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Effect of feeding frequency on growth performance, nutrient digestibility, diarrhea incidence and blood profiles in weaning pigs

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ABSTRACT

An experiment was conducted to evaluate the effect of feeding frequency on growth performance, nutrient digestibility, diarrhea incidence and blood profiles in weaning pigs. Piglets (264) (Average BW, 7.6 kg), were allotted to 2 treatments with 6 replicated pens (22 animals per pen; 11 males and 11 females) in a randomized complete block design based on body weight. Equal amount of diet was provided to all the animals. They were fed an early weaning diet for 14 d and a late weaning diet for 14 d. The control group was fed the diet twice (at 0700 and 1900 h) per day and treatment group was fed the diet four times (at 0700, 1100, 1500 and 1900 h) per day. The change of feeding frequency did not affect feed intake, body weight gain and gain to feed ratio. With increase in the feeding frequency, blood cortisol concentration was not changed. Also, in leptin and ghrelin analysis, there was no significant difference between treatments. Likewise, dry matter digestibility and diarrhea incidence showed no significant difference. In conclusion, the change of feeding frequency in weaning pigs did not affect the growth performance, nutrient digestibility, diarrhea incidence and blood profiles.

Key words: Feeding frequency, Growth performance, Weaning pigs

In swine production, weaning of piglets causes nutritional, social and environmental changes to them. These changes such as alteration of diet from liquid to solid type, fights for hierarchy due to mixing of unfamiliar piglets (McGlone 1985) and isolation from sow have negative effects on piglets (Held *et al.* 2001). It leads to low feed intake, poor weight gain, diarrhea, some diseases or even death of piglets (Blecha *et al.* 1985). To alleviate these harmful effects, nutritional methods such as feed additives, creep feed and antibiotics has been applied. How to feed, also, could reduce the problems after weaning. The feed which is fed to weaning pig could spoil rapidly because environmental condition of nursery house is relatively warm and humid compared with other growth stages of barn. Schneider *et al.* (2011) suggested that feeding many times more than once a day could be helpful for maximum feed intake and growth for pigs. Similarly, Botermans *et al.* (2000) reported that greater amounts of digestible enzymes are secreted from the exocrine pancreas when pigs are fed many small meals than 1 large meal per day. The frequent intake of small amount of feed positively affects the digestibility of the feed (De Haer and De Vries 1993). Thus, the objective of this study was to evaluate the effect of feeding frequency on growth performance, nutrient digestibility, diarrhea incidence and blood profiles in weaning pigs.

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MATERIALS AND METHODS

Experimental animals, treatment and diet: Total 264 crossbred (Landrace × Yorkshire) weaning pigs (25±3 days of age, 7.6±1.1 kg of body weight) were assigned to one of two treatments with six replications (22 animals/pen) considering equal sex and body weight in a randomized complete block design. The control group (F_2: feeding twice a day) was provided experimental diet twice a day (at 0700 and 1900 h) and the treatment group (F_4: feeding four times a day) was provided four times a day (at 0700, 1100, 1500 and 1900 h) during 28 days after weaning. The experimental diet was formulated based on corn-soybean meal. All nutrients of experimental diets met or slightly exceeded the nutrient requirements as delineated by NRC (2012). The composition of experimental diet and the total amount of diet fed to pigs daily were same for both groups. Feed and water were provided *ad lib.* through a feeder and a nipple during the whole experimental period. The temperature of the nursery pig house was kept at 29°C during the first 7 days and was lowered 1°C every week. Experimental period consisted of two phases (phase 1 from d 0 to d 14, phase 2 from d 14 to d 28), and body weight (BW) and feed intake were recorded every week to calculate average daily gain (ADG), average daily feed intake (ADFI) and gain to feed ratio (G : F ratio). The chemical composition of

Table 1. Chemical composition (%) of experimental diets; as-fed basis

Item	Phase I (d0–d14)	Phase II (d14–d28)
Gross energy (kcal/kg)	4,018	3,979
Crude protein	19.20	18.90
Total lysine	1.34	1.31
Methionine	0.49	0.47
Calcium	0.97	0.88
Total phosphorus	0.68	0.60

experimental diets is presented in Table 1.

Apparent total tract digestibility: For 5 days, from d 8 to d 12, all pigs were fed experimental diet containing 0.5% of chromium oxide. Feces were collected during 2 days (from d 13 to d 14) from the all pen and collected samples were stored at –20°C before chemical analysis. Digestibility of dry matter (DM) is calculated according to Kong and Adeola (2014).

Blood sampling and analysis: Twelve pigs were bled in BD vacutainer through anterior vena cava to analyze cortisol, leptin and ghrelin at the ends of phases. The concentration of cortisol was analyzed using an analyzer (E modular 170, Roche, USA). Leptin and ghrelin were analyzed based on RIA (Radioimmunoassay) using 2 analyzers (Cobra 5010 Series, Packard, USA) and (Cobra 5010 Quantum, Packard, USA), respectively.

Diarrhea incidence: Diarrhea incidence was measured at 07:30 h during the whole experimental period. Four pigs close to average BW of each pen were selected to record diarrhea incidence. Score of diarrhea incidence ranged from 0 to 4 (0, no pig showed diarrhea; 1, 1 pig; 2, 2 pigs; 3, 3 pigs and 4, 4 pigs showed diarrhea in each pen). After recording diarrhea incidence data, stain of diarrhea in butt of pigs was cleaned away.

Chemical analysis: Diets and feces were ground finely through 1 mm screen (Cyclotec 1093; Foss Tecator AB, Hoganas, Sweden) and analyzed. Diet samples were analyzed for gross energy using bomb calorimetry (Model C2000, IKA®, Germany). All samples were analyzed for dry matter (DM), crude protein (CP), ether extract (crude fat), lysine and methionine, calcium (Ca), phosphorus (P) and chromium (Cr) as described by AOAC (2005).

Statistical analysis: The experimental data were analyzed using the PROC MIXED of SAS package program (SAS Inst. Inc., Cary, NC, USA). The model included feeding frequency as a fixed variable and block as a random variable. Least squares means for each response variable were calculated and the experimental unit was the pen. Statistical differences were accepted at $P<0.05$.

RESULTS AND DISCUSSION

Growth performance and nutrient digestibility: There was no significant difference depending on feeding frequency in BW, ADG, ADFI and G:F ratio during the whole experimental period (Table 2). It is known that feeding frequency is one of the crucial factors to affect body weight gain in animals (Chaix *et al.* 2014, Le Naou *et al.* 2014, Liu *et al.* 2017). Rogers *et al.* (1960) suggested that feeding pigs at 3 h interval was reasonable for constant flow of digesta and absorption because approximately half amount of the feed ingested passed through the stomach in 3 h. In the present study, feeding interval of F4 treatment was established by 4 h considering previous research and experimental manager's labor. In accordance with our results, Batterham *et al.* (1974) reported that feeding frequency did not affect growth performance of growing pigs when compared to feeding once a day with six times a day. Similarly, there was no difference in amount and composition of digesta in the small intestines regardless of feeding frequency (Braude *et al.* 1970). On the contrary, Persson *et al.* (2008) found that fattening pigs fed 9 times showed lower body weight gain compared with feeding 3 times per day. Basically, BW and gastrointestinal track size of weaning pigs are much less than those of growing-finishing pigs. Many digestive enzymes, also, are not secreted and do not work well enough for a while after

Table 2. Effect of feeding frequency on growth performance in weaning*

Item	Feeding frequency		SEM[2]	P value
	F2 (2 times/d)	F4 (4 times/d)		
Body weight (kg)				
d 0	7.9	7.6	0.72	0.936
d 7	9.5	9.9	1.28	0.448
d 14	12.6	12.8	1.82	0.683
d 21	15.9	16.5	2.03	0.413
d 28	19.3	19.7	1.96	0.583
Average daily gain (g/d)				
d 0 to 7	277	321	85.0	0.182
d 7 to 14	440	422	80.3	0.712
d 14 to 21	467	528	45.0	0.208
d 21 to 28	495	464	31.5	0.504
d 0 to 14	358	371	80.7	0.651
d 14 to 28	481	496	16.0	0.485
d 0 to 28	420	434	45.7	0.542
Average daily feed intake (g/d)				
d 0 to 7	366	370	35.3	0.826
d 7 to 14	623	613	35.3	0.343
d 14 to 21	923	923	40.0	0.957
d 21 to 28	1,033	1,027	45.5	0.574
d 0 to 14	494	491	35.1	0.858
d 14 to 28	978	974	42.7	0.725
d 0 to 28	736	733	38.8	0.829
Gain:feed ratio				
d 0 to 7	0.73	0.85	0.185	0.286
d 7 to 14	0.70	0.68	0.095	0.861
d 14 to 21	0.51	0.57	0.041	0.187
d 21 to 28	0.48	0.46	0.040	0.672
d 0 to 14	0.71	0.75	0.123	0.628
d 14 to 28	0.49	0.51	0.020	0.393
d 0 to 28	0.57	0.59	0.039	0.499

*Least squares means for 6 pens/treatment with 22 pigs/pen. SEM, Standard error of the mean.

weaning. Given that growth performance data from this experiment, environmental conditions and nutritional composition of feed play much important role in growth of weaning pigs rather than feeding frequency. Body weight gain of pigs are affected by regulating the storage and partition of energy not modulating the digestibility and absorption of nutrients (Chastanet *et al.* 2007, Schneider *et al.* 2011). Similar with previous researches, digestibility of gross energy, dry matter, crude protein and ether extract was not affected by feeding frequency and did not affect growth performance (Table 3).

Blood profiles: Feeding frequency had no effect on serum concentration of cortisol, leptin and ghrelin in weaning pigs (Table 4). Cortisol is in the glucocorticoid class of hormones, which relates to stress. Generally, the higher serum cortisol level represents more stressful condition for animals (Rashkova *et al.* 2012), however, according to Salfen *et al.* (2004), increase of cortisol concentration may not reflect an increase in feeding behaviour. In our study, cortisol concentrations did not show any difference in both groups. Leptin, produced by white adipose tissue, and ghrelin, produced in the stomach and intestines, work antagonistically to each other. In other words, leptin decreased feed intake thereby affecting appetite in animals (Zhang *et al.* 2007) and ghrelin induced feed intake behaviour (Korbonits *et al.* 2004). These two hormones are modulated by neuropeptide Y (NPY) signaling in the hypothalamus (Bagnasco *et al.* 2002). In previous studies, fasting increased plasma ghrelin levels in rats (Bagnasco *et al.* 2002) and the concentrations of plasma ghrelin decreased after feeding in human. Those responses were regulated through vagal mediation and ghrelin affected the endocrine pancreas. Salfen *et al.* (2004) reported that weaning stress may be a factor for low ghrelin serum concentrations affecting poor body weight gain. There was, however, no statistical difference in ghrelin concentration for both groups. It is well documented that leptin modulated appetite and attenuated BW through regulation of feed intake. Weaning pigs have very little fat stores and therefore secrete very little leptin (Salfen *et al.* 2004). In our study, likewise serum ghrelin, no difference was observed in serum leptin concentration.

Diarrhea incidence: There was no difference in diarrhea incidence depending on feeding frequency in weaning pigs (Table 5). Generally, piglets suffered from diarrhea after weaning due to sudden change of environment, transportation and nutritional stress. The optimal feeding timing of creep feed for suckling pigs has been one of the most debated feeding strategies. Pluske *et al.* (1997) suggested that the immunopathological damage to the small intestine would vary depending on the total amount of creep feed intake before weaning. In other words, a low intake of creep feed before weaning predisposed piglets whereas a high intake of creep feed developed immune tolerance of piglets to diarrhea. In this experiment, few piglets showed diarrhea during the whole experimental period. That is because they were fed creep feed adequately before weaning based on the farm's management system. Therefore, feeding frequency may not affect the occurrence of diarrhea.

The change of feeding frequency in weaning pigs did not affect the growth performance, nutrient digestibility, diarrhea incidence and blood profiles in this experiment.

Table 3. Effect of feeding frequency on nutrient digestibility in weaning pigs*

Item	Feeding frequency		SEM	P value
	F2 (2 times/d)	F4 (4 times/d)		
Gross energy	85.2	84.5	1.12	0.420
Dry matter	84.4	86.2	2.46	0.374
Crude protein	82.8	83.2	1.03	0.611
Ether extract	76.8	76.3	1.61	0.665

*Equal amount of fecal samples were taken from every pen. SEM, Standard error of the mean.

Table 4. Effect of feeding frequency on blood profiles in weaning pigs*

Item	Feeding frequency		SEM	P value
	F2 (2 times/d)	F4 (4 times/d)		
Cortisol (μg/dL)				
d 14	1.71	2.19	0.185	0.245
d 28	1.82	1.85	0.092	0.921
Leptin (ng/mL)				
d 14	362	329	0.430	0.454
d 28	467	468	0.290	0.932
Ghrelin (pg/mL)				
d 14	1.28	1.14	0.041	0.175
d 28	1.18	1.39	0.039	0.653

*Blood samples were taken from 12 weaning pigs per treatment. SEM, Standard error of the mean.

Table 5. Effect of feeding frequency on diarrhea incidence in weaning pigs*

Item	Feeding frequency		SEM	P value
	F2 (2 times/d)	F4 (4 times/d)		
1 week	0.12	0.00	0.084	0.352
2 week	0.12	0.07	0.098	0.757
3 week	0	0	–	–
4 week	0	0	–	–

*Diarrhea incidence scores were taken from 24 weaning pigs per treatment. SEM, Standard error of the mean. [3]Diarrhea incidence: 0 (no occurrence) to 4 (diarrhea on 4 pigs).

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