	T	**	-
P2	617	821	423	884	722	599					
Nutrient deposition (g/day)											
Protein											
P1	160	158	135	146	150	150	24	*	*	**	-
P2	83	109	70	91	82	90					
Fat											
P1	361	347	271	308	293	313	61	*	-	**	T
P2	180	234	120	268	215	165					

T $P < 0.10$.
* $P < 0.05$.
** $P < 0.01$.