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ANIMAL

Effects of extra-feed intake during late gestation on reproductive performance of sow and piglet performance during weaning stage

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Abstract

This study explored the effect of increased feed intake during the late gestation on the reproductive performance of sows, and fecal score in sows and piglets. A total of 21 crossbred [Landrace × Yorkshire] multiparous sows were randomly distributed into three treatments with seven replicates per treatment. Treatments: CON, 2.4 kg/day; TRT1, 3.2 kg/day; TRT2 , 3.6 kg/day. Body weight and body condition score of sow in different stages were not altered ($p > 0.05$) due to extra feed in late gestation. A linearly higher ($p < 0.05$) difference in backfat thickness during farrowing was found in this study. Average daily feed intake was increased ($p < 0.05$) linearly with extra feed in this experiment. The weaning body weight of piglets was increased ($p < 0.05$) with extra feed in the sow. The fecal score of sows and their piglets was similar ($p > 0.05$) in different levels of feed intake. In conclusion, extra feed to gestation sow showed a beneficial effect on improving the weaning piglet's body weight. Although there is a small improvement in the body weight of weaning pigs of sow fed 3.6 kg feed/day in the late gestation period, it is unlikely to be profitable enough to justify the additional waste of feed.

Keywords: bump feeding, extra feed, fecal score, gestation sow, late gestation feed

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Introduction

Over the years, a litter size in pigs has increased as a result of intensive genetic improvement. There is a positive correlation between variation in piglet birth weight within a litter and preweaning mortality (Peltoniemi et al., 2021). Piglets with lower birth weights within a litter generally showed high mortality before weaning. The piglets with low birth weights not only have a higher risk of mortality, but they also face challenges in terms of growth and profitability. These piglets might struggle to compete with their littermates for feed. This could result in slower growth and a smaller size compared to their heavier counterparts. Collectively, these challenges can be attributed to an inadequate intake of colostrum (Mallmann et al., 2019). They require more time to reach target market body weights, and ultimately generate less profit (Camp Montoro et al., 2020).

Generally, the feed given to pregnant sows during the early gestation period is used to improve their body condition scores, especially for those sows that have lost body reserves from their previous pregnancy. Meanwhile, in the late gestation phase, this feed primarily supports fetal growth (NRC, 2012). For these reasons, proper feeding management during gestation is crucial for the production of healthy piglets as well as the maintenance of sow health and production performance. In the first two-thirds of gestation, a nutrient requirement for fetal growth and development is very low, but it increases aggressively in the last one-third of the gestation period. There are some techniques to improve the piglet's birth weight such as supplementing additional L-arginine and L-carnitine in the early gestation period (Seoane et al., 2020), supplementing additional lysine in diet in the late gestation period (Mallmann et al., 2019), and extra feed which is called "Bump feeding" (de Oliveira Araújo et al., 2020). Bump feeding is the increase of feed supply at the last stage of the gestation period focuses on the increase of fetal growth rate, milk production, higher piglets birth weights, and ultimately successive birth weight. For the above reasons, bump feeding is of great interest to researchers. Shelton et al. (2009) stated that the extra feed in the last stage of gestation in gilt increases the birth weight, however, this was not evident in sow litters. Gonçalves et al. (2016a) found increased birth weight in sow when they were fed with increased energy. Despite the reduction in birth weight associated with large litter sizes, only a few nutritional solutions have been found to solve this issue (Goodband et al., 2013). Additionally, some of the recent research has shown that increasing the amount of feed given in the early or middle stages of gestation does not affect the weight of piglets at birth (Gonçalves et al., 2016b). This study aimed to find out how the amount of feed given to pigs in the last gestation affects the weight of their piglets at birth and the sow's reproductive health. The hypothesis was that increasing feed consumption in the last stages of gestation would have a beneficial effect on piglet birth weight.

Material and Methods

The experimental protocol (DK-2-2209) for this study got the consent from Animal Care and Use Committee of Dankook University, Cheonan, Republic of Korea. Furthermore, the research that involved animals adhered to the guidelines established by the Canadian Council on Animal Care and the Guide for the Care and Use of Laboratory Animals.

Experimental design, animals, housing, and diets

A total of 21 multiparous crossbred (Landrace × Yorkshire) sows, (average parity of 3.2 ± 0.89) were randomly assigned to one of three distinct treatments, each with seven repetitions. Dietary treatments are: CON, 2.4 kg/day; TRT1, 3.2 kg/day; TRT2, 3.6 kg/day. This feeding plan was followed during the day 90 of the gestation until farrowing. Half of the daily allotted diet is given in the morning, and the other half is given 12 h later. The National Research Council's (NRC, 2012) recommendations for sows diets were followed throughout the feeding gestation and lactation period (Table 1 and 2). Sows were moved to the farrowing room on day 107 of gestation. In farrowing room sows were kept in individual farrowing crates (2.10 m × 1.80 m) each with a feed dish and water nipple. On the day of parturition, no feed was offered to the sows. A minimum temperature of 20℃ was maintained at all times in the farrowing house. Piglets were supplemented with additional heat using heat lamps. In order to ensure continuous milk production for the piglets, lactation feed was provided from day 1 of farrowing, and the feed allowance was progressively raised until day 4. Then, sows were fed 8 kg of feed until weaning.

The sows were fed 3.6 kg of feed daily after weaning until ovulation. To determine the average daily feed intake throughout the gestation, lactation, and ovulation periods, the remained feed was recorded daily. Within 24 h of birth, every piglet got a 1 mL iron injection and tail docking. In the first five days following birth, male piglets were castrated. Piglets and sows both

Table 1. Composition of gestation diets (as-fed basis).

Item	g/kg
Ingredients	
Maize	577.5
Soybean meal	100.0
Wheat bran	110.0
Rice bran	60.0
Rapeseed meal	47.0
Tallow	35.9
Molasses	36.0
Dicalcium phosphate	15.2
Limestone	9.9
NaCl	6.0
L-lysine-HCl (780 g/kg)	0.5
Vitamin premix[y]	1.0
Trace mineral premix[z]	1.0
Calculated value	
Dry matter	887.2
Metabolizable energy (MJ/kg)	13.05
Crude protein	132.2
Crude fat	70.1
Lysine	6.7
Calcium	8.5
Total phosphorus	7.6

[y] Provided per kilogram of complete diet: vitamin A, 12,100 IU; vitamin D3, 2,000 IU; vitamin E, 48 IU; vitamin K3, 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 B6, 2 mg; vitamin B12, 28 µg.
[z] Provided per kilogram of complete diet: 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; Se (as$Na_2SeO3 \cdot 5H_2O$), 0.25 mg.

Table 2. Composition of lactation diets (as-fed basis).

Item	g/kg
Ingredients	
Maize, ground	510.0
Soybean meal	267.3
Wheat bran	10.0
Rice bran	50.0
Rapeseed meal	35.0
Tallow	60.5
Molasses	35.0
Dicalcium phosphate	16.4
Limestone	7.6
NaCl	5.0
L-lysine-HCl (780 g/kg)	1.2
Vitamin premix[y]	1.0
Trace mineral premix[z]	1.0
Calculated value	
Dry matter	888.7
Metabolizable energy (MJ/kg)	14.47
Crude protein	183.4
Crude fat	91.6
Lysine	10.8
Calcium	10.6
Total phosphorus	7.3

[y] Provided per kilogram of complete diet: vitamin A, 12,100 IU; vitamin D3, 2,000 IU; vitamin E, 48 IU; vitamin K3, 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 B6, 2 mg; vitamin B12, 28 µg.
[z] Provided per kilogram of complete diet: 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; Se (as$Na_2SeO_3 \cdot 5H_2O$), 0.25 mg.

had full access to water, but during lactation, piglets were solely dependent on sow milk as they did not get creep feed.

Sampling and analysis

Body weight, body condition score, and backfat thickness (real-time ultrasound equipment, Pig Lot 105, SFK Technology, Denmark) of each sow were measured at the beginning of the feeding trial, after farrowing, at weaning, and on the day of ovulation. Following farrowing, the total number of piglets born, live piglets born, mummified fetuses, survival rate, birth weight of piglets, and weaning were recorded. The body weight of each piglet was recorded at birth and after 21 days of lactation (weaning). After weaning, sows were moved to enclosures that were close to adult boars and had direct exposure to it twice a day (at 08:00 and 16:00) for the purpose of detecting estrus. Estrus cycle of each sow was recorded. When a sow had a standing reaction in response to a back-pressure test, it was considered that a boar was nearby and that she was in estrus.

Fresh fecal samples from all sows were collected by rectal massage during day 90 of the gestation period and during lactation and between the weaning-ovulation period. The fecal score of suckling piglets was recorded daily and calculated in weekly basis. The incidence of constipation was determined by using a 5-grade score system (Sureshkumar and Kim, 2021), with grade 1 standing for hard, dry pellets in a small, hard mass, grade 2 indicating hard-formed stool that remains firm and soft, grade 3 for soft formed and moist stool that retains its shape, grade 4 for soft unformed stool that assumes the shape of the container, and grade 5 for watery liquid stool that can be poured.

Statistical analysis

In this experiment, individual sow was considered as the experimental unit. All of the collected data were statistically analyzed by a randomized totally block design applying SAS Institute Inc.'s General Linear Model method (SAS version 9.4, SAS Institute, USA). Differences among the means for treatments were determined by using Duncan's multiple-range test. Variability in the data was expressed as the standard error of means (SEM), and a probability level of $p < 0.05$ was considered significant and $p < 0.10$ was considered as trend.

Results

The effect of different feed amount in the late gestation sow on the reproductive performance is shown in Table 3. Gestation sows fed different amounts of feed did not show any significant difference ($p > 0.05$) in body weight difference in the experiment. Backfat thickness difference between starting of the experiment and after farrowing increased linearly ($p < 0.05$) in this experiment. However, backfat thickness differences in other stages were not altered significantly. Moreover, body condition score in sow during the different stage was not altered because of extra feed in late gestation sows. Linearly higher ($p < 0.05$) feed intake was found in the last early gestation as the sows were provided extra feed. However, in the other two stage feed intake was no significantly effect.

The effect of different amounts of feed intake in late gestation sow on the litter performance is shown in Table 4. Survival rates in different treatment groups did not show any significant difference. However, the body weight of weaning pigs increased linearly ($p < 0.05$) with the extra feed in their respective sows.

Table 3. The effect of extra feed to late gestation on reproduction performance in sow.

Item	CON	TRT1	TRT2	SEM	p-value	
					Linear	Quadratic
Parity	3.2	3.1	3.3	0.4	0.823	0.852
Body weight (kg)						
Initial	220.4	222.2	229.3	4.7	0.512	0.817
Farrowing	196.7	197.6	203.8	4.0	0.592	0.811
Weaning	188.5	190.2	196.1	3.9	0.58	0.854
Ovulation	192.7	193.4	199.8	4.0	0.597	0.800
Body weight difference 1[y]	23.7	24.6	25.5	1.4	0.360	0.989
Body weight difference 2[y]	8.2	7.4	7.8	0.5	0.581	0.373
Body weight difference 3[y]	4.2	3.2	3.8	0.4	0.395	0.098
Backfat thickness (mm)						
Initial	20.0	20.7	21.3	0.7	0.163	0.924
Farrowing	18.2	18.4	18.9	0.6	0.401	0.903
Weaning	15.7	15.9	16.3	0.8	0.506	0.878
Ovulation	16.5	17.0	17.3	0.6	0.324	0.871
Backfat thickness difference 1[z]	1.8b	2.3ab	2.4a	0.2	0.040	0.504
Backfat thickness difference 2[z]	2.5	2.6	2.6	0.4	0.874	0.925
Backfat thickness difference 3[z]	0.8	1.1	1.0	0.2	0.611	0.416
Body condition score						
Initial	3.4	3.5	3.7	0.2	0.229	0.749
Farrowing	3.2	3.3	3.4	0.1	0.312	0.955
Weaning	3.0	2.7	2.9	0.2	0.615	0.375
Ovulation	3.6	3.3	3.2	0.2	0.192	0.628
Litter size						
Total birth (head)	12.70	12.40	12.70	0.7	0.962	0.759
Total alive (head)	12.30	12.10	12.30	0.8	0.964	0.851
Stillbirth (head)	0.00	0.14	0.00	0.0	0.725	0.304
Mummification (head)	0.33	0.14	0.43	0.7	1.000	0.190
SUR1 (%)	97.53	97.62	96.36	1.9	0.627	0.739
ADFI (kg)						
Initial	2.63c	2.98b	3.35a	0.01	0.001	0.435
Farrowing	6.57	6.59	6.53	0.04	0.499	0.454
Ovulation	3.60	3.60	3.60	0.01	0.865	0.865
Estrus interval	3.80	4.10	4.30	0.40	0.400	0.852

CON, 2.80 kg feed/day; TRT1, 3.20 kg feed/day; TRT2, 3.6 kg feed/day; SEM, standard error of means; SUR1, survival rate of number of live pig per number of total born pigs; ADFI, average daily feed intake.

[y] Body weight difference: 1, initial to farrowing; 2, farrowing to weaning; 3, weaning to ovulation.

[z] Backfat thickness difference: 1, initial to farrowing; 2, farrowing to weaning; 3, weaning to ovulation.

a - c: Means in the same row with different letter differ significantly ($p < 0.05$).

Table 4. The effect of extra feed to late gestation sow on performance in suckling piglets.

Item	CON	TRT1	TRT2	SEM	p-value	
					Linear	Quadratic
INO	12.33	12.14	12.29	0.12	0.855	0.452
FNO	11.83	11.86	11.86	0.28	0.957	0.974
SUR2 (%)	95.94	97.62	96.52	2.03	0.842	0.573
Body weight (kg)						
Birth weight	1.50	1.54	1.57	0.03	0.157	0.979
Weaning	6.88b	6.95ab	7.21a	0.12	0.039	0.458
Average daily gain (g)						
Overall	257	258	269	6	0.151	0.511

CON, 2.80 kg feed/day; TRT1, 3.20 kg feed/day; TRT2, 3.6 kg feed/day; SEM, standard error of means; INO, the number of initial suckling piglet; FNO, the number of finish suckling piglet; SUR2, survival rate during lactation.
a, b: Means in the same row with different letter differ significantly ($p < 0.05$).

Table 5. The effect of extra feed to late gestation on fecal score in sow.

Item	CON	TRT1	TRT2	SEM	p-value	
					Linear	Quadratic
Fecal score[z]						
Pregnancy	2.98	2.96	2.96	0.03	0.483	0.616
Lactating	2.86	2.83	2.83	0.05	0.762	0.994
Ovulation	3.39	3.33	3.30	0.04	0.150	0.819

CON, 2.80 kg feed/day; TRT1, 3.20 kg feed/day; TRT2, 3.6 kg feed/day; SEM, standard error of means.
[z] Fecal score = 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.

Table 6. The effect of extra feed to late gestation sow on fecal score in suckling piglet.

Item	CON	TRT1	TRT2	SEM	p-value	
					Linear	Quadratic
Fecal score[z]						
Week 1	3.81	3.81	3.79	0.04	0.791	0.878
Week 2	3.79	3.81	3.77	0.03	0.754	0.590
Week 3	3.70	3.72	3.80	0.03	0.108	0.595

CON, 2.80 kg feed/day; TRT1, 3.20 kg feed/day; TRT2, 3.6 kg feed/day; SEM, standard error of means.
[z] Fecal score = 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.

The effect of feed amount on fecal score in sow is presented in Table 5. No significant difference was found in fecal score through extra feed during late gestation period. Moreover, no significant difference was found in fecal score of piglets of the respective sows after supplying extra feed during late gestation period (Table 6).

Discussion

The nutrition of gestation sows plays a crucial role in reducing within-litter variation, particularly for highly prolific sows in modern commercial environments. The maintenance requirements for sows during their early gestation period are lower compared to later stage. Because in the last stage nutrient requirement significantly increases to support the growth of fetal tissue, mammary tissue, placenta, and fluids (NRC, 2012). Nevertheless, in this study the weight gains of sows were not affected by the extra feed (3.6 kg/day) in late gestation period. In a previous study de Oliveira Araújo et al. (2020) also found that supplementing increased feed (3.0 kg/day) to the gestating sows from day 81 has no effect on the sow body weight gain. On the other hand, Mallmann et al. (2019) showed that supplementing 3.3 kg/day during the late gestation period increased body weight gain at 112 days of gestation. Furthermore, the body weight gain of gestating sows (Gatlin et al., 2002), poultry (Hossain et al., 2023) can be increased through supplying energy-rich diet, or amino acid supplemented diet (Gonçalves et al., 2016a) to the gestating sows. However, the higher energy consumed in this experiment may be used for fatal development, as seen in the weaning weight of piglets. Backfat loss in sows was shown to increase linearly with increased feed consumption throughout the late gestation stage in this study. In line with our study, Mallmann et al. (2019) found that supplementing 3.3 kg/day during the late gestation period increased backfat thickness. Moreover, sows fed higher energy-rich diet during late gestation showed higher backfat loss (Laws et al., 2018). On the other hand, Cools et al. (2014) demonstrated that *ad libitum* feeding in the pregnant sow lost less body fat compared to the normal diet group. When sows are fed a diet high level of fat or carbohydrates, or higher feed intake, it provides them with surplus energy. This surplus energy, if not utilized for fetal development, maintenance, or milk production, can be stored as adipose tissue including backfat. That is why supplementing higher amounts of feed, specifically energy-rich diets, during late gestation can result in increased backfat thickness (Mallmann et al., 2019). Therefore, the higher sow backfat loss after farrowing in this study might have been due to increased nutritional energy intake throughout the late gestation stage.

In this study, extra feed consumption in the late gestation period did not affect body condition score of the sow in different stage. Cerisuelo et al. (2008) showed that 50% extra feed in the mid pregnancy period did not change the body condition of during farrowing period. Additionally, no variations in litter size or litter weight were identified between treatment groups in this study. However, Hoving et al. (2011) discovered that the 30% additional feed group had larger litter sizes than the control group. Nonetheless, no influence of giving additional feed during gestation on productive performance was reported in several experiments (Ren et al., 2018; Mallmann et al., 2019). The reproductive performance is often measured in terms of litter size and birth weight of piglets, it is influenced by a complex interplay of many factors, including genetics, health status, and diet (Koketsu et al., 2017; Vázquez-Gómez et al., 2020). While nutrition is an important factor, it seems that in our study, the additional feed did not significantly alter the energy balance to the point where it influenced the birth weight of piglets.

The body weight of piglets at birth and at weaning was not changed when gestating sows were supplied higher amount of feed (4.00 kg/day) from 50 days of gestation until parturition (Bee, 2004). Moreover, Nissen et al. (2003) noted that, piglet body weight at weaning was not changed through *ad libitum* feeding of pregnant sows from day 25 to 50 or day 25 to 70 of gestation. However in this study, extra feed amount to pregnant sows resulted in linearly higher body weight of piglets at the weaning stage compared to the control diet. Increased feed intake during this period can provide the necessary nutrients for mammary gland growth and differentiation (Farmer, 2018). Well-developed mammary glands have a higher capacity for milk production during lactation (Svennersten-Sjaunja and Olsson, 2005). As a result, the enhanced milk production might explain why the piglets in the extra-diet group were heavier than the piglets in the control group.

Fecal score is an indicator of the moisture content in pig feces. While there is limited research on the effect of extra feed on fecal score in gestating and lactating sows, this study showed that extra feed during the late-gestation sow had no impact on fecal score in gestating or lactating sows, or even in suckling piglets. During the transition from pregnancy to lactation, sows undergo various physiological changes and are often fed *ad libitum* to support milk production and limit the mobilization of body reserves (Dourmad et al., 1996). As sows approach farrowing, mild constipation is common due to decreased intestinal activity (Kamphues et al., 2000), and water absorption in the intestine increases to meet the fluid demands of milk production (Mroz et al., 1995). Previous studies have attempted to address these issues, but the results have been inconsistent. For example, one study found that lactating sows fed a high fiber diet had higher feed and water intake (Oliviero et al., 2009), while another found that sows fed *ad libitum* before farrowing drank more water than those fed restrictively (Tabeling et al., 2003). However, this study did not observe any instances of constipation or diarrhea, indicating that providing extra feed to sows has no negative effect on either the sow or their offspring.

Conclusion

Improving the feed amount to during the late gestation increased feed intake and backfat thickness difference between the period of the start of the experiment until farrowing. Additionally, providing extra feed to gestating sows resulted in higher weaning weights for their piglets. However, no change in fecal score was found in sow and weaning piglets throughout the experiment. In conclusion, while providing extra feed to gestating sows can result in a small improvement in the body weight of weaning pigs, the additional feed may not be justified by the potential increase in profitability.

Data availability statement

The supporting data of this study will be shared upon proper request to the corresponding author.

Conflict of Interests

No potential conflict of interest relevant to this article was reported.

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