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Effects of dietary energy levels on growth performance in lactating sows and piglets

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Abstract

Twenty-five sows and 265 piglets (Landrace × Yorkshire) were used to evaluate the effects of dietary energy level on the pre-weaning and post-weaning performance of piglets and first parity sows. Sows with an average initial B.W. of 217.54 ± 25.47 kg were randomly assigned to 2 treatments. The treatments consisted of a T1 diet containing 3,100 kcal, and the T2 diet contained 3400 kcal of metabolizable energy (ME)/kg, respectively. Data were analyzed using Duncan statements to test the effect of the dietary energy levels on growth performance in lactating sows and piglets. In this study, Dietary T2 sows had a greater number of weaned piglets per litter ($p < 0.05$). Dietary T2 had a higher ($p < 0.05$) body weight than that of T1 in the weanlings, meanwhile it had a higher total average daily gain ($p < 0.05$) than that of T1. Dietary T1 had a higher average feed intake than that of T2 in gestation and lactation. There were no significant differences on the litter size or litter birth weight. No differences ($p > 0.05$) were noted in the survival of the piglets as well as in the backfat thickness and body weight loss in sows. In conclusion, these results show that high-energy diets had no effect on the body weight and backfat thickness of sows during gestation and lactation but influenced the body weight and average daily gain of weanling pigs during the lactation period.

Keywords: dietary energy allowance, multiparous sows, piglets, reproductive performance

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Introduction

The energy balance of the lactating sow was discussed in detail by the ARC (1981). The requirement for energy may not always be satisfied either because the management system limits the maximum amount supplied to sows or because of the inability of the sow to consume such quantities of feed. The probable results of either situation are reduced milk yield and excessive loss of body weight and then will influence the growth performance in suckling piglets. Thus, studies on effects of energy supplementation are quite necessary for sows. In 1990s, earlier studies reported effects of different energy supply levels during gestation and lactation on body composition of sows (Beyer et al., 1993a; Park et al., 2016) considering also the growth of conceptus and reproductive tissues (Beyer et al., 1993b;

1994a), on energy and nitrogen metabolism of pregnant and lactating sows (Beyer et al., 1994b) and on litter weight gain (Jentsch et al., 1995) during suckling in 1st, 2nd, and 4th parity sows. In the 21st century, Beyer et al. (2007) continued evaluate the effects of energy supply levels during gestation and lactation on milk production and composition in sows of 1st, 2nd, and 4th parity. Also low energy intake during gestation period may increase the risk of being culled due to pregnancy failure (Kongsted, 2005). O'Grady et al. (1973) found that birth weights of the piglets were significantly affected by the energy intakes in the previous lactations, being greater for the sows on the higher energy levels. Noblet and Etienne (1986) found that the ability of sows to mobilize body lipids in order to maintain the output of energy in milk is reduced as body fat reserves are depleted. Indeed, Mahan (1993) demonstrated that weight at weaning is more important than growth rate post-weaning in determining the time needed to reach market weight. It is therefore imperative to find new management schemes that will increase growth rate of suckling piglets and weanling pigs.

However, prior research in energy supplementation in the diet is still controversial. Further to say, not enough studies have been conducted to evaluate the use of different energy intake from lactating sows to weanling sows. Additionally, we wondered if higher dietary energy levels could reduce stress during lactation or improve sow and piglet growth performances. The objective of this study was to evaluate effects of different energy level on growth performance, backfat thickness, body weight loss, in lactating sows and body weight, average daily gain (ADG) in piglet.

Materials and methods

All animals received humane care as outlined in the guide for the care, and use of experimental animals (Dankook University, Animal Care Committee, Korea).

Experimental Design, Animals, Housing

A total of 25 multiparous sows (Landrace × Yorkshire), which were at 7 days before farrowing, were assigned to two treatments comprising of different dietary energy levels. There were twelve and thirteen replicates per treatment, respectively. This experiment was completed during a 5-week period from the January to March. Dietary treatments were corn-soybean meal-based diets with the metabolizable energy (ME) of 3100 kcal/kg (T1) and 3400 kcal/kg (T2), respectively. The sows were housed individually in 2.1 × 1.8 m^2 farrowing crates with solid concrete floors combined with slats of iron. The temperature in the farrowing house was maintained at a minimum of 20℃. Supplemental heat was provided for piglets using heat lamps. Piglets were treated according to routine management practices that included teeth clipping, tail docking, ear notching.

Diets and feeding

From day 108 of gestation until farrowing sows were fed their experimental gestation diets (Table 1). On the day of parturition, the sows were fed 1 kg/d of their experimental lactation diets respectively. After farrowing, daily feed allowance was increased gradually until sows had *ad libitum* access to feed. All diets were provided in meal form twice daily and sows had free access to drinking water throughout the experimental period. Piglets were provided with creep feed from two weeks of age. The sow diets (Table 1) were based on corn-soybean meal and were formulated to meet or exceed the nutrient requirements recommended by NRC (2012). The metabolizable energy levels were designed at 3.10 Mcal/kg and 3.40 Mcal/

kg according to the guide.

Sampling and measurements

Individual sow was weighed and scanned for back fat thickness at day 108 of gestation, the day after farrowing and at weanling (26 - 29 d) to determine weight and back fat thickness loss. The back fat thickness of the sows (6 cm off the midline at the 10th rib) was measured using a real-time ultrasound instrument (Piglot 105; SFK Technology, Herlev, Denmark). The feed consumed during the gestation and lactation periods was recorded for each sow to calculate average daily feed intake. After farrowing, daily feed allowance increased 1 kg/day until day 6 postpartum, and then sows were given ad libitum access to feed and water.

During the experimental period, individual piglets were weighed within the first 24 h of farrowing as well as at weaning (26 - 29 d). The numbers of piglets alive and death per litter were recorded to calculate survival ratio. To guarantee that all sows nursed a similar number of piglets, litter sizes were adjusted by cross-fostering piglets within 24 h of birth (Zhou et al., 2012).

Table 1. Formula and chemical composition of gestating and lactating diets (%).

Items	Gestating diets (ME, kcal/kg)		Lactating diets
	3,100	3,400	
Ingredients (%)			
Corn	56.59	50.50	67.51
Soybean meal (46% CP)	10.09	11.12	25.57
Sugar molasse	-	-	1.00
Tallow	0.45	5.50	-
Soy oil	-	-	1.30
Barley	25.00	25.00	-
Rapeseed meal	3.60	3.60	-
L-lysine HCL	0.41	0.40	0.60
DL-methionine	0.04	0.04	-
Dicalciumphosphate	2.36	2.43	2.30
Limestone	0.86	0.81	0.85
Vit. Mix[x]	0.10	0.10	0.20
Min. Mix[y]	0.10	0.10	0.10
Salt	0.25	0.25	0.42
Choline chloride-50	0.15	0.15	0.15
Chemical compositions[z] (%)			
ME (kcal/kg)	3,100	3,400	3,265
CP	13.08	13.08	17.07
Lys	0.86	0.86	1.26
Met	0.23	0.23	0.25
Ca	0.90	0.90	0.90
Total P	0.70	0.70	0.70
Available P	0.42	0.42	0.41

ME, metabolizable energy; CP, crude protein.
[x] Provided per kg of diet: Vit. A, 10,000 IU; Vit. D_3, 1,500 IU; Vit. E, 35 IU; Vit. K_3, 3 mg; Vit. B_2, 4 mg; Vit. B_6, 3 mg; Vit. B_{12}, 15 μg; pantothenic acid, 10 mg; biotin, 50 μg; niacin, 20 mg; folic acid 500 μg.
[y] Provided per kg of diet: Fe, 75 mg; Mn, 20 mg; Zn, 30 mg; Cu, 55 mg; Se 100 μg; I, 250 μg; Co, 250 μg.
[z] Calculated value.

Statistical analyses

All experimental data were analyzed using the GLM procedure of SAS version 8.2 (SAS Inst. Inc., Cary, NC, USA) as a randomized complete block design according to their body weight (BW). The sow or litter of piglets was used as the experimental unit. The analysis of sow backfat thickness and change during lactation used fat depth at farrowing as covariates. Piglet birth weight was used as covariates for weaning weights during lactation. Lactation length was used as a covariate for piglet survivability, sow and piglet weaning weight, sow feed intake, and backfat thickness depth change. Duncan's multiple range test, and a probability level of $p < 0.05$ was regarded as statistically significant. Variability in the data was expressed as standard error.

Results and Discussion

Growth performance in lactating sows

In this study, Dietary T2 sows provide more number of weaned piglets per litter ($p < 0.05$) among dietary treatments (Table 2). During gestation and lactation, the average daily feed intake (ADFI) in T1 treatment were greater ($p < 0.05$) than sows fed the T2 treatment. There were no significant impacts observed on total birth piglet, total live piglet, body weight, and backfat

Table 2. Effect of different dietary energy levels in lactating sows.

Items	T1	T2	SE
Parity	3.0	3.2	0.4
Litter			
Total birth piglet	10.2	10.6	0.4
Total live piglet	9.8	10.3	0.2
Weaned piglet	9.4b	10.1a	0.2
Survival (%)	95.8	97.8	0.3
Body weight (kg)			
Before farrowing	217.1	218.0	7.4
After farrowing	195.1	196.2	7.8
Weanling	187.9	191.2	7.4
Body weight loss1[y]	22.0	21.7	0.8
Body weight loss2[y]	7.2	5.0	1.1
ADFI (kg)			
Gestation	2.43b	2.79a	2.61
Lactation	6.11b	6.70a	6.40
Backfat thickness (mm)			
Before farrowing	20.3	20.2	0.4
After farrowing	19.8	19.9	0.4
Weanling	17.7	18.4	0.4
Backfat thickness loss1[z]	0.4	0.3	0.1
Backfat thickness loss2[z]	2.2	1.5	0.3

T1, 3100 kcal of metabolizable energy (ME)/kg; T2, 3400 kcal of metabolizable energy (ME)/k; SE, Standard error; ADFI, average daily feed intake.
[y] Body weight loss: 1, before farrowing to after farrowing; 2, after farrowing to weanling.
[z] Backfat thickness loss: 1, before farrowing to after farrowing; 2, after farrowing to weanling.
a, b: Means in the same row with different superscripts differ ($p < 0.05$).

thickness in the whole experimental period (p > 0.05). The relationship between sow reproductive performance and energy has been reported a lot. Some research concluded that the level of feed energy does not have significant impact on the amount of born. However, the current experiment showed that when the level of feed energy at 3.40 Mcal/kg the number of weaned piglet can improve. In the early period of gestation, using the high energy level feed would increase the number of still embryos, as the result of which, in the past, we suggested that reducing the level of feed energy during the sow early period of gestation and improved the feed energy at a certain level during the sow latter gestation and lactation. To some extent, NRC (2012) is correct proved by the result of experiment, which suggested dietary energy levels for 140 kg BW gilts during gestation between 6,678 kcal of ME/kg to 7,932 kcal of ME/kg daily. However, our results suggested that litter size was not affected by increasing dietary energy, which may be considered to be a balance between gestation preparation and early gestation. High energy levels had positive effects on the ovulatory rate (Jindal et al., 1996), while low energy supplies from day 3 after mating until day 15 do not affect embryo survival. On the contrary, it has positive effect on the number of weaned piglet.

In addition, we made a resemble observation in that dietary energy had no effects on BW loss at parturition, which ranged between 21.7 and 22 kg (Table 2). This is consistent with the study of Beyer et al. (1994b), who observed no influence on the result of conception in sows that were fed the three energy levels during pregnancy, and conception weight was assumed to total 22.8 kg per sow independent of gestational energy consumption levels.

Besides BW, changes in body lipid reserves exerted a significant influence on the reproductive function of modern sows (Prunier et al., 2001; Sinclair et al., 2001). Typically, backfat thickness is positively correlated with total fat content of sows, because lipids are primarily deposited in the subcutaneous fat of pigs (Wood et al., 2008). Therefore, backfat can be used to determine whether sows maintained an optimal body condition (Maes et al., 2004). Sows with high backfat had reduced feed intake, and greater lipid and weight loss during lactation (Revell et al., 1998). In particular, it is desirable for sows to have 16 - 17 mm backfat thickness at mating and 17 or greater at farrowing. Sows are predicted to lose 3 - 4 mm of backfat during lactation and exceed 13 mm of backfat at their subsequent service (Young et al., 2004). Wang et al. (2016) said that, pregnant sows fed the high energy allowance had an ideal backfat thickness at farrowing (19 mm) and weaning (14.64 mm), whereas pregnant sows fed the Low energy allowance had an undesirable backfat thickness, which was lower than 16 and 13 mm at farrowing and weaning, respectively. Unexpectedly, in the recent study, pregnant sows that fed the high energy diet had no ideal effect on backfat thickness during farrowing and weaning period compared with low energy diet. The possible reasons for no effect on backfat thickness with higher energy supplementation are perhaps related to the different of energy level, digestion and metabolism of the feed, the stress of the farrowing and weaning, maybe feeding environment also, etc. Thus, further studies are in need to be conducted to evaluate the effect of different energy level on backfat thickness in sows.

The nutritional status and body condition of sows during lactation have great influence to the next mating, the survival rate and the performance of the piglets. During the lactation period, the better of sow nutritional status; and the more of piglet body weight, the less of the risk of the sows delay estrus after weaning. For the lactating sows, the feed intake of sows affects the milk yield, the nutritional status of piglets and the performance of sows during re-mating (Van den Brand et al., 2000). If remain a high feed intake, the production efficiency of sows could be improved. Studies have shown that the growth rate of the piglets fed by human are much greater than that of the piglets raised by sows. This phenomenon indicates that the growth rate of piglets fed by sows still has the potential to increase. One of the main factors restricting the growth rate of piglets is the sow's lactation ability and the nutritional status during the lactation (Clows et al., 2003). Therefore, the growth performance of piglets could be further improved by increasing the nutritional intake of lactating sows. The role factor of sow feed intake is the energy level in the diet. The previous researches have shown that the account of feed decreases as the energy levels increase, but total intake is tend to increase (Van den Brand et al., 2000; Van den Brand et al., 2001). This result has the same consequence that we have obtained, so we can draw a conclusion that the ADFI is negatively related to dietary energy levels.

Growth performance in piglets

As shown in Table 3, piglets fed T2 diet had the higher body weight than the T1 diet during weanling ($p < 0.05$). During d 1 - d 14, d 14 - d 26, and overall, the ADG in the piglets fed T2 diet was higher than the piglets fed the T1 diet ($p < 0.05$).

There are many of scientific studies assessing the effects of increased feed or energy intake in gestating sows on piglet birth weight. Daily energy requirements during gestation include maintenance for the sow maternal gain as well as uterine growth. Increased energy intake during late gestation can positively affect fetal growth (NRC, 2012). In this experiment, there was no treatment effect on litter birth weight and individual piglet birth weight, which is consistent with the results from Long et al. (2010), who demonstrated that the average piglet BW at farrowing was not affected by energy levels in gestation diets. Increased feed intake during gestation also did not increase the litter weight or individual piglet weight (Piao et al., 2010). But under the 3.40 Mcal/kg energy level, the weanling body weight was significant increased. This phenomenon might be related to the number of piglet. The source of the nutrients is limited, when the number of piglet increase, each embryo will inevitably reduce the amount of nutrient substance. The litter weight, which can correctly reflect the litter size and birth weight, showed an increasing trend with the increase of feed energy level. This result indicated that increasing the feed energy level could improve the reproductive performance of sows. Based on the present study, the direct relationship between nutrition and reproductive performance of sows is still controversial, the correlation of these two are still need to be discussed.

In the current study, piglets fed T2 diet had the higher body weight than the T1 diet during weanling ($p < 0.05$). During d 1 - d 14, d 14 - d 26, and overall, the ADG in the piglets fed T2 diet was higher than the piglets fed the T1 diet ($p < 0.05$), which agreed with the results of Saleri et al. (2009), who observed a similar report that increased ADG of piglet during gestation and lactation with higher leptin. Then we speculate that high energy diet can improved the ADG of piglets.

Table 3. Effect of different dietary energy levels in suckling piglets.

Items	T1	T2	SE
Body Weight (kg)			
Initial	1.396	1.381	0.173
d 1	1.488	1.474	0.032
d 14	4.156	4.238	0.037
Weanling	7.461b	7.772a	0.055
ADG (g)			
Initial - d 1	91	93	1
d 1 - d 14	205b	213a	1
d 14 - d 26	275b	294a	5
Total Average daily gain	233b	246a	2

T1, 3100 kcal of metabolizable energy (ME)/kg; T2, 3400 kcal of metabolizable energy (ME)/kg; SE, Standard error; ADG, average daily gain.
a, b: Means in the same row with different superscripts differ ($p < 0.05$).

Conclusion

In conclusion, these results indicated that high-energy diets had no effects on the body weight and backfat thickness in sows during gestation and lactation, but influenced the weanling pig's number and body weight and ADG during lactation period, meanwhile, it also can effect the ADFI in sows. Thus, we concluded that the high-energy diet had the positive effects on growth performance in sows and piglets.

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