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Effects of Various Feeding Methods for Gestating Gilts on Reproductive Performance and Growth of Their Progeny*

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ABSTRACT : This study compared the effect of four different feeding methods for gestating gilts on reproductive performance and growth of their progeny. A total of 40 F1 primiparous sows (Yorkshire×Landrace) were allotted to four treatments in a completely randomized design (CRD). For treatments, gestating period of sows was divided into three trimesters (0-35 d, 36-90 d and 91-110 d) and different amounts of feed were provided to each treatment group by Flat, Down-Up-Down (DUD), Up-Down-Up (UDU) and Down-Up-Up (DUU) feeding methods. The experimental diet was formulated to meet or exceed the standards of NRC (1998). Body weight gain of gestating gilts from d 0 to 110 was affected by feeding method ($p<0.05$). When gilts were fed constant feed ration (Flat feeding), less body weight loss was observed during lactation (-0.9 kg, $p<0.05$) and desirable backfat thickness (average 19.5 mm) was acquired at 110 days of gestation. Feed intake of lactating sows tended to be greater (4.22, 3.60, 3.97 and 4.13 kg/d, $p>0.05$) as sows in Flat feeding treatment had lower backfat thickness during gestation compared with other treatments ($p<0.05$). When gestating gilts were fed higher amount of feed during mid-trimester, the number of stillborn (1.4 piglet per litter, $p<0.05$) and mummies (0.8 piglet per litter, $p = 0.25$) were increased compared to other treatments. Feeding methods for gestating gilts had no effect on litter weight and gain of litter weight during the nursing period. Flat feeding method resulted in decreased plasma glucose concentration at 7 d postpartum ($p<0.05$), and increased LH concentration at 21 d postpartum ($p<0.01$) compared to other treatments. These results suggested that higher feed intake of gestating gilts resulted in detrimental effects on body condition and reproductive performance of sows. When gestating gilts consumed constant feed during gestation (2 kg/d), better reproductive performance and less body weight loss in lactation were observed because sows consumed more feed during the whole lactation period. Consequently, Flat feeding will be a desirable feeding strategy for gestating gilts to maximize reproductive performance, and better body condition of sows without any negative influence on the growth of their progeny. (**Key Words :** Feeding Method, Gilts, Body Weight, Backfat Thickness, Reproductive Performance, LH)

INTRODUCTION

Numerous feeding methods for gestating sows have been introduced continually. However, recent high producing sows require much more nutrients for better reproductive performance and growth performance of their progeny. Currently, the most common strategies of feeding to gestating sows are to provide a single diet with constant or adjusted feeding levels during gestation by their body conditions (Trottier and Johnston, 2001). The constant feeding ration has been widely accepted as an efficient way for pregnant primiparous sows, but a multi-phase feeding method for pregnant primiparous sows might be efficient in enhancing fetal growth and maternal protein accretion. According to NRC standard, the feed intake of gestating sows has been recommended between 1.80 and 1.96 kg daily (NRC, 1998). The effect of inadequate levels of nutrients by low feed intake during gestation on reproductive performance is more pronounced in primiparous sows than that of multiparous sows because their body as well as fetus should be grown simultaneously. However, excessive feed consumption of gestating sows subsequently causes decreasing feed intake during the following lactation (Weldon et al., 1994; Revell et al., 1998). Sows may be often in a catabolic state during lactation, resulting in tissue mobilization due to a high demand for nutrients for milk production and as a result of inadequate nutrient intake, especially in primiparous sows (Boyd et al., 2000). These body tissue losses have direct effects upon the subsequent weaning-to-estrus intervals (Trottier and Johnston, 2001), litter size (Kirkwood et al., 1987) and

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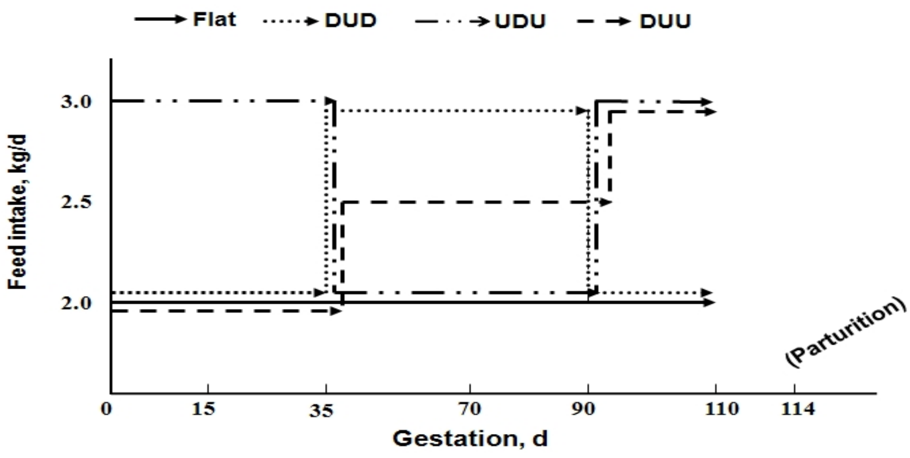

Figure 1. Four different feeding methods for gestating gilts.

farrowing rate (Koketsu et al., 1996) of sows. Voluntary feed intake of sows during lactation is generally increased with litter size but often remained insufficient to satisfy nutrient needs during the first lactation (Dourmad et al., 1996).

Nutrient intake of sows influenced reproductive performance through alteration in the metabolic and endocrine status during gestation and lactation (Close and Cole, 2000). Kemp et al. (1995) suggested that dietary energy level differentially affected some of the reproductive hormone release. Whitley et al. (2002) demonstrated that insulin targeted reproduction somewhat nonspecifically interacted not only with nutrition and body condition, but also with other management factors. The mechanisms involved in blood metabolites and hormones, especially in the first parity sow, are not clearly understood. Moreover, nutritional impacts on reproduction may be mediated in part through associated effects on reproductive hormone concentration.

There is still a distinct lack of consensus as the better feeding strategy for high producing sows. Thus, this study was conducted to investigate the effects of various feeding methods for gestating gilts on reproductive performance, plasma metabolite concentrations during lactation and the growth of their progeny.

MATERIALS AND METHODS

Experimental design and diet

A total of 40 pregnant F1 primiparous sows (Yorkshire×Landrace) were randomly allotted to four different feeding method treatments by their body weights (139.6±10.90 kg) in a completely randomized design (CRD) with ten replicates during gestation. Four different feeding methods are described in Figure 1. The amounts of feed provided for 3 subsequent gestation period (0-35 d, 36-90 d and 91-110 d) to supply their nutrient need were divided into i) constant feeding [Flat]: 2.0 kg/d, ii) Down-Up-Down [DUD]: 2.0-3.0-2.0 kg/d, iii) Up-Down-Up [UDU]: 3.0-2.0-3.0 kg/d, iv) Down-Up-Up [DUU]: 2.0-2.5-3.0 kg/d.

Experimental diet for gestating gilts was corn-SBM based diet and it contained 3,265 kcal of ME/kg, 12.80% CP, and 0.75% lysine, respectively. All other nutrients of experimental diet were met or exceeded NRC standard (1998). To evaluate the carryover treatment effects from gestation to lactation, all sows were fed the same diet during lactation. The lactating diet was formulated to contain 3,266 kcal of ME/kg, 16.80% CP and 1.08% lysine, respectively and the chemical compositions of gestation and lactation diets are presented in Table 1.

Animals and managements

Primiparous sows were selected at 6 mo of age and approximately 105 kg body weight, then housed in an environmentally controlled barn with 24 pens (2.5×3.5 m^2, 2 sows/pen). Feed and water were provided *ad libitum* until 120 kg of body weight, then feed was restricted until breeding. After two or three times of estrus, a progestagen was provided to gilts for 14 d to synchronize estrus cycle of gilts (Regumate®, 20 mg/d, Janssen-Cilag, Issyles-Moulineaux, France). After withdrawal of Regumate®, estrus was diagnosed twice daily by contact with mature boar and artificial insemination (AI) was done with fresh diluted semen (Darby AI center, Korea) when primiparous sows showed estrus response. The AI was repeated at 12 h interval if primiparous sows maintained estrus status. Pregnancy of primiparous sows was diagnosed on day 28 and 42 postcoitum, and gestating gilts were housed in an individual gestation stall with concrete slatted floor (0.64×2.40 m^2). All sows were fed each ration of treatment diet twice daily during gestation.

Table 1. Chemical composition of experimental diet for gestation and lactation

Ingredients	Gestation	Lactation
Corn	80.66	70.66
SBM-46	14.40	23.83
Mixed animal fat	0.84	0.85
Fish meal	0.00	0.72
Monocalcium phosphate	1.80	1.52
Limestone	1.44	1.38
L-lysine·HCl	0.20	0.27
Vitamin.mixture[1]	0.20	0.20
Mineral .mixture[2]	0.10	0.10
Salt	0.31	0.42
Antibiotics[3]	0.05	0.05
Total	100.00	100.00
Chemical compositions		
ME (kcal/kg)	3,265	3,266
Crude protein (%)	12.80	16.80
Lysine (%)	0.75	1.08
Methionine (%)	0.22	0.28
Calcium (%)	0.90	0.90
Total phosphorus (%)	0.70	0.70

[1] Supplied the following per kilogram of complete diet: 10,000 IU of vitamin A; 1,500 IU of vitamin D_3; 30 mg of vitamin E; 2 mg of vitamin K_3; 2 mg of thiamine; 4 mg of riboflavin; 20 mg of niacin; 10 mg of pantothenic acid; 3 mg of pyridoxin; 0.02 mg of biotin; 3 mg of folic acid; 0.02 mg of vitamin B_{12}; 500 mg of choline.
[2] Supplied the following per kilogram of complete diet: 80 mg of Fe; 10 mg of Cu; 40 mg of Mn; 100 mg of Zn; 0.1 mg of Co; 0.60 mg of I; and 0.15 mg of Se (Organic:Inorganic = 1:1).
[3] Antibiotics: 55 ppm Neomycin.

At 110 d postcoitum, gestating gilts were washed, moved from gestation stall to farrowing crates and fed their treatment ration until farrowing. Heating lamp was installed in each farrowing crate to maintain a constant temperature and the temperature of farrowing barn was kept at 28±3°C during lactation. Lactating sows were fed the same diet regardless of dietary treatments. Feeders were often checked daily and remained feed was weighed in the early morning before fresh feed was supplemented. Nursing pigs were weaned at 24±3 day of age.

Measurements and sampling

Primiparous sows were weighted at breeding, 110 d postcoitum, and at farrowing, 7, 14 d and d 21 postpartum. Simultaneously, backfat thickness of sows was also measured at each side of P_2 position using a Lean-Meater (Renco Corp., Minneapolis, MN). During lactation, feed intake of sows was recorded weekly when sows were weighed. Lipid and protein mass of primiparous sows were calculated using the equations of Mullan et al. (1989) and Mullan and Willams (1988), respectively:

$$\text{Lipid (kg)} = \text{BW (kg)}\times(0.128+0.0088\times P_2\text{ (mm)})$$

$$\text{Protein (kg)} = (0.11\times\text{BW (kg)})-(0.14\times P_2\text{ (mm)}) -(0.05\times\text{day of lactation})+6.72$$

Blood samples were collected from the jugular vein of sows with heparinized glass tubes and centrifuged immediately at 3,000 rpm at 4°C, then the plasma was separated and stored at -20°C until later analysis.

Plasma free fatty acid (FFA) concentrations were determined according to the Acyl-CoA synthetase, Acyl-CoA oxidase, colorimetry (ACS-ACOD) method (Shimizu et al., 1979) using a commercial kit (Wako FFA C Kit; Wako chemical, Osaka, Japan). Plasma glucose concentration was measured using an enzymatic kit (Glucose hexokinase kit, Bayer, USA). Insulin was analyzed by using a RIA kit (Coat-A-Count®; Diagnostic Products, Los Angeles, CA). The concentration of luteinizing hormone (LH) in the peripheral blood plasma was determined using a solid-phase RIA kit (Coat-A-Count®; Diagnostic Products, Los Angeles, CA).

Colostrum and milk samples of each treatment sows were collected from functional mammary glands at 24 h, 7, 14 and 21 d postpartum, respectively. After collection, samples were stored in a freezer (-20°C) until milk solids no fat (SNF), protein, fat and lactose were analyzed.

Litter size and individual piglet weight were recorded weekly. Within 24 h after birth, the cross-fostering was done within treatment if it was needed. Then all piglets were given an iron injection, and subsequent ear-notched, clipped needle teeth and tails were carried out.

Statistical analysis

All performance data were analyzed using SAS GLM procedure (SAS, 2004) and a main effect in the model was gestational feeding method treatments.

RESULTS

The effect of gestation feeding methods on body weight and backfat thickness is presented in Table 2. Body weight of gestating gilts was increased when gilts were fed more feed, resulting in significant differences at 110 d postcoitum ($p<0.05$). Body weight of gestating gilts in Flat treatment was lower than that of other treatments at farrowing ($p<0.05$). Subsequently, body weight of lactating sows was affected by gestation feeding methods and less body weight loss was observed in Flat treatment (-0.90 kg) than other treatments ($p<0.05$). The actual maternal weight gain from breeding to weaning was also affected by feeding methods and was lowered in Flat feeding treatment ($p<0.05$).

Backfat thickness of sows was increased during gestation and was higher when gilts were fed more feed during gestation (Table 2, $p<0.05$). However, backfat thickness changes of lactating sows were not affected by

Table 2. Effect of gestating feeding methods on reproducing sows performance responses in first parity

Item	Treatments[1]				SEM[2]
	Flat	DUD	UDU	DUU	
No. of sows	10	10	10	10	-
Live body weight (kg)					
Breeding	139.55	139.95	142.60	136.55	1.70
Day 110 postcoitum	190.30[b]	213.85[a]	215.20[a]	212.30[a]	2.66
Change of BW (breeding to 110 d)	50.75[b]	73.90[a]	72.57[a]	75.72[a]	1.92
Day 1 postpartum	169.45[b]	187.00[a]	190.65[a]	184.90[a]	2.56
Day 21 postpartum	168.50	181.25	181.45	177.15	2.54
Farrowing to 21 d	-0.90[a]	-5.75[b]	-9.20[b]	-7.75[b]	1.36
Backfat thickness (mm)					
Breeding	17.35	17.25	18.30	17.95	0.38
Day 110 postcoitum	19.45[b]	24.70[a]	23.30[a]	23.80[a]	0.37
Change of backfat (breeding to 110 d)	2.10	7.45	5.00	5.85	0.56
Day 1 postpartum	17.60[b]	22.75[a]	21.60[a]	21.35[a]	0.68
Day 21 postpartum	16.45[b]	20.95[a]	20.30[a]	19.45[ab]	0.64
Farrowing to 21 d	-1.15	-1.80	-1.30	-1.90	0.30
Lipid[3] (kg)					
Day 1 postpartum	47.87[B]	61.70[A]	60.83[A]	58.48[A]	1.69
Day 21 postpartum	45.89[b]	56.91[a]	55.67[a]	53.05[a]	1.48
Farrowing to 21 d	-1.99	-4.77	-5.14	-5.40	0.74
Loss, % lipid mass at d1	3.82	7.14	8.11	9.28	1.22
Protein[3] (kg)					
Day 1 postpartum	22.86	24.06	24.62	24.02	0.26
Day 21 postpartum	21.90	22.67	22.77	22.43	0.28
Farrowing to 21 d	-0.94	-1.38	-1.83	-1.59	0.15
Loss, % protein mass at d1	3.96	5.81	7.51	6.67	0.60
Protein/lipid ratio					
Day 1 postpartum	0.48[a]	0.40[b]	0.41[b]	0.42[b]	0.01
Day 21 postpartum	0.48[a]	0.41[b]	0.41[b]	0.43[b]	0.01
Farrowing to 21 d	0.48[a]	0.40[b]	0.41[b]	0.42[b]	0.01
Weaning to estrus interval (d)	6.11	6.43	6.29	6.13	0.28
Culling rate (%)	10	30	30	20	-

[1] Gestating period of primiparous sows was divided for three trimesters (0-35 d, 36-90 d and 91-110 d) and treatments were Flat, Down-Up-Down, Up-Down-Up and Down-Up-Up feeding methods.

[2] Standard error of mean.

[3] The chemical composition of the body weight on d 1 and 21 of lactation as well as its variation were calculated from the body weight and backfat thickness measurements using the equations proposed by Mullan et al. (1988, 1989): lipid (kg) = body weight (kg)×(0.128+0.0088×P_2(mm)), protein (kg) = (0.11×body weight (kg))-(0.14×P_2 (mm))-(0.05×day of lactation)+6.72.

[A, B] Means with different superscripts in the same row significantly differ (p<0.01).

[a, b] Means with different superscripts in the same row significantly differ (p<0.05).

feed intake of primiparous sows during gestation. Backfat thickness and body weight of lactating sows were affected by feeding methods during gestation (p<0.05) and these differences were derived from the calculated body lipid masses. Body protein masses during lactation, however, was not affected by gestation feeding methods, resulting in significant difference in protein to lipid ratios (p<0.05).

The primary reason of culling sows was reproductive failure and lameness of leg problems. The percentage of culling rate in Flat, DUD, UDU and DUU treatment was shown at 10, 30, 30 and 20%, respectively (Table 2), and this result could be explained by the differences of body weight change during gestation.

Feed intake of gestating gilts was affected by different feeding methods and average feed intake of Flat, DUD, UDU and DUU treatment was 2.00, 2.50, 2.50 and 2.43 kg daily, respectively (Table 3). Consequently, dietary intake of energy, protein and lysine during gestation was lower in

Table 3. Effect of gestation feeding methods on feed, energy, protein, and lysine intake of primiparous sows during gestation and lactation

Item	Treatments[1]				SEM[2]
	Flat	DUD	UDU	DUU	
No. of sows	10	10	10	10	-
Gestation					
Daily feed intake (kg/d)					
Breeding-35 d	2.00	2.00	3.00	2.00	-
35-90 d	2.00	3.00	2.00	2.50	-
90-110 d	2.00	2.00	3.00	3.00	-
Breeding-110 d	2.00	2.50	2.50	2.43	-
ME intake (Mcal/d)	6.53	8.16	8.16	7.94	-
Protein intake (g/d)	256.00	320.00	320.00	311.04	-
Lysine intake (g/d)	15.00	18.75	18.75	17.51	-
Feed cost[3] during gestation					
Feed cost (US$/parity/sow)	74.8[C]	93.5[A]	93.5[A]	91.0[B]	1.24
Relative feed cost (%)	100.0	125.0	125.0	121.6	-
Lactation					
Daily feed intake (kg/d)					
0-7 d	3.68	3.12	3.65	3.54	0.13
8-14 d	4.10	3.58	3.85	3.88	0.15
15-21 d	4.89	4.12	4.40	4.96	0.16
Farrowing-21 d	4.22	3.60	3.97	4.13	0.10
ME intake (Mcal/d)	13.78	11.58	12.98	13.50	0.52
Protein intake (g/d)	708.73	595.91	667.74	694.62	26.76
Lysine intake (g/d)	45.56	38.31	42.92	44.65	1.72
ME requirement[4] (Mcal/d)	16.63	15.76	17.59	17.38	0.34
Lysine requirement[5] (g/d)	42.06	39.67	43.00	42.99	0.65
ME balance (Mcal/d)	-2.85	-4.18	-4.61	-3.88	0.52
Lysine balance (g/d)	3.51	-1.36	-0.08	1.66	1.64

[1] Gestating period of primiparous sows was divided for three trimesters (0-35 d, 36-90 d and 91-110 d) and treatments were Flat, Down-Up-Down, Up-Down-Up and Down-Up-Up feeding methods.
[2] Standard error of mean.
[3] Feed cost of gestation diet was 0.34 US$/kg (breeding to 110 d).
[4] Total metabolizable energy (ME) requirements of sows during lactation were estimated according to the equation of Noblet et al. (1990): ME requirement (Mcal/d) = (0.46×body weight$^{0.75}$+28.95×litter weight gain-0.52×number of piglets)/4.12.
[5] Total lysine estimated requirement of sows during lactation was estimated using the equation proposed by Dourmad et al. (1998): Lysine (g/d) = (525+0.392×litter weight gain)/29.8.
[A, B, C] Means with different superscripts in the same row significantly differ (p<0.01).

Flat feeding treatment than other treatment groups. The feed intake of lactating sows, however, tended to be greater in Flat feeding treatment (p = 0.46) than that of other treatment groups. All sows had a negative energy balance during lactation, but less negative balance was observed in Flat treatment compared to other feeding treatments. A negative lysine balance was observed in DUD treatment during lactation due to the fact that feed intake of sow was the lowest in this treatment. Additional benefit of Flat feeding compared to other feeding methods was saving of feed cost approximately between 21 and 25% (0.15-0.17 US$/d).

As shown in Table 4, there were no significant differences in fat, protein, and lactose levels both in colostrum and milk. However, higher SNF level of colostrum was observed when high amount of feed was provided to primiparous sows during gestation but its level was gradually decreased in milk.

The total number of pig born, born alive and dead pigs were not affected by the gestation feeding methods (Table 5). Moreover, there was no significant difference in the number of weaned pigs among treatments groups. Survival rate of nursing pigs before weaning was over 96% regardless of gestation treatments, however, the DUD treatment showed more stillborn pigs compared to other treatments (p<0.05). During lactation, neither the litter weight nor the average piglet weight was affected by gestation feeding methods.

Plasma free fatty acid (FFA) concentration of sows was lower in Flat feeding treatment at each lactation measurement interval but the response was not significant (Table 6). Blood glucose concentration at 7 d postpartum was lower in Flat feeding treatment than that of other treatments (p<0.05), but its difference was restored when sows consumed more feed during lactation (Table 6).

Table 4. Effect of gestating feeding methods on milk composition of primiparous sows during lactation

Item	Treatments[1]				SEM[2]
	Flat	DUD	UDU	DUU	
No. of sows	10	10	10	10	-
Fat (%)					
Colostrum	9.77	9.91	9.21	9.67	0.43
7 d	8.05	7.29	7.17	10.10	0.44
14 d	9.13	6.68	8.48	9.13	0.45
21 d	5.97	5.66	6.14	5.52	0.42
Protein (%)					
Colostrum	5.79	6.42	5.63	5.64	0.28
7 d	4.39	4.39	5.31	4.35	0.20
14 d	4.81	4.29	4.85	4.44	0.16
21 d	4.89	4.24	3.96	4.83	0.22
Lactose (%)					
Colostrum	3.79[bc]	3.43[c]	4.23[a]	4.07[ab]	0.09
7 d	5.42	4.63	4.97	4.71	0.16
14 d	4.73	4.80	5.09	5.19	0.11
21 d	4.29	4.99	4.74	5.55	0.27
Solid no fat (%)					
Colostrum	10.60[b]	12.87[a]	12.10[ab]	10.34[b]	0.35
7 d	10.37[ab]	9.32[b]	10.78[a]	9.50[b]	0.22
14 d	10.27[a]	9.77[b]	9.67[b]	10.35[a]	0.10
21 d	10.33	9.25	8.82	10.19	0.33

[1] Gestating period of primiparous sows was divided for three trimesters (0-35 d, 36-90 d and 91-110 d) and treatments were Flat, Down-Up-Down, Up-Down-Up and Down-Up-Up feeding methods.
[2] Standard error of mean.
[a, b, c] Means with different superscripts in the same row significantly differ ($p<0.05$).

Table 5. Effect of gestating feeding methods on litter size and litter weight during lactation

Item	Treatments[1]				SEM[2]
	Flat	DUD	UDU	DUU	
No. of sows	10	10	10	10	-
Litter size, No. of piglets					
Total born	11.1	12.8	11.5	12.5	0.46
Stillborn	0.3[a]	1.4[b]	0.4[a]	0.2[a]	0.17
Mummies	0.3	0.8	0.3	0.4	0.12
Born alive	9.7	9.9	10.3	11.0	0.39
Weaning	9.9	9.8	10.0	10.4	0.14
Litter weight (kg)					
At birth	14.12	15.27	16.01	16.84	0.46
7 d	23.86	22.80	26.21	26.51	0.60
14 d	38.01	36.26	40.84	41.33	0.90
21 d	52.65	49.57	55.38	55.75	1.16
Change (birth to 21 d)	39.02	35.73	40.53	40.51	1.01
Piglets weight (kg)					
At birth	1.30	1.24	1.43	1.39	0.04
7 d	2.39	2.26	2.63	2.57	0.06
14 d	3.83	3.65	4.10	4.08	0.08
21 d	5.31	4.98	5.56	5.36	0.10
Change (birth to 21 d)	4.01	3.74	4.13	4.10	0.10

[1] Gestating period of primiparous sows was divided for three trimesters (0-35 d, 36-90 d and 91-110 d) and treatments were Flat, Down-Up-Down, Up-Down-Up and Down-Up-Up feeding methods.
[2] Standard error of mean.
[a, b] Means with different superscripts in the same row significantly differ ($p<0.05$).

Table 6. Effect of gestating feeding methods on average concentration of FFA, glucose and insulin during lactation

Item	Treatments[1]				SEM[2]
	Flat	DUD	UDU	DUU	
FFA (μEq/L)					
Farrowing	300.0	384.7	430.3	360.3	43.44
7 d	214.7	276.7	233.3	245.7	31.54
14 d	195.7	710.0	550.3	583.7	79.26
21 d	230.0	261.3	300.3	260.0	29.76
Glucose (mg/dl)					
Farrowing	77.7	84.7	80.7	80.0	2.87
7 d	74.7[b]	87.0[a]	86.7[a]	84.3[ab]	1.99
14 d	67.6	77.3	72.0	70.0	2.11
21 d	72.7	77.0	76.3	74.7	1.27
Insulin (mIU/ml)					
Farrowing	14.5	8.7	12.0	12.0	0.92
7 d	19.9	10.1	12.3	14.1	1.86
14 d	9.6	5.1	6.5	7.8	1.03
21 d	8.5	4.1	7.8	8.4	0.84

[1] Gestating period of primiparous sows was divided for three trimesters (0-35 d, 36-90 d and 91-110 d) and treatments were Flat, Down-Up-Down, Up-Down-Up and Down-Up-Up feeding methods.
[2] Standard error of mean.
[a, b] Means with different superscripts in the same row significantly differ (p<0.05).

Insulin concentration was not affected by gestation feeding methods, however, sows in Flat feeding treatment had a slightly higher insulin concentration compared to other treatments. The plasma LH concentration is presented in Figure 2. Flat feeding treatment had higher plasma LH concentration compared to DUD and UDU treatment at 21 d postpartum (p<0.01).

DISCUSSION

At the end of gestation, body weight and backfat thickness of sows in Flat feeding treatment were lower than those of other feeding methods (DUD, UDU and DUU) and Flat feeding method showed lower fat mass gain. These results were expected because higher feed intake during gestation generally resulted in a higher body weight and body fatness of sows at farrowing (Weldon et al., 1994; Xue et al., 1997). When sows were fed diet by Flat feeding method, target backfat thickness was achieved (19.5 mm) at the end of gestation compared to other feeding methods, which indicated that the Flat feeding method would be a better feeding method for maintaining adequate level of

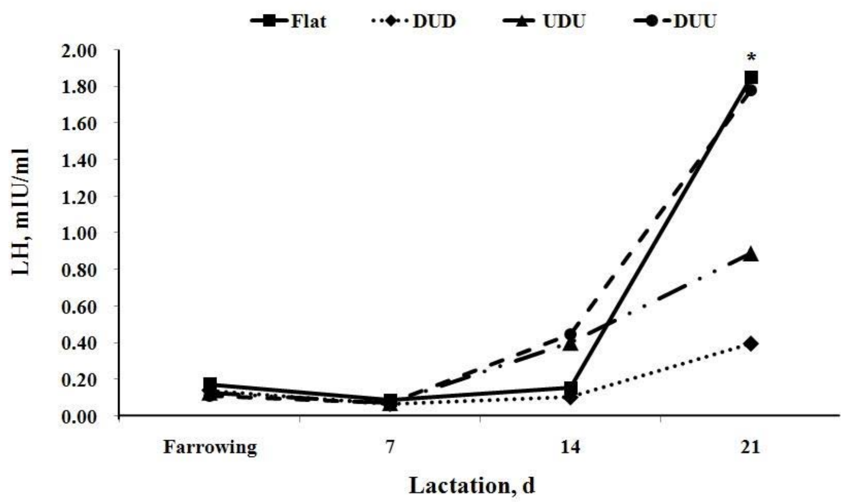

Figure 2. Effect of gestation feeding methods on plasma luteinizing hormone of primiparous sows during lactation. Concentrations of plasma luteinizing hormone (LH) among the treatments differed at 21 d postpartum of lactation (p<0.01).

backfat thickness of primiparous sows during gestation.

As gestation feed intake increased, feed intake of lactating sows was decreased by 14.69%, 5.92% and 2.13% in DUD, UDU and DUU, respectively, compared to Flat feeding treatment. This result demonstrated that voluntary feed intake during lactation may be affected by body condition and body composition of sows during gestation. Many of previous researches indicated that increasing body fatness at farrowing is likely to decrease feed intake during lactation (Dourmad, 1991; Xue et al., 1997; Revell et al., 1998; Young et al., 2004). Therefore, high feed intake of lactating sows in Flat feeding treatment could be explained by their lower body fatness. The relation between body condition at farrowing and voluntary feed intake during lactation, however, is not fully understood yet. One possible reason was that lower feeding level had relatively lower energy reserve at farrowing than sows fed higher feeding level, which resulted in increasing feed intake of lactating sows in order to meet their increased energy requirements during lactation. Moreover, lower fatness probably reduced circulating concentration of adipose tissue-derived anorexigenic hormones such as leptin, which lead to increased feed intake (Barb et al., 1998).

The relationship between body tissue reserves and feed intake in lactation has been observed primarily in multiparous sows, but not in primiparous sows (Lynch, 1989; Yang et al., 1989). Noblet et al. (1990) demonstrated that primiparous sows in all feeding methods did not consume an adequate amount of energy during their first lactation. Yang et al. (1989) also suggested that a low intestinal capacity of primiparous sows interfered with adequate consumption of feed. The other reason would be the rising of environmental temperature above the thermoneutral range of the sows (NRC, 1998). Generally sows could only control its body temperature by increasing heat loss through evaporation or by reducing its heat production by eating less (Williams, 1998). In this experiment, the farrowing barn temperature was recorded more than 25°C during parity 1, which might influence the voluntary feed intake of lactating sows.

Buitrago et al. (1974) reported adverse effects of increased gestation energy intake on the number of piglet born live. Increasing feed allowance between 50 to 80 d of gestation might increase the number of piglet born dead per litter (Louise et al., 2008). In agreement with previous studies, increased feed intake during gestation (DUD and UDU groups) was not related to a higher number of piglets born alive. Conversely, DUD treatment had higher number of dead pig per litter compared with Flat feeding treatment. These results demonstrated that increased sow backfat thickness at farrowing was associated with excessive gestation feeding level, resulting in having difficulty at farrowing of sows and increasing the number of stillborn pigs. The majority of experiments assessing the effects of increased feed intake of gestation sows on piglet birth weight progressively increased when sow feed or energy intake was increased during pregnancy (NRC, 1998). Contrary to expectation, the Flat feeding treatment had similar piglet birth weight compared to DUD, UDU and DUU groups. This result demonstrated that increased feed intake during gestation caused the increment of backfat thickness as well as body weight gain of gestating gilts. However, increased body weight and backfat did not induce the increased in litter weight or individual pig weight. In addition, an increase in the birth weight with a maternal feed intake of more than 6.0 Mcal of ME/kg/d was seldom significant (ARC, 1981).

It is worth to note that there were differences in SNF levels between fat and lean sows. The interpretation of this result was appeared from increases in body fatness during gestation, in which fatty sows showed an increase in the SNF level of colostrum. However, in this experiment, sows in Flat feeding treatment had higher milk SNF levels compared with fatty sows presumably because they consumed more feed during lactation compared to other treatments. Tokach et al. (1992) found that there was a strong interaction between dietary lysine and energy intake on milk composition. In the present study, sows in Flat feeding treatment consumed adequate level of lysine (15 g and 46 g/d during gestation and lactation, respectively), resulting in higher SNF levels in milk.

It is known that insulin can reduce the activity of carnitine palmitoyltransferase I and subsequently would reduce the oxidation of FFA for the production of energy (Gamble and Cook, 1985). Insulin was also accompanied by a decrease in glucose concentrations (Quesnel and Prunier, 1998). Similarly, postprandial insulin concentration was higher in Flat feeding treatment than other treatments during lactation. And lower concentrations of glucose and FFA were observed in Flat feeding treatment. It can be assumed that the effect of insulin on feed intake in lactating sows might depend on the body condition of sows and metabolites (glucose and FFA). When gestating gilts were fed excessive amount of feed during gestation, it may cause the fatty sows to become insensitive to insulin, most likely by affecting the number of insulin receptors and the degree of affinity. The fatty sows will then exhibit a smaller response in glucose clearance to the same amount of insulin. The latter also could reduce feed intake during lactation. In this study, the decrease of lactation feed intake in sows with three feeding methods except Flat feeding method probably led higher imbalance energy intake, resulting in greater losses of lipid mass (from 3.86 to 6.00%). These observations are in agreement with the previous study reported by Bauman and Currie (1980), who demonstrated that lower energy intake in lactating sows could increase FFA concentration corresponding with an increase in fat mobilization from the adipose tissues, wherein lipolysis was increased and lipogenesis was decreased.

The average concentration of LH was increased beginning on d 10-20 of lactation (Rojkittikhun et al., 1993). King and Martin (1989) and Koketsu et al. (1996) further suggested that the effect of inadequate nutrient intake during lactation on subsequent reproduction is mediated through decreased secretion of LH before weaning. Similarly, in the present study, sows in Flat feeding treatment enhanced the LH concentration at 21 d postpartum due to the fact that sows consumed more lysine or energy during lactation compared to other treatments. These results demonstrated that LH concentration may be affected by increased lysine and energy intake during lactation, which influenced on subsequent reproductive performance.

CONCLUSION

When gestating gilts were fed diet by Flat feeding method, there was a beneficial effect on their body condition, subsequently, less body weight loss and better reproductive performance of sows were observed. In addition, sows in Flat feeding treatment consumed approximately 47.5 to 55.0 kg/parity/sow less feed during gestation compared with other treatments, subsequently, feed cost could be saved about 21.5 to 25.0% (16.1 to 18.7 US$). Consequently, when gestating gilts were fed diet by Flat feeding method, desired body condition was achieved during gestation and feed cost was saved without any detrimental effects on reproductive performance.

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