Feeding behavior of growing–finishing pigs reared under precision feeding strategies[1]

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ABSTRACT: The feeding behavior of growing–finishing pigs reared under precision feeding strategies was studied in 35 barrows and 35 females (average initial BW of 30.4 ± 2.2 kg) over 84 d. Five different feeding programs were evaluated, namely a conventional 3-phase program in which pigs were fed with a constant blend of diet A (high nutrient density) and diet B (low nutrient density) and 4 daily phase-feeding programs in which pigs were fed daily with a blend meeting 110, 100, 90, or 80% of the individual Lys requirements. Electronic feeder systems automatically recorded the visits to the feeder, the time of the meals, and the amount of feed consumed per meal. The trial lasted 84 d and the database contained 59,701 feeder visits. The recorded database was used to calculate the number of meals per day, feeding time per meal (min), intervals between meals (min), feed intake per meal (g), and feed consumption rate (feed intake divided by feeding time per meal, expressed in g/min) of each animal. The feeding pattern was predominantly diurnal (73% of the feeder visits). Number of meals, duration of meals, time between meals, feed consumed per meal, and feed consumption rate were not affected by the feeding programs. The females ingested 19% less feed per meal and had a 6% lower feed consumption rate in comparison with the barrows ($P < 0.05$). Pig feeding behavior was not correlated with diet composition. However, feed efficiency was negatively correlated with amount of feed consumed per meal ($r = -0.38$, $P < 0.05$) and feed consumption rate ($r = -0.44$, $P < 0.05$). Feed consumption rate was also negatively correlated with protein efficiency ($r = -0.44$, $P < 0.05$). Multivariate analysis indicated that feed consumption rate and number of meals per day are the variables related most closely to pig production performance results. Current results indicate that using precision feeding as an approach to reduce Lys intake does not interfere with the feeding behavior of growing–finishing pigs.

Key words: feed intake pattern, meal pattern, nutrient requirements, nutrition, precision farming, swine

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INTRODUCTION

Phase feeding is the most widely used feeding technique in pig production. This feeding program is designed to maximize animal growth performance by providing the same feed to all pigs of a batch within a certain growing phase. However, the pigs' nutritional requirements change over time following individual patterns and also vary greatly among individuals of a batch (Pomar et al., 2003; Brossard et al., 2009). By disregarding these variability issues, the conventional group phase-feeding programs lead to inaccurate nutrient supply, usually with most of the pigs receiving more nutrients than they actually need (Hauschild et al., 2010). In this context, feeding pigs

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to maximize population responses may be associated with high feeding costs and high levels of nutrient excretion to the environment (Pomar et al., 2009).

Precision feeding is a modern alternative to take between-animal variation into account, given that pigs are fed individually with diets adjusted in real time according to the pigs' own patterns of feed intake and growth (Pomar et al., 2009; Hauschild et al., 2012). Previous results clearly indicate that precision feeding is an effective approach for reducing nutrient excretion while maintaining the productive performance of pigs (Andretta et al., 2014, 2016). Despite its benefits, precision feeding is a new concept, and no previous trials have been conducted to assess the impact of this approach on feeding behavior.

Feed behavior is an important research area that links the nutritional and behavioral sciences (Nielsen, 1999). A better understanding of pig feeding behavior could provide critical information for improving feeding strategies, productivity, and animal well-being. Electronic feeders may be an important tool in this research area, as this equipment allows recording detailed and quantitative information on feeding behavior (such as time, size, and duration of each meal), overcoming the lack of control over individual behavior intrinsic to other group-housing systems (Nielsen, 1999; Chapinal et al., 2008). The aim of the present study was therefore to conduct an exploratory study of the feeding behavior of group-housed growing–finishing pigs reared under precision feeding strategies.

MATERIALS AND METHODS

Animals, Housing, and Management

A total of 70 pigs (35 females and 35 barrows; 7.28 ± 0.85 kg) that were of the same high-performance genotype (Fertilis 25 × G Performer 8.0; Genetiporc Inc., Saint-Bernard, QC, Canada) and that had normal growth performance and no clinical signs of disease were randomly selected in a commercial farm and shipped in a single batch to Agriculture and Agri-Food Canada Centre in Sherbrooke, QC, Canada. Pigs were housed in a single pen and had free access to feeders and drinkers that provided ad libitum feed and fresh water throughout the experiment. Animals were cared for in accordance with a recommended code of practice (AAFC, 1993) and the guidelines of the Canadian Council on Animal Care (CCAC, 2009).

Pigs were fed with a commercial starter diet during the pre-experimental period. Conventional feeders were used during the first 2 wk. Afterward, 1 transponder (plastic button tag containing passive transponders of radio frequency identification; Allflex, St-Hyacinthe, QC, Canada) were installed in the right ear of each pig using the specific tagger pliers, and the animals were introduced to the electronic feeders. Animals were randomly assigned to the experimental treatments at 30.4 ± 2.2 kg BW. Pigs were housed in a single 48-m^2 pen with a fully slatted floor in a mechanically ventilated room. On d 42 of the performance trial, the pen area allowance was adjusted to 96 m^2 to meet the space requirements for finishing pigs. Temperature and wind velocity were controlled by an automated system. The room temperature was progressively decreased from 22°C when the pigs arrived to 18°C when the pigs reached around 100 kg BW, thus ensuring thermoneutral conditions. Fluorescent lighting was controlled by a timer switch and provided from 0600 to 1800 h.

Water was delivered with 12 low-pressure nipple drinkers distributed all over the pen, and feed was provided individually with 5 feeding stations (Automatic and Intelligent Precision Feeder; University of Lleida, Lleida, Spain) installed side by side in front of the pen. The functioning of these feeders was described previously (Pomar et al., 2011). Briefly, the feeding station identified each pig when its head entered the feeder, and the station then delivered a blend of feeds in response to each animal's estimated allowance. Pigs tended to empty the feeder hopper or leave only very small amounts of feed behind at each visit, providing assurance that each pig received the assigned amount of blended feeds (Pomar et al., 2011). The feeders were equipped with a monitoring tool that continuously registered each visit of each pig with start and stop time (day, hour, minute, and second) and the amount of feed consumed. The feeder calibration (match between recorded and provided amounts of feed) was checked weekly.

Diets and Feeding

Two experimental diets (i.e., diet A and diet B) were independently formulated on the basis of NE and standardized ileal digestible (**SID**) AA, using the same ingredient composition database (analyzed gross composition of ingredients derived according to the EvaPig software, version 1.3.1.4; INRA, Saint-Gilles, France) and with no growth promoters or other additives (Table 1). Diet A had high nutrient-to-NE ratios to meet the requirements of the most demanding pigs at the beginning of the first growing phase. Diet B had low nutrient-to-NE ratios given that it should meet the estimated requirements of the least demanding pigs at the end of the last growing phase. Diets were formulated according to standard recommendations for AA profiles (NRC, 2012) and digestible P (Jondreville and Dourmad, 2005). Diets were produced in 1 batch each and were provided in steam-pelleted form. The appropriate final feed composition was obtained by

Table 1. Ingredient and chemical composition of experimental diets

Item	Diet A High nutrient/NE density	Diet B Low nutrient/NE density
Ingredient composition, as-fed basis, %		
Wheat	15.0	15.0
Corn	54.8	83.2
Soybean meal	25.4	0.17
Limestone	1.61	0.42
Monocalcium phosphate	1.22	–
Salt	0.63	0.50
DL-Met	0.09	–
L-Lys HCl	0.44	0.09
L-Thr	0.13	–
Choline 60, 51.7%	0.10	0.10
Vitamin and mineral premix[1]	0.50	0.50
Chemical composition		
DM, %	89.6	87.9
CP, %	16.4	7.8
Total Lys, %	1.37	0.33
SID[2] Lys, calculated,[3] %	1.15	0.26
SID Thr, calculated, %	0.70	0.23
SID Met, calculated, %	0.34	0.14
SID Met + Cys, calculated, %	0.62	0.31
SID Trp, calculated, %	0.18	0.05
SID Ile, calculated, %	0.68	0.26
SID Val, calculated, %	0.75	0.33
SID Leu, calculated, %	1.36	0.83
SID Phe, calculated, %	0.80	0.35
SID Phe + Tyr, calculated, %	1.37	0.63
SID His, calculated, %	0.43	0.19
SID Arg, calculated, %	1.08	0.34
ME, calculated, Mcal/kg	3.11	3.17
NE, calculated, Mcal/kg	2.32	2.53
Ca, %	0.92	0.21
Total P, %	0.60	0.29
Digestible P, calculated, %	0.32	0.07
Crude fiber, %	2.46	2.09
Ash, %	5.36	2.33

[1]Premix should provide at least the following nutrient amounts per kilogram: 456,000 IU vitamin A, 45,600 IU vitamin D, 1,400 IU vitamin E, 80 mg vitamin K, 1.2 mg vitamin B_{12}, 800 mg niacin, 600 mg pantothenic acid, 80 mg pyridoxine, 120 mg riboflavin, 80 mg thiamine, 4.9 g copper, 12 mg iodine, 4 g iron, 2.5 g manganese, 12 mg selenium, and 6.1 g zinc.

[2]SID = standardized ileal digestible.

[3]All calculated values for growing pigs were estimated from the gross composition of the ingredients according to the EvaPig software program (version 1.3.1.4; INRA, Saint-Gilles, France).

blending the 2 diets at each pig visit to the feeder, thus creating a complete feed.

The performance trial consisted of 3 feeding phases, each 28 d long. Five feeding programs (treatments) were evaluated in this study. The control treatment (3-phase feeding program [**3P**]) consisted of a 3-phase feeding program that provided all pigs in this group with a fixed blend of feeds A and B within each feeding phase. The blend for each phase was determined during the first 3 d of the phase to satisfy the requirements of the 80th-percentile pig in the population; that method was demonstrated earlier with an in silico simulation that maximized the population response in terms of BW gain (Hauschild et al., 2010).

Pigs assigned to the different multiphase treatments were fed a blend of diets A and B that was adjusted daily to match 110 (**MP110**), 100 (**MP100**), 90 (**MP90**), or 80% (**MP80**) of the estimated Lys requirements of each individual pig. The required concentration of SID Lys was estimated for each pig with a mathematical model using individual daily feed intake and weekly BW information. In this model, the empirical component estimates the expected BW, feed intake, and daily gain for the next day, whereas the mechanistic component uses these 3 estimates to calculate, with a factorial method, the optimal concentration of AA that should be offered that day to each pig in the herd to meet the animal's requirements. In this mechanistic component of the model, daily SID Lys requirements (g/d) were calculated by adding together the maintenance and growth requirements. Daily maintenance Lys requirements were estimated by adding together basal endogenous losses (0.313 g Lys/kg DM × daily feed intake), losses related to desquamation in the digestive tract (0.0045 g Lys/kg$^{0.75}$·d^{-1} × BW$^{0.75}$), and losses related to the basal renewal of body proteins (0.0239 g Lys/kg$^{0.75}$·d^{-1} × BW$^{0.75}$; van Milgen et al., 2008). The SID Lys requirements for growth were calculated assuming that 7% of body protein is Lys (Mahan and Shields, 1998) and that the efficiency of Lys retention from dietary digestible Lys is 72% (Möhn et al., 2000). The protein content in live weight gain was predicted using a regression equation empirically obtained with data collected in previous studies in which body lean mass was measured by dual-energy X-ray absorptiometry (**DXA**).

Representative samples of the diets were taken on delivery and once weekly throughout the experiment. Samples of each feed were mixed at the end of the experiment to obtain a representative composite sample. The composite feed samples were analyzed according to Association of Official Analytical Chemists (AOAC, 1990) standard methods for lyophilization (method 938.18) and for determination of total protein (method 992.15), lipids (extraction method 991.36), DM (method 950.46), and ash (method 920.153). Calcium concentration was obtained by inductively coupled plasma spectrometry (ICP-ES Perkin-Elmer Optima 3000; PerkinElmer Inc., Waltham, MA; method 984.27) whereas phosphorus concentration was obtained by colorimetric analysis (Lambda-35 spectrometer; PerkinElmer Inc.; method 995.11; AOAC, 1990). For AA (excluding

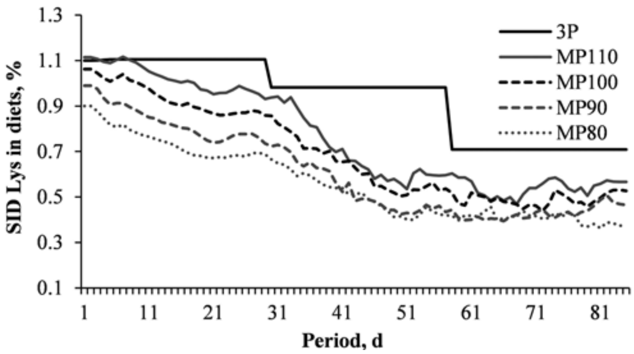

Figure 1. Dietary standardized ileal digestible (SID) Lys concentration in feeds provided to pigs fed in 1 group according to a 3-phase feeding program (3P) or individually with daily tailored diets providing 110 (MP110), 100 (MP100), 90 (MP90), or 80% (MP80) of the estimated Lys requirements.

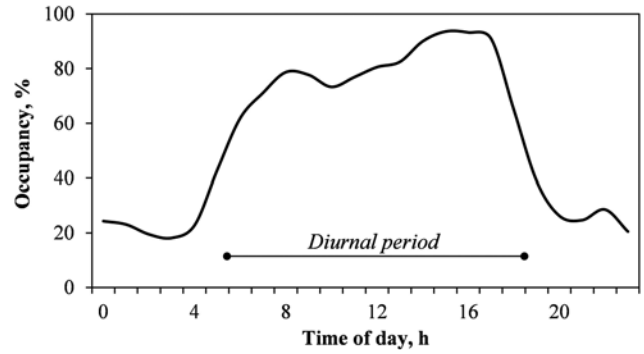

Figure 2. Circadian variation of feeder occupancy rate.

tryptophan), feed samples were ground to pass through a 0.5-mm screen and acid-hydrolyzed with 6 *N* phenol-HCl for 24 h at 110°C (method 994.12), and AA concentrations of the hydrolysates were determined by the isotope dilution method, as described by Borucki Castro et al. (2007). Analyzed feed composition was similar (maximum 3% variation) to the calculated composition.

Performance and Body Composition

Pigs were weighed individually on conventional scales at arrival, twice during the pre-experimental phase, and weekly during the trial. Total body lean content was measured by DXA on d 0, 28, 56, and 84 with a densitometry device (GE Lunar Prodigy Advance; GE Healthcare, Madison, WI). Pigs were scanned in prone position using the total body scanning mode (GE Lunar enCORE, version 8.10.027; GE Healthcare). Anesthesia was induced with sevoflurane (5%) and maintained with isoflurane (4%) during the scans. The DXA body lean mass value was converted to its protein chemical equivalent, as proposed by Pomar and Rivest (1996). The efficiency of protein deposition was calculated by dividing the gain of protein (estimated using the values obtained by DXA) by the CP intake. The details of this protocol were described elsewhere (Andretta et al., 2016).

Data Compilation and Statistical Analysis

Feeder visits by the same pig with intervals that were less than 1 min apart were combined together as a single meal in a revised spreadsheet. Feeding information collected on days on which animals were handled (weighed or scanned) was removed from the data set. After this preliminary review procedure, the database was used to calculate the number of meals per day, feeding time per meal (min), intervals between meals (min), feed intake per meal (g), and feed consumption rate (feed intake divided by feeding time per meal, expressed in g/min) of each animal.

Each pig was considered an experimental unit, as each animal was an independent observation and all animals were raised in exactly the same conditions except of those considered in the analytical models. Data were submitted to variance analysis (MIXED procedure) considering the fixed effects of treatment, feeding phase, sex, and interactions. The effect of repeated measures over time in the same individual was also considered. Analyses were performed using the SAS software program (version 9.3; SAS Inst. Inc., Cary, NC). Differences were considered significant if $P < 0.05$. Residuals of all dependent variables were normally distributed. Partial correlations (adjusted for treatment, feeding phase, and sex effects) were tested among the behavior and performance responses.

Multivariate analysis was used to evaluate the range of interactions among quantitative variables using the MULTIV software program (version 3.13b; Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil; Pillar, 2006). This software program accepts qualitative, quantitative, and mixed information. Vector transformation within raw variables was performed through standardizing by marginal total. Ward's method was applied to cluster the studied variables. This method uses *F*-values (ANOVA) to evaluate the distance among clusters giving strong statistical power (Mooi and Sarstedt, 2011).

RESULTS AND DISCUSSION

Throughout the trial, pigs consumed feed and gained weight according to the expected performance of the genotype. No health issues were detected during the experimental period other than some inflammatory foot problems not related to the treatments observed in 3 barrows on d 70, and these animals were removed from the pen and their data were not considered in the analysis. Therefore, the data presented in this paper are the means of 14 pigs for each of the 3P, MP100,

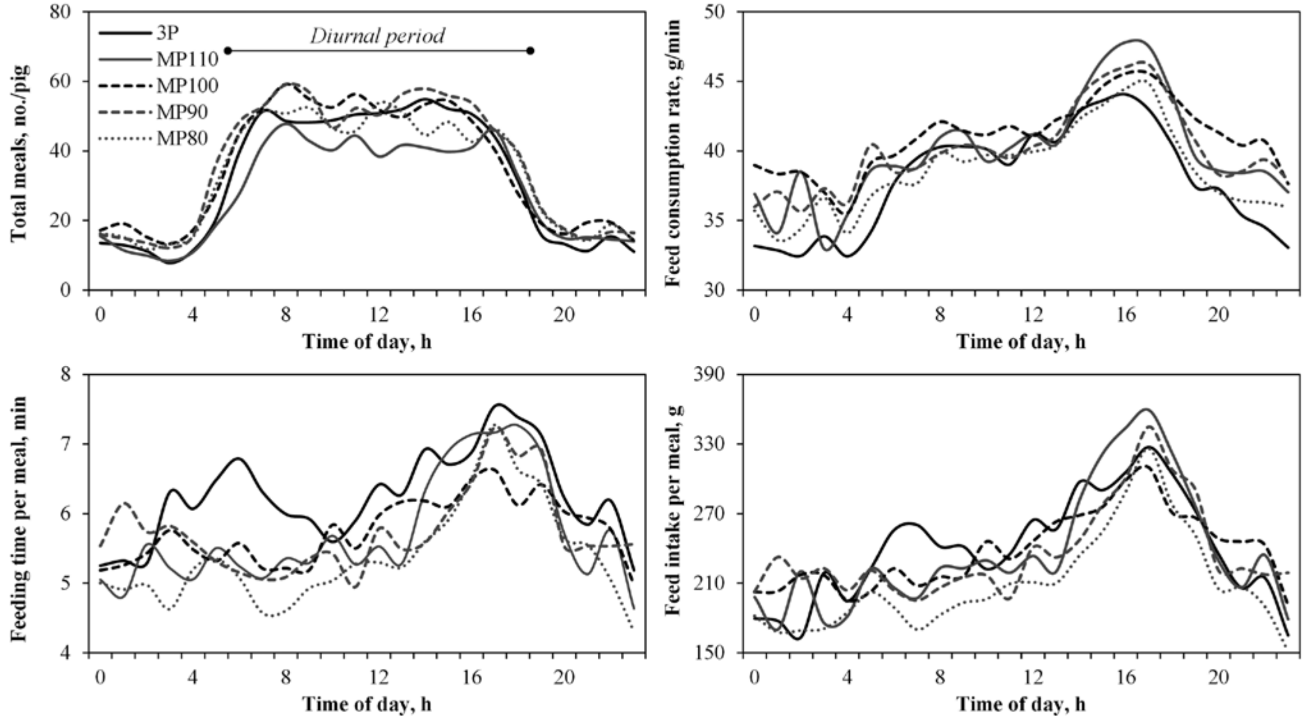

Figure 3. Circadian variation of total number of meals (of each pig during the 84 d of the experiment), average feed consumption rate, feeding time per meal, and feed intake per meal of pigs fed in 1 group according to a 3-phase feeding program (3P) or individually with daily tailored diets providing 110 (MP110), 100 (MP100), 90 (MP90), or 80% (MP80) of the estimated Lys requirements.

and MP90 treatments, 13 pigs for the MP80 treatment, and 12 pigs for the MP110 treatment.

Precision feeding (MP100) made it possible to reduce the content of dietary SID Lys by 26% in relation to the 3P diets (Fig. 1). Detailed performance responses are available in a recently published paper (Andretta et al., 2016). Briefly, feed intake and feed efficiency were similar across treatments. Feeding pigs in a daily program providing 110, 100, or 90% of the estimated individual requirements also did not influence weight gain, suggesting that the mathematical model was properly calibrated for estimating the Lys requirements.

The feeding behavior data included 59,701 feeder visits for which the identity of the pig, the entry and exit times, and the amount of feed consumed were recorded. The average feeder occupancy rate was 55% (Fig. 2). The feeding pattern was predominantly diurnal (Fig. 3 and 4), given that 73% of the meals were performed during light time. Nocturnal time spent at the feeder was inversely correlated ($r = -0.64$, $P < 0.05$) with BW. This inverse partial correlation was corrected for the feeding phase effect and, therefore, probably indicates an effect of dominance hierarchy, with heavier pigs having preference during diurnal periods (Chen et al., 2010), when the feeder occupancy rate was higher. The diurnal character of feed intake increased with age. Diurnal meals accounted for 64% of total meals in the first feeding phase, 74% during the second phase, and 82% during the last phase. Although the number of meals was well distributed during the light time, other variables showed peaks over the day. Therefore, pigs consumed 21% more feed per meal and had an 8% higher feed consumption rate between 1500 and 1800 h in comparison with the rest of the light time. These changes in feeding patterns are probably related to the circadian rhythm because pigs subjected to constant temperatures tended to consume the most feed 2 h after the lights were turned on and 3 h before the lights were turned off (Feddes and DeShazer, 1988). Social facilitation and increasing competition for the feeders may also explain these circadian variations in feeding patterns.

All feeding behavior responses were influenced ($P < 0.05$) by feeding phase (Table 2). Feed intake per meal and feed consumption rate increased overtime, which may be related to the increasing age and BW, the gradual changes in the physiological state of the animal (degree of maturity), and the level of experience. Previous publications also related increasing age to changes in feeding behavior, such as reduced number of feeder visits per day, enlarged meal sizes, and increased feeding rates (Nielsen, 1999).

Interactions between treatment and feeding phase were observed ($P < 0.05$) for feed intake per meal and feed consumption rate. However, feeding behavior responses did not differ among the treatments in the overall period. Individually feeding growing pigs with daily tailored diets is an effective approach to reduce Lys supply with no effect on the pigs' performance (Andretta et al., 2014, 2016). Based on current and

Table 2. Feeding behavior[1] of pigs fed in a group according to a 3-phase feeding program (3P) or individually with daily tailored diets providing 110 (MP110), 100 (MP100), 90 (MP90), or 80% (MP80) of the estimated Lys requirements

	Treatments					Sex		Feeding phases			*P*-values[2]						
Response	3P	MP110	MP100	MP90	MP80	Barrows	Females	1	2	3	Trt	Sex	Trt × sex	FP	Trt × FP	FP × sex	Trt × FP × sex
Interval between meals, min	280 (13)	275 (13)	234 (10)	241 (9)	241 (11)	263 (7)	267 (7)	227^{c} (6)	301^{a} (9)	268^{b} (9)	0.07	0.79	0.72	<0.01	0.08	0.99	0.66
Feeding time per meal, min	6.39 (0.26)	5.85 (0.19)	5.77 (0.19)	5.70 (0.24)	5.44 (0.32)	6.46 (0.17)	5.82 (0.13)	6.21^{a} (0.16)	6.44^{a} (0.20)	5.76^{b} (0.20)	0.50	0.08	0.87	<0.01	0.63	0.06	0.74
Feed intake per meal, g	258 (17)	250 (15)	243 (12)	239 (15)	217 (12)	286 (11)	231 (6)	194^{c} (6)	279^{b} (10)	301^{a} (12)	0.46	<0.01	0.49	<0.01	0.03	0.02	0.21
Feed consumption rate, g/min	39.8 (1.6)	41.5 (1.8)	41.7 (1.6)	41.0 (1.3)	39.7 (1.3)	42.7 (1.0)	39.9 (0.9)	31.4^{c} (0.6)	42.4^{b} (0.8)	50.2^{a} (0.8)	0.61	0.04	0.45	<0.01	<0.01	0.97	0.11
Number of meals per day	9.81 (0.4)	10.1 (0.3)	10.8 (0.3)	11.1 (0.5)	11.1 (0.4)	10.5 (0.3)	10.7 (0.2)	11.0^{a} (0.2)	9.42^{b} (0.2)	11.3^{a} (0.3)	0.46	0.82	0.79	<0.01	0.06	0.36	0.99

$^{a–c}$Values within a row and within the comparison (among treatments or feeding phases) with different superscripts differ significantly at $P < 0.05$ according to Tukey's test.

[1]Least squares means (SE).

[2]Probability of treatment (Trt); feeding phase (FP); interaction between treatment and feeding phase (Trt × FP); sex; interaction between treatment and sex (Trt × sex); interaction between feeding phase and sex (FP × sex); and interaction between treatment, feeding phase, and sex (Trt × FP × sex) effects.

previous results, the precision feeding programs may be applied in industrial pig operations without feeding behavior or performance implications.

The average dietary content of CP and SID Lys showed no correlation with number of meals per day, feeding time per meal, intervals between meals, feed intake per meal, or feed consumption rate. In a previous publication, Hyun et al. (1997) found that increased CP and Lys levels in diets decreased the number of meals per day and increased the feed intake per meal. Additionally, increased activity levels were previously found to be a consequence of CP restriction in growing pigs (Jensen et al., 1993). Current observations were performed in a controlled environment and were based in a limited range of dietary nutritional levels. In different conditions, the feed formulation procedures may interfere in the feeding behavior and this possible impact should be considered by the nutritionist.

A sex × feeding phase interaction ($P < 0.05$) was observed for feed intake per meal. No differences between sexes were observed for this response in the first experimental phase. However, the females ingested less feed per meal than the barrows did in the second (309 vs. 249 g) and third phases (339 vs. 263 g). The females also had ($P < 0.05$) a feed consumption rate 6% lower than that of the barrows in the overall period. Results of previous research also indicated that barrows consume feed distributed in more meals per day than females (Hyun et al., 1997). However, the subject is still uncertain and no effect of sex on feeding patterns was observed in some studies (Young and Lawrence, 1994). Differences observed in current study may be related to performance responses, such as feed intake or BW, given that gilts showed lower ADFI (2.26 vs. 2.69 kg/d) and ADG (0.96 vs. 1.07 kg/d) than the barrows (Andretta et al., 2016).

The dispersion of individual feeding behavior responses in the herd under evaluation is presented in Table 3. Individual patterns varied greatly in the studied group. The time spent at the feeder per meal varied from 3.4 min for the pig with the lowest mean to 10.4 min for the pig with the highest mean in the group. The individual means for feed intake per meal ranged from 139 to 458 g. On average, 16% of the pigs showed feeding behavior responses below 1 SD of the mean, and another 16% of the group showed responses above 1 SD (data not shown). Very few studies dealing with the variation of feeding behavior responses are available in the literature. However, this information may be useful in investigating population performance patterns and should be assessed in future studies.

In support of previous observations (Auffray et al., 1980), the amount of feed ingested in a meal was positively correlated with the time until the start of the next meal (postprandial period; $r = 0.28$, $P < 0.05$)

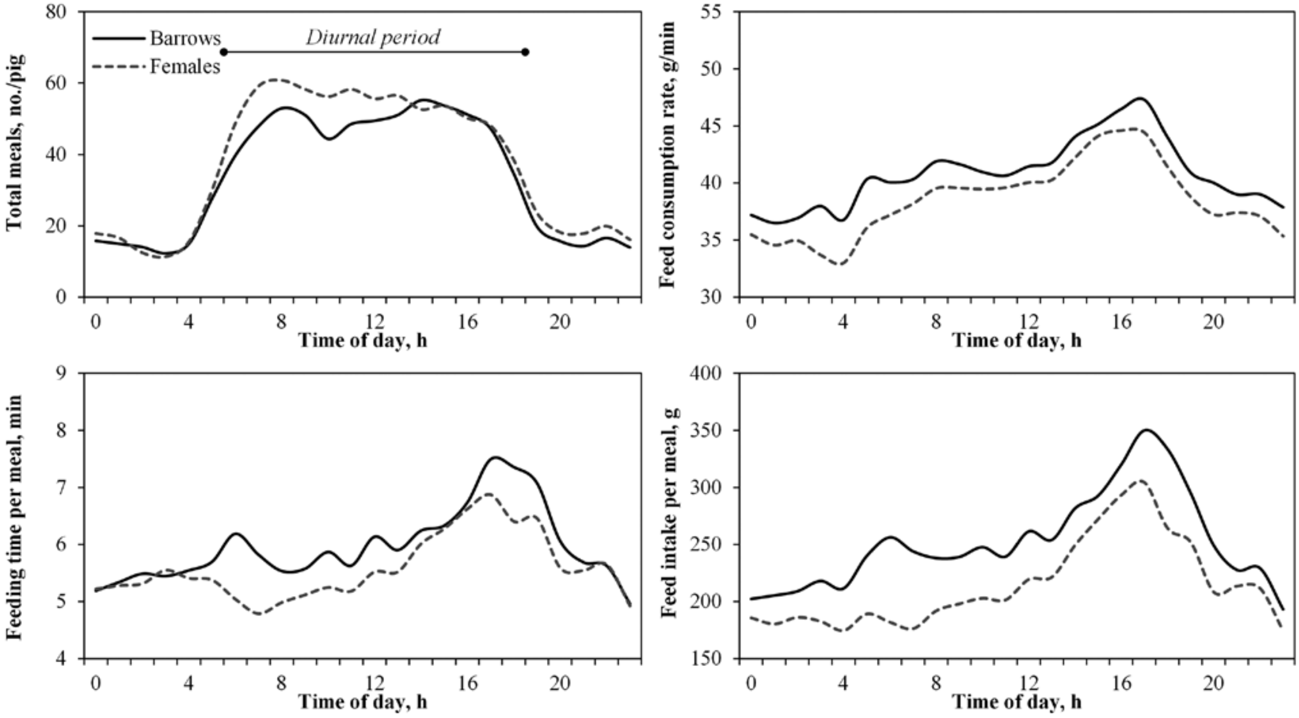

Figure 4. Circadian variation of total number of meals (of each pig during the 84 d of the experiment), average feed consumption rate, feeding time per meal, and feed intake per meal according to sex.

and with the amount of feed ingested in the next meal ($r = 0.21$, $P < 0.05$). The correlation between meal size and postprandial interval was previously described in several species (Maselyne et al., 2015). However, the previous results obtained in pigs are diverse, and pre- and postprandial correlation could not be observed in all pigs in the herd (Young and Lawrence, 1994).

Feed efficiency (ADG:ADFI) was negatively correlated with feed intake per meal ($r = -0.38$, $P < 0.05$) and feed consumption rate ($r = -0.44$, $P < 0.05$). In the same way, CP efficiency showed a negative correlation with feed consumption rate ($r = -0.44$, $P < 0.05$). These results are in accordance with those of previous publications that also classified feed intake per meal and rate of feed intake as feeding behavior criteria that are more closely associated with performance traits (Labroue et al., 1997). Meal size and rate of feed intake appear to negatively influence nutrient utilization, probably through effects on the rate of passage or digestive enzyme performance (de Haer and de Vries, 1993; de Haer et al., 1993). However, the finding correlations are low and studies with controlled experimental designs are necessary to complete understand the relationships among feeding and performance variables.

A cluster dendrogram of performance and behavior variables is shown in Fig. 5. The results of multivariate analysis indicated 2 main clusters. The first cluster contained predominantly behavior variables (feed intake per meal and duration of meals were more closely related, joined by the intermeal interval), and the second cluster contained performance variables (feed conversion efficiency, CP deposition efficiency, BW, and daily weight gain) joined closely by feed consumption rate and daily feed intake and later by the number of daily meals. In other words, the cluster analysis indicated that feed consumption rate and number of meals are the variables most closely related to pig performance results. Therefore, more research is necessary to investigate and interpret the importance of these traits in larger groups.

Feeding rates and other behavior information may be valuable tools in pig production. According to the literature, feeder-use patterns in group-housed pigs may be affected by several factors, such as photope-

Table 3. Dispersion of individual feeding behavior responses in the pig herd under evaluation

Response	Minimum	First quartile	Median	Third quartile	Maximum
Interval between meals, min	138.50	216.20	263.50	294.20	443.10
Feeding time per meal, min	3.43	4.89	5.90	6.92	10.39
Feed intake per meal, g	138.68	195.29	247.15	302.28	457.70
Feed consumption rate, g/min	31.12	36.56	40.43	44.75	58.26
Number of meals per day	6.49	8.80	10.23	12.05	15.38

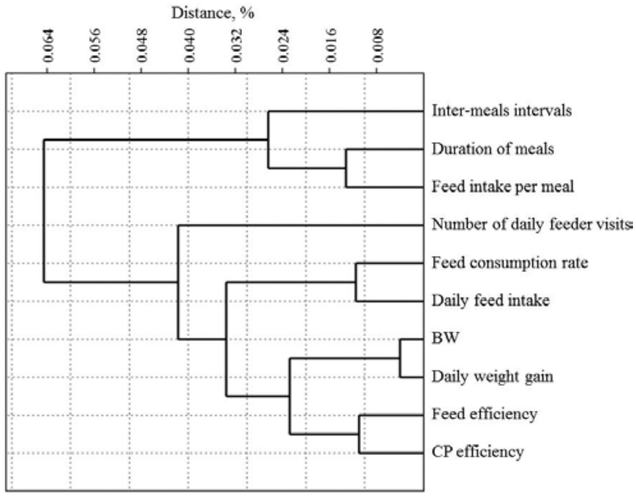

Figure 5. Dendrogram obtained by multivariate analysis of performance and behavior variables in growing–finishing pigs.

riodicity, group size, social interaction, management, feed allowance, equipment design, and the type of environment in which feeder use is observed (Nielsen, 1999; Chapinal et al., 2008). Some feedback systems related to nutrient intake and based on internal metabolic balances may also influence feeding behavior, especially in terms of short-term regulation. However, it is clear that no single control mechanism regulates intake in all situations (Mertens, 1996). More knowledge is required to better characterize the effect of diet plans and other environmental aspects on feeding behavior.

Individually feeding growing pigs with daily tailored diets is an effective approach to reduce Lys supply with no effect on the pigs' performance (Andretta et al., 2014, 2016) or feeding behavior. Results presented in this paper are valid mainly for pigs fed in automated and ad libitum feeding programs. However, the current study helped in indicating several factors that may play an important role in the regulation of feeding behavior in group-housed pigs. These factors may be considered in the definition of feeding programs for commercial pig production. Further research is necessary to better define these mechanisms and associations.

LITERATURE CITED

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