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CREEP FEED: EFFECTS OF FEED FREQUENCY ON PRE-WEANING AND POST-WEANING PERFORMANCE AND BEHAVIOR OF PIGLET AND SOW

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This study was conducted to evaluate the effects of creep feed frequency on pre- and post-weaning performance and behavior of piglet and sows. A total of 30 sows (Landrace × Yorkshire) and their litters were employed in this study. Sows were randomly assigned with 1, 2 or 3 + parities into 1 of 3 treatments. Dietary treatments included: 1) CON, creep feeding 3 times daily; 2) TRT1, creep feeding 4 times daily; 3) TRT2, creep feeding 5 times daily. The behavior of sows (nursery, eating and standing) and piglets (eating, sleeping and fighting) in each treatment was observed throughout experiment. Each piglet was weighted on 0, 21 day (weaning) and 7 d after weaning to evaluate average daily gain (ADG). Sows and piglet were bled on the weaning day to evaluate the blood characteristics. Back fat and estrus interval were investigated to evaluate the effect of dietary frequency on the sows. In this study, varying creep feed frequency did not affect the pre-weaning and post-weaning piglet growth performance ($P > 0.05$) in the present study. Pig with different frequency did not affect ($P > 0.05$) the IgG, epinephrine, norepinephrine and cortisol concentration ($P < 0.05$), as well as the post-weaning diarrhea scores and behaviors in the current study. Moreover, creep feeding frequency did not affect ($P > 0.05$) the weaning-to-estrus interval and backfat loss of sows. Varying dietary frequency did not affect the cortisol, epinephrine and norepinephrine in sows. No differences ($P > 0.05$) in eating, or standing times, nor backfat loss during lactation were noted in the current study. In conclusion, varying creep feeding frequency did not affect the performance and behavior of piglet and sow in this study.

Key words: Behavior, creep feed, piglet, sow

As demonstrated elsewhere, lactating sows need to produce at least 18 kg of milk per day to meet the energy requirements of a 10-pig litter at 21 d, which is greater than the typical production of 10 to 12 kg of milk produced in modern sows (Boyd et al., 1995). Therefore, creep feeding may help supplement the deficiencies in sow milk supply and composition to positively influence pre-weaning growth. It is well suggested that creep feeding begins largely as an exploratory or social activity (Pajor et al., 1991). Mavromichalis, (2006) had suggested higher creep feeding frequency with small amount can stimulate intake and manage feed wastage in pigs. Hessel et al. (2006) also reported increased feed frequency evidenced more antagonistic behavior, greater scores for skin lesions, higher rooting and belly-nosing behaviors compared with the low feed frequency group. Therefore, we hypothesized increased feed frequency could be a factor to increase the exploratory or social activity of piglet during lactation. Moreover, Van Putten, (1978) have suggested that increasing feed frequency could induce in opportunities to satisfy chewing and biting needs and results in higher exploratory and social activity. Botermans et al. (2000) demonstrated that higher frequency trigger a greater output of enzymes from the exocrine pancreas. De Haer and Merks (1993) also suggested that repeated intake of small portions of feed positively influenced the digestibility of the feed. Therefore, we hypothesized creep feeding frequency could be a factor affecting the performance of piglet during lactation.

The behavior and reproductive performance of sows is known to be influenced by the metabolic state of the sow and the suckling stimulus of the piglets (Foxcroft, 1992). Several studies also documented that a

variety of factors could influence the behavior, including environmental quality, food quality, and piglet behavior in some species (Berger, 1979; Hauser and Fairbanks, 1988). Our previous studies also suggested that those blood characteristics of sows could be affected by the varying creep feeding duration, varying energy density and flavor supplementation in creep feed (Yan et al., 2010a, b, c), since creep feed may cause piglets to consume more solid food and hence vocalize less when nursing frequency declines, which weakens the sow's responses to such vocalizes (Pajor et al., 2002; Weary et al., 1996). Therefore, the effects of creep feed on sows' performance were investigated in this study, in consideration of its results on piglet behavior and nursing-associated vocalization.

Collectively, the objectives of this study were 1) to determine the effects of creep feeding frequency on the pre- and post-weaning growth performance and behavior of piglets and 2) to determine differences in creep feeding frequency on performance and behavior of sows.

MATERIALS AND METHODS

The experimental protocols employed in this study were approved by the Animal Care and Use Committee of Dankook University.

Animals and Housing

A total of 30 sows (Landrace × Yorkshire) and their litters were used in this study. Sows were assigned randomly to 1 of 3 creep feeding groups, with parities of 1, 2, or 3+. At day 107 of gestation, the sows were relocated to farrowing crates in an environmentally regulated farrowing house, and assigned to 1 of 4 dietary treatment groups. Dietary treatments were: 1,) creep feeding 3 times daily; 2,) creep feeding 4 times daily; 3,) creep feeding 5 times daily. The mean parity of the sows was 2.6 ± 0.4. Sows were fed on a commercial lactation feed (Table 1), divided into 2 daily meals. Diets composition of creep feed was present in Table 2. Water was provided on an *ad libitum* basis. The sows and their offspring were individually housed in farrowing crates (2.4 × 1.8 m), which were constructed of 1.95 m^2 of solid floor and 2.37 m^2 of slatted floor. This space included a piglet nest equipped with an infrared lamp (500 W), a piglet drinking nipple, and a piglet feeder placed on a dimpled rubber matting to collect any spillage from the feed. The temperature in the farrowing house was maintained at a minimum of 20 °C. Drinking nipples provided water *ad libitum* to the piglets.

Table 1. Sow diet composition (as-fed basis)

Items	Gestation diet	Lactation diet
Ingredients, %		
Corn	57.10	51.12
Soybean meal, 46% CP	10.65	24.61
Wheat bran	12.00	4.00
Rapeseed meal	3.70	2.50
Rice bran	6.00	5.00
Tallow	3.59	6.05
Molasses	3.60	3.50
Dicalcium phosphate	1.52	1.64
Limestone	0.99	0.76
Salt	0.60	0.50
Lys, 98%	0.05	0.12
Vitamin premix[1]	0.10	0.10
Mineral premix[2]	0.10	0.10
Calculated composition		
ME, MJ/kg	3.19	3.44
CP, %	13.10	17.10
Crude fat, %	6.89	9.10
Lys, %	0.65	1.00
Ca, %	0.87	0.85
P, %	0.76	0.73

[1]Provided per kilogram of complete diet: vitamin A, 10,000 IU; vitamin D_3, 2,000 IU; vitamin E, 48 IU; vitamin K_3, 1.5 mg; riboflavin, 6 mg; niacin, 40 mg; d-pantothenic, 17 mg; biotin, 0.2 mg; folic acid, 2 mg; choline, 166 mg; vitamin B_6, 2 mg; and vitamin B_{12}, 28 µg.

[2]Provided per kilogram of complete diet: Fe (as $FeSO_4 \cdot 7H_2O$), 90 mg; Cu (as $CuSO_4 \cdot 5H_2O$), 15 mg; Zn (as $ZnSO_4$), 50 mg; Mn (as MnO_2), 54 mg; I (as KI), 0.99 mg; and Se (as $Na_2SeO_3 \cdot 5H_2O$), 0.25 mg.

Litter size at birth varied from 7 to 14 piglets, and was standardized to 10 piglets (6 male and 4 female) per litter within 2 day after birth by cross-fostering within each batch. All piglets received injections of 1 mL of iron dextran and the males were castrated 2 day after birth. At weaning, the

sows were relocated to a mating room, with the piglets remaining in the pen for one week (weanling pigs).

Table 2. Piglet diet composition (as-fed basis)

Items	
Ingredients, %	
Digestible corn	22.40
Soybean meal	8.00
Soy oil	4.50
Whey	24.16
Fish meal	2.50
Fermented soybean meal	10.00
Coconut oil	4.17
Lactose	8.00
Plasma powder	4.00
Sugar	3.05
Isolated soybean protein	6.15
Dicalcium phosphate	1.25
DL-Methionine	0.38
L-Lysing·HCl	0.41
Threonine, 98%	0.13
Zinc oxide	0.30
Choline Cl, 50%	0.10
Vitamin premix[1]	0.10
Mineral premix[2]	0.18
Probiotics	0.12
Antibiotics, 9.75%	0.10
Analysis composition, %	
DE, kcal/kg	4,000
CP	22.00
Lys	1.74
Met	0.70
Ca	0.81
P	1.00

[1]Provided per kilogram of complete diet: vitamin A, 1,298 IU; vitamin D_3, 260 IU; vitamin E, 2.4 IU; menadione (sodium bisulfate form), 143 µg; vitamin B_{12}, 3.3 µg; riboflavin, 880 µg; d-pantothenic acid, 2.6 mg; niacin, 4.4 mg.
[2]Provided per kilogram of complete diet: Ca, 849 mg; Zn, 150 mg; Fe, 132mg; Mn, 20 mg; Cu, 12 mg; Se, 0.31 mg; I, 0.79 mg.

Measurements

Individual piglet BW was assessed on day 0, 21(weaning), and 7 day after weaning to calculate the average daily gain (ADG). Creep feed residuals and general health was checked daily. The backfat thickness of the sows (6 cm off the midline at the 10th rib) was measured within a few hours after farrowing and on the day of weaning (21 day) using a real-time ultrasound instrument (Piglot 105, SFK Technology, Herlev, Denmark). The incidence of diarrhea in piglets was observed and recorded 3 times per day throughout the study. In order to assess the severity of diarrhea, feces from each pig were scored by determining the moisture content according to the method described by Hart and Dobb (1988). In brief, the scores were as follows: 0, normal, firm feces; 1, possible slight diarrhea; 2, definitely unformed, moderately fluid feces; or 3, very watery and frothy diarrhea. A cumulative diarrhea score per diet and day was then assessed (Montagne et al., 2004).

To assess blood characteristics, the sows were bled via puncture of the vena cava at weaning (21 day) to determine the concentrations of epinephrine, norepinephrine, and cortisol. Two piglets from each offspring were selected randomly and bled via jugular venipuncture at weaning. Blood samples were collected into non-heparinized tubes (Becton Dickinson Vacutainer Systems, Franklin Lakes, NJ, USA) to obtain serum, which was separated via 30 min of centrifugation at 4,000 × *g* at 4 °C, the aliquot was stored at - 4 °C. IgG concentration were subsequently determined using an automatic biochemistry blood analyzer (HITACHI 747, Hitachi, Tokyo, Japan). The serum were removed and stored at - 20 °C until being used in cortisol analysis. Serum concentrations of cortisol were determined with a standardized solid phase radioimmunoassay kit (Diagnostic Products Corporation, Los Angeles, CA). Norepinephrine (NE) and epinephrine (EPI) were assayed using an ion-exchange purification procedure followed by liquid chromatography with electrochemical detection, as described previously by Hay and Mormède (1997). In brief, the samples were loaded onto cationic columns, and the catecholamines were eluted with boric acid. The eluates were assayed via HPLC with electrochemical detection with an oxidizing potential of + 0.65 V. The intra- and

interassay CV were 7.0% and 7.1% for NE and 6.5% and 11.6% for EPI, respectively

Detection of estrus was conducted twice per day from weaning onward, at 0830 and 1600 every day. A sow was considered to be in estrus when exhibiting a standing response induced by a back pressure test when in the presence of a boar. Activity in the farrowing crates was recorded by 24 h time-lapse video recording. The video camera was positioned to provide a view of the entire farrowing crate. Behavior was recorded from the commencement of partitioning to weaning. All behavior of the litter was continuously recorded to determine the time spent by piglets at the creep feeder, sleeping, and fighting during lactation. The time spent by sows on eating, lying and standing was also determined. Nursing was considered to have begun with the sow lying in the nursing posture with at least 80% of the litter in contact with the udder.

Statistical Analysis

All data in this experiment were analyzed in accordance with a completely randomized design using the GLM procedure (SAS Inst. Inc. Cary, NC). The individual sow or litter of piglets was used as the experimental unit. For the blood profile data, the initial data was used as a covariate. Differences among treatment means were determined via Duncan's multiple range test, and a probability level of $P < 0.05$ was regarded as statistically significant.

RESULTS AND DISCUSSION

Effect of Creep Feed Frequency in Piglet

In the current study, varying creep feeding frequency did not affect (P>0.05) the growth performance, blood characteristics and behaviors in piglet (Table 3 and Table 4). Previously, Pajor et al. (1991) had proposed that exploratory investigation and social activity might be the key factors in the initiation of creep feeding. Mavromichalis, (2006) demonstrated higher creep feeding frequency with small amount can stimulate intake and manage feed wastage in pigs. Hessel et al. (2006) also reported increased feed frequency evidenced more antagonistic behavior, greater scores for skin lesions, higher rooting and belly-nosing behaviors compared with the low feed frequency group. Therefore, we hypothesized that increased feed frequency could increase the exploratory or social activity of piglet, and subsequently increased the creed feed intake during lactation. Moreover, it is well demonstrated the ingestion of solid food during lactation can speed up the induction of amylase and protease enzymes (De Passille et al., 1989) and stimulate acid production (Cranwell et al., 1976), which increase the average daily gain and feed conversion values relative to non-creep-fed animals (Sohn and Maxwell, 1995). Van Putten, (1978) have suggested that increasing feed frequency could induce in opportunities to satisfy chewing and biting needs and results in higher exploratory and social activity. Botermans et al. (2000) demonstrated that higher frequency trigger a greater output of enzymes from the exocrine pancreas. Therefore, it is plausible that increasing pre-weaning creep feeding frequency can increase exploratory behavior and feed consumption in the current study. However, varying creep feeding frequency did not affect the growth performance and behavior throughout this study. The reason for this lack of significant difference is unknown in this study; it may have occurred due to the small sample number, because of the large variation among individual piglets or as a result of replication and other systematic experimental errors.

Effect of Creep Feeding Duration in Sow

In this study, creep feeding frequency did not affect (P>0.05) the sow's and productivity performance among treatments. Serum concentrations of epinephrine (EPI), norepinephrine (NE) and cortisol were also not affected (P>0.05) by the creep feeding frequency in the present study (Table 5). No difference was observed on the behavior in sow throughout the experiment (Table 6). Generally, it is well suggested that increased cortisol secretion and higher basal levels of NE and EPI is a valid indicator of stress in pigs (Becker et al., 1985; Smulders et al., 2006), because the social stress can activate the hypothalamic-pituitary-adrenal axis and

Table 3. Effects of creep feed frequency on piglet performance and blood characteristics

Items[1]	CON	TRT1	TRT2	SE[2]
Suckling pigs				
ADG, g	214	225	231	15.2
ADFI, g	15	16	15	2.3
Weaning pigs (0-7d)				
ADG, g	201	206	208	7.2
ADFI, g	210	214	219	6.3
G:F	0.957	0.962	0.949	0.0225
Diarrhea score[3]	1.7	1.9	1.8	0.03
Corisol, ug/dl	1.93	1.83	1.97	0.42
Epinephrine, pg/ml	282.3	277.7	290.4	18.24
Norepinephrine, pg/ml	886.2	870.0	868.2	36.15
IgG, mg/dl	427.9	452.6	472.6	32.82

[1] Abbreviation: CON, creep feeding 3 times; TRT2, creep feeding 4 times; TRT3, creep feeding 5 times.
[2]Pooled standard error.
[a,b,c]Within a row, means with different superscripts differ ($P < 0.05$).
[3]Diarrhea score: 0, normal, firm feces; 1, possible slight diarrhea; 2, definitely unformed, moderately fluid feces; or 3, very watery and frothy diarrhea; Data were measured by average total diarrhea score during 7 day post-weaning.

Table 4. Effects of creep feeding times on pre-weaning piglet behavior

Items[1], %	CON	TRT1	TRT2	TRT3
Suckling[3]	43.25	41.85	41.76	2.51
Sleeping[4]	42.15	41.34	39.81	2.18
Fighting[5]	17.28	18.86	19.43	1.56

[1] Abbreviation: CON, creep feeding 3 times; TRT2, creep feeding 4 times; TRT3, creep feeding 5 times.
[2]Pooled standard error.
[3]Suckling movements with a teat in the mouth or with the nose in contact with udder.
[4]Lying on the side or belly with closed eyes without performing any other described behavior.
[5]Fighting with others.

the sympathetic-adrenal-medullary axis, and subsequently induced an elevation of catecholamines in the peripheral blood (Axelrod and Reisine, 1984; Ehrhart-Bornstein and Borstein, 2008). Tsuma et al. (1995) also noted that suckling and weaning induced increases in the concentrations of peripheral plasma cortisol and endorphins. Our previous studies also suggested that those blood characteristics of sows could be affected by the varying creep feeding duration, varying energy density and flavor supplementation in creep feed (Yan et al., 2010a, b, c), since creep feed may cause piglets to consume more solid food and hence vocalize less when nursing frequency declines, which weakens the sow's responses to such vocalizes (Pajor et al., 2002; Weary et al., 1996). Moreover, Hessel

Table 5. Effect of creep feeding frequency on lactating sow performance

Items[1]	CON	TRT1	TRT2	TRT3
Estrus interval, day	5.36	5.22	5.28	0.236
Back fat, mm				
Lactation	23.5	22.8	22.9	0.69
Weaning,	19.6	19.4	19.1	0.73
Back fat loss	3.9	3.4	3.8	0.36
Epinephrine, pg/ml	37.15	34.58	35.39	1.78
Norepinephrine, pg/ml	202.8	191.2	188.4	12.28
Cortisol, mg/dl	6.72	6.28	6.47	0.52

[1] Abbreviation: CON, creep feeding 3 times; TRT2, creep feeding 4 times; TRT3, creep feeding 5 times.
[2]Pooled standard error.
[a,b] Within a row, means with different superscripts differ ($P < 0.05$).

Table 6. Effect of creep feed flavor supplementation on lactating sow behavior

Items[1], %	CON	TRT1	TRT2	SE[2]
Eating diet[4]	18.6	19.4	18.4	2.09
Lying	76.8	73.5	72.8	2.51
Standing[5]	23.8	25.8	24.6	2.11

[1] Abbreviation: CON, creep feeding 3 times; TRT2, creep feeding 4 times; TRT3, creep feeding 5 times.
[2]Pooled standard error.
[3]Suckling movements with a teat in the mouth or with the nose in contact with udder.
[4]Eating from the food trough or chewing food.
[5]Standing from the floor with 4 feet.

et al. (2006) also reported increased feed frequency evidenced more antagonistic behavior, greater scores for skin lesions, higher rooting and belly-nosing behaviors. However, it should be noted that the behavior of the sow and piglets were not affected by varying creep feed frequency. Therefore, we hypothesized that the lack of effect in those blood characteristics may be attributed to the absent effect on the behavior and other characteristics investigated in the present study. However, to the best of our knowledge, studies concerning the effects of creep feeding on sow performance are somewhat limited. There are no available studies with results that would allow for a clear comparison to the results of this study; therefore, further study will clearly be required to determine with more accuracy the effects of piglet stimulation on sows.

CONCLUSION

In conclusion, varying creep feeding frequency did not affect the performance and behavior of piglet and sow in this study.

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