Soybean Checkoff-funded Research

Project Title: Effects of U.S. Dehulled Soybean Meal on Productivity of Gilts

Investigators: Song, Young Min, Byung Jo Chae, Ki Hway Chung, Chung Hee Kim, Jung Man Noh, Yoon Kyong Choi, Ji Hee Ha and Seung Ho Ha

Institution: Swine Science Technology Center, Jinju National University, Korea

Reference: Final Report for a research project funded by the American Soybean Association-International Marketing and the United Soybean Board, 16305 Swingley Ridge Road, Suite 200, Chesterfield, MO., 63640.

Research Objectives:
The positive effects of U.S. dehulled soybean meal known for its highly available protein and amino acids protein have been demonstrated in many animal studies. Also, plentiful results on the economic effects of U.S. dehulled soybean meal in swine feeds have been reported (Kim et. al., 2000).

It is well recognized that U.S. dehulled meal is superior to non-dehulled soybean meals of South American and Indian origin and other plant-origin protein meals in nutritional compositions. Its use in sow diets has been increasing to balance dietary levels of amino acids that used to be relatively deficient in grains and grain by-products (Swick, 1995; Swick, 1998).

Park(1998) evaluated the feeding values of U.S. dehulled meal, Brazilian non-dehulled meal and Indian non-dehulled meal in growing and finishing pigs. He reported that the iso-caloric and iso-nitrogenous diets containing U.S. dehulled meal resulted in 3.8% increase in feed intake, 10% in body weight gain and 6.1% in feed conversion compared with those with Brazilian non-dehulled meal, but no significant differences compared with Indian non-dehulled meal.

Chung et. al. (1988) also reported that the weaning pigs fed U.S. dehulled meal-containing diets showed an improvement in growth rate, leading to 6.3% savings in feed costs per 1 kg weight gain even though significant differences in feed intake and body weight gain were not observed.

In China, an experiment was carried out to compare the effects of dehulled meal and non-dehulled meal on the performance of growing pigs. The results showed that no significant differences in the performances were found during the early phase of grower, but appeared significant during the late phase of grower, therefore, feed costs per weight gain reduced greatly (Bushman, 1998).

Park(1998) described that U.S. dehulled meal which tends to be high in metabolizable energy improved body weight gain and feed efficiency of pigs, resulting in reduction in feed costs for pig production.

Meanwhile, it became an important issue to swine industry that the ways to increase feed intake of sows capable of producing more piglets by development of breeding techniques should be devised (Van Kempton et. al. 1995). It is always imperative to such genetically-improved sows because their nutrient requirements cannot be met adequately enough to produce milk for piglets. Considering of adequate milk yield to maintain normal growth of piglets, delay of heat due to excessive loss of body protein and fat, and resultant shortening of life span, it must be important to increase feed intake of lactating sows.

Hwang et. al. (2000), reported that sows fed the diets containing U.S. dehulled meal for the duration of gestation to weaning produced heavier litter weight than those fed the diets containing Brazilian and Indian soybean meal. He also reached to a conclusion that economic benefits brought during the period of grower and finisher phase would be greater in groups fed U.S. dehulled meal than those fed non-dehulled meals of Brazilian and Indian origin because of their heavier litter weight.

Meanwhile, heat recurrence of sows tends to happen within 3 to 7 days after weaning. However, low energy intake during lactation period would lead to delay of estrus. It has been well recognized that addition of fats to feeds for lactating sows could reduce loss of body weight as well as increase fertilization rate (Seerley, 1981).

Sow performances are often evaluated in terms of improvement in litter size (Kim and Kim, 1998), days required to re-estrus (Robinson, 1990) and compositions of nutrients and immune substances in milk (Close and Cole, 2000). Also, intake of high quality colostrum by nursery piglets could provide immune globulin to prevent body from being infected with germs, viruses and microorganism detrimental to health (Kim and Kim, 1998).

On the while, it was reported by Etienne et. al. (1985) that sows have tendency to lose body weight during the nursery period, in other words, low energy intake during the nursery period would lead to increasing loss of body fat depositions. Excessive loss of body fat in sows is associated with delay of estrus (Dourmad et. al. 1994), thus, feed intake during the nursery period would influence reproductive performances of sows (Aherne and Kirkwood, 1985). Also, there was a similar report to this that reduction in feed intake of lactating sows could result in decreasing intake of amino acids and energy, therefore, delaying re-estrus (King and Dunkin, 1986).

In general, about 25% of new-born piglets tend to decease or be culled before weaning. Seerley et. al. (1974, 1978) and Boyd et. al. (1978) indicated that glycogen in liver and muscle of newly-born piglets was about to run out 24 to 72 hours after farrowing. Therefore, they normally should be provided energy from the exterior immediately after 48 hours after farrowing for survival.

Boyd et. al. (1978) and Cast et. al. (1977) reported that feeding animal fats to sows on the late gestation increased glycogen contents in liver of piglets, leading to increase their survival rate.
Moser and Lewis (1980) found out that supplementing fats to feeds for the late gestation increased milk yield and fat contents in colostrum of sows (Okai et. al., 1977; Pettigrew, 1978), glucose level in blood of piglets and ability to reserve glycogen in liver (Pettigrew, 1978).

Litter size and litter weight at weaning became critical variables in evaluating performances of sow (Christain, 1992). Graham et. al. (1981) reported that growth of piglets after weaning was greatly influenced by body weight at weaning, in other words, heavy-weight piglets at the time of weaning tended to exhibit higher growth rate than other light-weight groups (Tokach et. al., 1992).

The Gyeongnam Advanced Swine Research Institute (2005) reported that based on analysis of the data on the reproductive performances of American Berkshire lines that have been collected from 2003 to 2005, it was estimated 9.17 for litter size, 7.23 for actual litter size excluding death and abortion, 6.74 for weaning piglets, 9.5 kg for litter weight at birth, 38.5

kg for litter weight at weaning and 14.4 days for the duration required to re-estrus.

Based on the evaluation of American Berkshire line GGP by the Gyeongnam Advanced Swine Research Institute (2004), litter sizes termed as total number of born, total number of born alive and total number of weaned are 9.97 and 8.94, 7.27 and 7.45 and 7.22 and 7.21 for parity 1 and 2, respectively, and average litter weights at birth are 1.41 kg and 1.50 kg and average litter weight at the age of 21 days are 5.98 kg and 6.19 kg, for parity 1 and 2, respectively. In addition, the performances of the 1st generation female pigs used for brand pork production were evaluated 767 g for daily weigh gain, 14.8 mm for back fat thickness and 153.7 days for the period to reach 90 kg, while, the male pigs were 798 g for daily weight gain, 14.1 mm for back fat thickness and 149.6 days for the period to reach 90 kg, respectively.
Usually, longevity and reproductive performances of pigs depend upon growing and health conditions put during mating season. Also, it is essential that nutrients supply should be assured enough to maintain body weight and fat deposits to the proper level during the maturing because body weight and back fat reserves tend to decrease during the gestation and farrowing period (Quiniou and Noblet, 1999).

Whittemore (1996) reported that at first mating, 14~25 mm of back fat thickness was most adequate to gilts. It is also known that back fat thickness would impact on the age of the first estrus, milk yield and frequency of re-estrus.

Meanwhile, there was an opposite report that reproductive performance was not influenced by body compositions of replacement gilts such as back fat thickness until the third parity (Rozeboom et. al., 1996; Newton and Mahan, 1993; Young et. al., 1990).

Sohn et. al., (2003) reported that the age at first estrus, age at fertilization and litter size are estimated 180.32 days, 211.12 days and 9.33 heads for gilts with back fat thickness of 13~16 mm and 162.20 days, 195.43 days and 10.17 heads for gilts with back fat thickness of 17~20 mm, implicating that the thinner the back fat thickness is, the more delayed age on first estrus is, while the thicker the back fat thickness is, the more increased litter size is.

Consequently, this study was carried out to identify whether the diets with U.S. dehulled soybean meal, when formulated based on amino acid contents and digestibility, in which U.S. dehulled soybean meal have been known to be superior to Indian and South American non-dehulled meals, could improve the reproductive performances of gilts as measured by number of piglets at birth, at weaning, survival rate and growth performance of piglets, and subsequently, have positive influences on the next parity.

Ⅱ. Materials and Methods

1. Experimental period

This feeding trial was performed for 160 days from April 9, 2006 to September 15, 2006 using 60 replacement gilts, which consisted of 3 weeks of mating by artificial insemination, 17 weeks of gestation and 3 weeks of farrowing, nursing and weaning.

2. Experiment site

The experiment site (farm) was one of the largest Berkshire hog farms named "Chollyong Pork", which is located in Hamyang, Gyeongsangnam-do province maintaining 600 sows and gilts on average throughout a year and marketing 10,000 weaning piglets annually. The swine farm, lying on 1.5 acres, has a two-story windowless-confined house equipped with a consistent flow system for replacement gilts and sows from mating to weaning.

3. Experimental animal

60 American Berkshire line currently being preferred by Korean consumers was selected as experimental subjects. The selected animals were artificially inseminated with semen collected from the same variety.

4. Experimental design

A total of 60 American Berkshire gilts were assigned to three treatments according to body weight and health conditions. The treatments were three diets which were iso-caloric and iso-nitrogenic and containing U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal as a major protein source, respectively. The gilts were fed the three diets from gestation to weaning and had free-access to water for the whole period of experiment. Feed intake, weight gain and back fat thickness of gilts were measured and total number of piglets born, total weight of piglets born, mortality, abortion and other loss during farrowing were recorded for calculation.

Table 1. Experimental design applied to feeding trial

Items	Treatments1)		
	T1	T2	T3
No. of gilt	20	20	20
Total		60	

T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

5. Experimental diets

The diets were manufactured in mesh form and formulated to meet the nutrient requirements suggested by NRC (1988), including U.S. dehulled soybean meal (T1), Indian non-dehulled soybean meal (T2) and Argentine non-dehulled soybean meal (T3) as a major protein ingredient, respectively. The inclusion level of each soybean meal were maintained at 16.50% for gestation stage and at 29.00% for lactation stage.

The protein levels of gestation diets were 14.97 %, 14.87 % and 14.64 for T1, T2 and T3, respectively, and those of lactation diets were 18.99 %, 19.03 %, and 18.59 % in the same order, respectively. Metabolizable energy of all three diets was maintained at 3,265 kcal/kg for gestation and at 3,300 kcal/kg for lactation.

The market price of U.S. soybean meal at the time of beginning experiment was 278 won/kg and that of Indian and Argentine soybean meal were 250 won/kg. The finalized prices of the diets manufactured using the above soybean meals were calculated 182.71 won/kg, 177.47 won/kg and 177.19 won/kg in the order of T1, T2 and T3 for gestation, and 200.89 won/kg, 195.00 won/kg and 195.25 won/kg in the same order, respectively, for lactation.

The formulas of experimental diets for gestation and lactation are shown in Table 2 and 3. The diets were manufactured by a feed mill owned by Pukyong Pig Farmers Cooperative located in Kimhae, Gyeongsangnam-do province, to the order of SSTC.

Table 2. Formula of experimental diets (gestation)

Feeds(SBM-origin)	Gestation			
	W/kg	T1	T2	T3
DSBM(USA)	278	16.50	-	-
SBM(Argentina)	250	-	-	16.50
SBM(India)	250	-	16.50	-
Corn-grain	140	60.60	63.50	63.58
Wheat bran	130	12.59	9.70	9.64
Corn-GF	150	3.00	3.00	3.00
Animal fat	510	3.55	3.51	3.50
DL-Methionine(100%)	2,920	0.01	0.02	0.02
Choline-chloride(50%)	1,040	0.03	0.03	0.03
DCP	330	1.27	1.32	1.32
Lime stone	29	1.34	1.31	1.31
Salt	110	0.55	0.55	0.55
Minerals	435	0.25	0.25	0.25
Vitamins	1,620	0.30	0.30	0.30
Total		100.00	100.00	100.00
Diet Cost(Won/kg)		182.71	177.47	177.19
Composition	Min. Limit(Calculated values)			
ME(kcal/kg)	3,265	3,265	3,265	3,265
CP(%)	13.50	14.97	14.64	14.87
CA(%)	0.85	0.85	0.85	0.85
AP(%)	0.35	0.35	0.35	0.35
Total Lys(%)	0.65	0.71	0.69	0.68
Dig. Lys(%)	0.52	0.55	0.54	0.53
Total SAA(%)	0.48	0.50	0.49	0.49
Dig. SAA(%)	0.40	0.40	0.40	0.40
Total Thr(%)	0.47	0.53	0.51	0.52
Dig. Thr(%)	0.37	0.38	0.37	0.37
Total Tryp(%)	0.15	0.17	0.16	0.16
Dig. Tryp(%)	0.12	0.14	0.13	0.13

T1 : DSBM(Dehulled soybean meal from U.S).
T2 : SBM(Non-dehulled soybean meal from India).
T3 : SBM(Non-dehulled soybean meal from Argentine).

Table 3. Formula of experimental diets (lactation)

Feeds(SBM-origin)	Lactation			
	W/kg	T1	T2	T3
DSBM(USA)	278	29.00	-	-
SBM(Argentina)	250	-	-	29.00
SBM(India)	250	-	29.00	-
Corn-grain	140	55.16	55.38	55.35
Wheat bran	130	4.98	3.76	3.77
Corn-GF	150	2.00	2.00	2.00
Animal fat	510	3.00	3.96	3.96
C-molasses-27	170	2.00	2.00	2.00
L-lysine(78%)	1,750	0.06	0.08	0.11
DL-Methionine(100%)	2,920	-	0.01	-
Choline-chloride(50%)	1,040	0.04	0.04	0.04
DCP	330	1.30	1.34	1.34
Lime stone	29	1.34	1.31	1.31
Salt	110	0.55	0.55	0.55
Minerals	435	0.27	0.27	0.27
Vitamins	1,620	0.30	0.30	0.30
Total		100.00	100.00	100.00
Diet Cost(Won/kg)		200.89	195.00	195.23
Composition	Min. Limit(Calculated values)			
ME(kcal/kg)	3,300	3,300	3,300	3,300
CP(%)	18.50	18.99	18.59	19.03
CA(%)	0.90	0.90	0.90	0.90
AP(%)	0.35	0.35	0.35	0.35
Total Lys(%)	1.00	1.03	1.03	1.03
Dig. Lys(%)	0.85	0.85	0.85	0.85
Total SAA(%)	0.52	0.54	0.52	0.54
Dig. SAA(%)	0.42	0.44	0.43	0.44
Total Thr(%)	0.65	0.68	0.65	0.66
Dig. Thr(%)	0.48	0.51	0.49	0.49
Total Tryp(%)	0.22	0.23	0.22	0.22
Dig. Tryp(%)	0.17	0.19	0.18	0.18

T1 : DSBM(Dehulled soybean meal from U.S).
T2 : SBM(Non-dehulled soybean meal from India).
T3 : SBM(Non-dehulled soybean meal from Argentine).

6. Management of animals

Experimental animals were provided ad-libitum the mesh-formed gestation diets for 3 weeks of mating and 14 weeks of gestation, and then daily 2.4 kg from the day 100 after mating until farrowing. All animals had free-access to water through nipple attached to the feeder. The lactating gilt were fed 1 kg of diet on the first day of farrowing, 2 kg on the second day, 3 kg on the third day, 4 kg on the fourth day, and twice a day (in the morning and evening) from the fifth day of farrowing. For three weeks since then, the mesh-formed lactation diets were provided with water through feeder equipped with nipple.

On the day of weaning, 1.5 kg of diet was provided to gilts, and after then, 3.0 kg of diet was provided. Water was provided freely through nipple attached to the feeder.

The diet left in the feeder was collected every morning and weighed and discarded. At each time of feeding, fresh diets were provided to experimental animals.

The gestation stall has 60 cm in width and 200 cm in length. Gilts were transferred to the farrowing unit 1 week before farrowing. The size of individual farrowing stall was 180 cm wide and 200 cm long. Other managements, disinfection and disease control followed the general practices by the farm.

7. Response criteria and methods

1) Approximate compositions of soybean meals originated from U.S., India and Argentina were analyzed according to AOAC (2005). 50 ㎎ of soybean meal sample was collected into 13 ㎖ of tube, added with 3 ㎖ of 6N-HCl, injected with N2 gas and sealed. After 24-hr hydrolysis on 110 ℃ heating block, the solution was filtered, concentrated on the condenser with a reducing-pressure control (EYELA, USA), removed of Cl gas using N2 gas, added with 5 ㎖ of pH 2.2 sodium citrate buffer, and filtered through 0.2 ㎛ membrane filter for analysis of amino acids (Biochrom 20, England).

2) It is practically impossible to measure body weight of sow immediately before and after farrowing although such times are most ideal to identify any changes in body compositions followed by farrowing. It is because measuring body weight of sow at those times could easily cause mis-carriage, abortion, mortality and such unideal maternal behaviour affecting her subsequent mating, pregnancy and farrowing. Therefore, in this experiment body weights were measured instantly after moving to the farrowing unit and on the day of weaning, as practiced at the farm.
Total weight gain was gained by subtracting body weight at initiation from body weight at termination, and daily weight gain was obtained by dividing total weight gain by the days from initiation to termination. Weight gain of piglet was calculated using body weight measured immediately after farrowing and body weight measured at the time of weaning.

3) Total feed intake of gilt was gained by multiplying daily feed intake by the days of feeding and subtracting the total left in the feeder from it. Daily feed intake was obtained by dividing total feed intake by the days of feeding. Feed intake of creep feeds by nursery piglets was removed from the criteria because those are spreaded over the floor according to the farm's management practices.

4) Measurement of back fat thickness of gilt was conducted at the time of mating, immediately after transferring to the farrowing unit and on the day of weaning piglet at the age of 21 days, using Digital backfat indicator (Renco lean-meter, USA). Measurements on the location of the first and tenth rib and the lumbar vertebrae were averaged for comparison.

6) Total litter size, litter weight at birth, total number of piglet survived, survival rate and litter weight at weaning were recorded. Total litter size and litter weight included healthy, weak and dead piglets at birth. The newly-born piglets were individually weighed and

marked and weighed again at the time of weaning to calculate weight gain. Survival rate of litter was calculated by excluding culled and dead piglets until weaning.

7) As for evaluation of re-estrus, after experimental animals (gilt) were moved from the farrowing unit to the gestation unit, 1.5 kg of diet was fed on the day of weaning and 3 kg of diet every day since then. The days required to re-estrus were recorded after gilts were indirectly exposed to boar.

8) For analysis of blood profiles of piglets, three litters were randomly selected from each treatment. 2 ㎖ of blood was collected using K3 EDTA Vacuum tube (Becton Dickinson Vacutainer Systems, Franklin Kakes, NJ) for analysis. WBC (white blood cell), lymphocyte and monocyte were measured using a blood cell counter (VET abc, france, 2002). For biochemical examination of blood, 5 ㎖ of blood was collected using Vacuum tube (Becton Dickinson Vacutainer Systems, Franlin Lakes, NJ), centrifuged at 2,000 × g for 30 minutes at 4 ℃ to obtain blood serum. Using a blood biochemical analyzer (Express Plus, Bayer USA, 2002), total protein and Albumin were determined.

9) For economical efficiency analysis, the costs of the diets based on U.S. dehulled soybean meal (T1), Indian non-dehulled soybean meal (T2) and Argentine non-dehulled soybean meal (T3) were calculated 182.71 won/kg, 177.47 won/kg, and 177.19 won/kg, respectively, for gestation, and 200.89 won/kg, 195.00 won/kg and 195.23 won/kg, respectively, for lactation. Total diet costs were calculated by multiplying total feed amount consumed by each gilt during the experimental period by the diet cost per kg and the diet costs required to produce one piglet and 1 kg of piglet were also calculated for comparison.

8. Statistical analysis

All the data and results obtained from this feeding trial were analyzed using SAS/GLM (General Linear Model) procedure (SAS, 1999) and comparison among treatment means was performed by Tukey Test.

Ⅲ. Results and Discussion

1. Approximate compositions, gross energy and KOH protein solubility

Approximate compositions, gross energy and KOH protein solubility (0.2%) of U.S. dehulled soybean meal, Indan non-dehulled soybean meal and Argentine non-dehulled soybean meal used for this experiment are shown in Table 4.

Crude protein contents were 47.42 %, 44.54 % and 44.38 % in the order of U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal, respectively.

Crude ash contents were 6.06 %, 5.86 % and 7.01 % in the order of U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal, respectively.

Crude fiber contents, an indicator of extent of dehulling, were 3.25 %, 6.86 % and 6.74 % in the order of U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal, respectively.

Gross energy contents were measured at 4,171 cal/g for U.S. dehulled soybean meal, 3,922 cal/g for Indian non-dehulled soybean meal and 4,127 cal/g for Argentine non-dehulled soybean meal, respectively.

KOH(0.2%) protein solubility of U.S. dehulled soybean meal was determined 88.47%, which was highest among the three soybean meals tested. Those of Indian and Argentin non-dehulled soybean meals were 84.04 % and 84.79 %, respectively, being 3.5~4.0% lower than U.S. dehulled soybean meal.

Table 4. Approximate compositions, gross energy and KOH protein solubility of soybean meals used in the experiment

Items	USDSM	INDSM	ANDSM
Moisture(%)	12.14±0.02	11.38±0.13	11.97±0.06
Ether extract(%)	1.51±0.06	1.76±0.11	1.64±0.09
Crude protein(%)	47.42±0.05	44.54±0.15	44.38±0.95
Crude ash(%)	6.06±0.07	5.86±0.11	7.01±0.22
Crude fiber(%)	3.25±0.25	6.86±0.10	6.74±0.17
Gross energy(cal/g)	4,171	3,922	4,127
KOH(0.2%)solubility, %	88.47±0.47	84.04±0.04	84.79±0.97

USDSM : US. dehulled soybean meal
INDSM : Indian non-dehulled soybean meal
ANDSM : Argentine non-dehulled soybean meal

2. Amino acid compositions

Amino acid compositions of U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal used in the experimental diets are listed in Table 5.

Sulfur-containing amino acids, Cystine and Methionine, were higher for U.S. dehulled soybean meal than the other non-dehulled soybean meals of Indian and Argentine origin. In addition, the contents of Leucine, Isoleucine, Valine and Phenylalanine were higher in U.S. dehulled soybean meal than those of Indian and Argentine non-dehulled soybean meals.

Percentages of most amino acid contents against protein contents appeared to be slightly greater in U.S. dehulled soybean meal than the other non-dehulled soybean meals of Indian and Argentine origin. Lysine content was highest for U.S. dehulled soybean meal among the tested three soybean meals of which lysine contents were analyzed to be 2.75 %, 2.71 % and 2.63 %, respectively, in the order of U.S., Indian and Argentine origin.

Contents of essential amino acids present in U.S. dehulled soybean meal, Indian non-dehulled soybean meal and Argentine non-dehulled soybean meal were 19.29 %, 19.09 % and 18.85 %, respectively, being highest in the U.S. origin.

Table 5. Essential and non-essential amino acid compositions of soybean meals of U.S., Indian and Argentine origin (%)

Items	USDSM	INDSM	ANDSM
Essential AA			
Threonine	1.55±0.21	1.57±0.32	1.60±0.34
Valine	2.22±0.31	2.20±0.54	2.16±0.28
Isoleucine	2.11±0.22	2.10±0.14	2.09±0.08
Leucine	3.24±0.12	3.17±0.07	3.18±0.23
Phenylalanine	2.28±0.21	2.25±0.18	2.19±0.14
Lysine	2.75±0.10	2.71±0.04	2.63±0.51
Arginine	3.30±0.34	3.22±0.34	3.18±0.23
Histidine	1.21±0.33	1.27±0.04	1.20±0.07
Methionine	0.63±0.01	0.60±0.06	0.62±0.04
Total	19.29±0.77	19.09±0.80	18.85±0.79
Non-essential AA			
Aspartic acid	4.86±0.05	4.89±0.14	4.79±0.04
Serine	1.86±0.14	1.79±0.12	1.83±0.02
Glutamic acid	8.13±0.31	7.87±0.21	8.02±0.24
Proline	2.20±0.35	2.39±0.34	2.22±0.14
Glycine	1.88±0.02	1.88±0.11	1.89±0.05
Alanine	2.01±0.41	2.01±0.09	1.90±0.36
Tyosine	1.55±0.36	1.55±0.13	1.53±0.16
Cystine	0.40±0.04	0.36±0.02	0.38±0.04
Total	22.89±0.82	22.74±0.71	22.56±0.45

USDSM : US. dehulled soybean meal
INDSM : Indian non-dehulled soybean meal
ANDSM : Argentine non-dehulled soybean meal

Like essential amino acids, non-essential amino acid contents were highest in U.S. dehulled soybean meal among the three soybean meals which were determined to contain 22.89 %, 22.74 % and 22.56 %, respectively, in the order of U.S., India and Argentine origin.

3. Effects on gestation gilts

Feed intake, body weight and back fat thickness of gilts provided the three experimental diets containing U.S. dehulled soybean meal, Indian and Argentine non-dehulled soybean meal for 100 days after mating are represented in Table 6.

Out of total 60 gilts assigned for this trial, 7 were culled, 1 from T1, 2 from T2 and 4 from T3, respectively, due to radical changes in room temperature and unidentified stress factors exerted during the experimental period.

Table 6. Effects of feeding the three experimental diets to gilts during gestation

Items	T1	T2	T3
No. of gilts, at start	20	20	20
No. of gilts, abortion	1	2	4
Fertility(%)	95	90	80
Gestation duration (d)	114.23	114.35	114.36
Feed intake (100 days, kg)	265.00	272.00	270.00
Feed intake (14 days, kg)	11.20	11.48	11.62
Feed intake (kg/d)	2.42	2.49	2.47
Body weight			
at mating (kg)	171.84±2.93	171.37±4.65	170.20±3.45
d-100 after mating (kg)	205.10±2.61^{a}	201.26±2.28^{b}	200.15±2.73^{b}
change (kg)	33.26±1.88^{a}	29.89±1.40^{b}	29.95±1.66^{b}
change (kg/day)	0.33±0.01	0.30±0.01	0.30±0.01
Back fat thickness			
at mating (mm)	12.74±1.05	12.06±1.66	12.56±1.46
d-100 after mating (mm)	15.32±1.34	14.56±1.72	15.13±1.54
change (mm)	2.58±0.52	2.50±0.51	2.56±0.51

$^{a-b}$Means±SD in the same row with different superscripts differ significantly(p<0.05).
T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

Total feed intakes for 100 days after mating were 265.00 kg, 272.00 kg and 270.00 kg in the order of T1, T2 and T3, respectively, being highest for the T2. Feed intakes for 14 days since then were 11.20 kg, 11.48 kg and 11.62 kg, respectively, in the order of T1, T2 and T3. Average daily feed intake of T1, T2 and T3 were 2.42 kg/day, 2.49 kg/day and 2.47 kg/day, respectively, without any significant differences among treatments (P<0.05).

Average body weights of gilts on the day 100 after mating were 205.10 kg, 201.56 kg and 200.15 kg in the order of U.S., Indian and Argentine origin, respectively (P<0.05). Looking to the changes in body weights of gestation gilts fed the experimental diets, T1, T2 and T3 showed the differences of 33.26 kg, 29.89 kg and 29.95kg between the two points of timing, respectively, being highest for the T1 fed the U.S. dehulled meal-containing diet (P<0.05).

Consequently, daily body weight changes (kg/day) were 0.33 kg, 0.30 kg and 0.30 kg in the order of T1, T2 and T3, respectively (P<0.05).

At mating, back fat thickness was 12.74 mm, 12.06 mm and 12.56 mm in the order of T1, T2 and T3, respectively, while back fat thickness measured on the day 100 after mating was 15.32 mm, 14.56 mm and 15.13 mm, respectively, with the differences of 2.58 mm, 2.50 mm and 2.56 mm, showing no significant differences among treatments.

4. Effects on lactation gilts

Performances of gilts fed the three experimental diets containing U.S. dehulled meal, Indian and Argentine non-dehulled meal during lactation are shown in Table 7.

Table 7. Effects of feeding three experimental diets containing U.S. dehulled meal, Indian and Argentine non-dehulled meal to gilts during lactation

Items	T1	T2	T3
No. of heads	19	18	16
Total feed intake(kg)	67.62	68.25	68.04
Daily feed intake(kg/일)	3.22	3.25	3.24
Body weight			
Day 100 after mating(kg)	205.10±1.61[a]	201.26±1.28[b]	200.15±1.73[b]
At weaning(kg)	195.13±1.59[a]	191.63±1.65[b]	191.22±2.11[b]
Change(kg)	-9.97±1.37[a]	-9.62±1.11[a]	-8.85±0.07[b]
Back fat thickness			
Day 100 after mating (mm)	15.32±1.34	14.56±1.72	15.13±1.54
At weaning(mm)	15.58±1.30	14.72±1.49	15.44±1.46
Change(mm)	0.26±0.65	0.17±1.10	0.26±0.56
Days to re-estrus			
1~3 days after weaning, No. of heads	3	2	0
4~6 days after weaning, No. of heads	7	5	5
7~9 days after weaning, No. of heads	9	11	11
Total no. of heads on re-estrus	19	18	16
Average days to re-estrus	6.47	6.67	7.00

[a-c]Means±SD in the same row with different superscripts differ significantly($p<0.05$).
T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

Total feed intake of gilts during lactation was 67.62 kg, 68.25 kg and 68.04 kg in the order of T1, T2 and T3, respectively, without any significant differences among treatments. Daily feed intake of gilts during lactation was 3.22 kg, 3.25 kg and 3.24 kg in the same order, respectively, without any significant differences among treatments.

Body weights measured on the day 100 after mating were 205.10 kg, 201.26 kg and 200.15 kg in the order of T1, T2 and T3, with T1 showing the highest among treatments ($P<0.05$). Body weights measured on the day of weaning were 195.13 kg, 191.63 kg and 191.22 kg, respectively, in the same order, with T1 showing the highest among treatments ($P<0.05$).

Looking to the changes in body weights of gilts, T1, T2 and T3 showed -9.97 kg, -9.62 kg and -8.85 kg, respectively, with T1 showing the greatest change in body weight among treatments.

Back fat thickness of gilts on the day 100 after mating was 15.32 mm, 14.56 mm and 15.13 mm for T1, T2 and T3, respectively, without any significant differences among treatments, while back fat thickness after weaning was 15.58 mm, 14.72 mm and 15.44 mm for T1 T2 and T3, respectively, without any significant differences among treatments. The differences in back fat thickness from the day 100 after mating to the day of weaning were 0.26 mm, 0.17 mm and 0.26 mm in the order of T1, T2 and T3, respectively, with T2 showing the lowest change among treatments.

The number of gilts on heat 1 to 3 days after weaning were 3, 2 and 0 for T1, T2 and T3, respectively, with T1 showing the highest among treatments, and the number of gilts on heat 4 to 6 days after weaning were 7, 5 and 5 in the order of T1, T2 and T3, respectively, with T1 being highest among them. The number of gilts on heat 7 to 9 days after weaning was 9, 11 and 11 for T1, T2 and T3, respectively. In conclusion, the average days required to reach re-estrus were estimated 6.47 days, 6.67 days and 7.00 days in the order of T1, T2 and T3, with T1 showing the highest among treatments.

5. Effects on nursery piglets

Reproductive performances of gilts fed the three experimental diets containing U.S. dehulled meal, Indian non-dehulled meal and Argentine non-dehulled meal for the duration from gestation to lactation are shown in Table 8.

Table 8. Effects of feeding three experimental diets containing U.S. dehulled meal, Indian and Argentine non-dehulled meal to gilts from gestation to lactation on piglets

Items	T1	T2	T3
Litter size (piglets/litter)	10.21±1.51[a]	8.61±1.38[b]	8.19±1.33[b]
Born dead (piglets/litter)	0.25±0.55	0.28±0.12	0.18±0.12
Culled(piglets/litter)	0.07±0.26	0.12±0.33	0.12±0.33
Born alive (piglets/litter)	9.89±1.20[a]	8.21±1.11[b]	7.89±1.41[b]
Survival rate(%)	96.87	96.01	96.34
Litter weight (kg/litter)	12.97±1.81[a]	10.75±1.67[b]	10.34±1.84[b]
Litter weight (kg/piglet)	1.31±0.57	1.31±0.46	1.31±0.25
Litter weight at weaning (kg/litter)	75.48±1.00[a]	62.04±0.90[b]	59.13±1.00[b]
Litter weight at weaning (kg/piglet)	7.71±0.27	7.65±0.38	7.63±0.32
No. of piglets at weaning (piglets/litter)	9.79±1.13[a]	8.11±1.02[b]	7.75±1.41[b]
Weaning rate (%)	98.98	98.78	98.23

[a-b]Means±SD in the same row with different superscripts differ significantly($p<0.05$).
T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

Reproductive performances of gilts fed the three experimental diets containing U.S. dehulled meal (T1), Indian non-dehulled meal (T2) and Argentine non-dehulled meal (T3) as a major protein ingredient from gestation to lactation (21 days of nursing) were compared to evaluate their effects on productivity,

Litter size at birth (piglets/litter) were 10.21, 8.61 and 8.19 in the order of T1, T2 and T3, respectively, indicating that T1 containing U.S. dehulled meal was highest ($P<0.05$).
Number of piglets born dead (piglets/litter) were 0.25, 0.28 and 0.18 in the order of T1, T2 and T3, showing that T3 is lowest without any significant differences among treatments, but number of piglets culled before weaning (piglets/litter) were 0.07, 0.12 and 0.12 in the same order, respectively, although T1 appeared to be lowest among treatments without any significant differences.

Litter weight at birth of T1 fed the U.S. dehulled meal was 12.97 kg, and those of T2 and T3 fed the Indian and Argentine non-dehulled meal were 10.75 kg and 10.46 kg, respectively, demonstrating that T1 was significantly higher than T2 and T3 ($P<0.05$).

Number of piglets survived prior to weaning (piglets/litter) were 9.89, 8.21 and 7.88 for T1, T2 and T3, respectively, showing that T1 was highest among treatments (P<0,05), and survival rates of litter were 96.87%, 95.35% and 96.34% in the order of T1, T2 and T3, respectively, although T1 appeared to be higher than T2 and T3.

Litter weight at birth were 12.97 kg, 10.75 kg and 10.34 kg in the order of T1, T2 and T3, showing that T1 was highest among treatments ($P<0.05$), and body weights per piglet born were 1.31 kg, 1.31 kg and 1.31 kg for T1, T2 and T3, respectively.

Litter weights at weaning were 75.48 kg, 62.04 kg and 59.13 kg in the order of T1, T2 and T3, respectively, showing that T1 was highest among treatments ($P<0.05$), and body weight per piglet at weaning were 7.71 kg 7.65 kg and 7.63 kg in the order of T1, T2 and T3, respectively, without any significant differences among treatments.

Number of piglets weaned per litter (piglets/litter) were 9.79, 8.11 and 7.75 in the order of T1, T2, and T3, respectively, indicating that T1 was highest among treatments ($P<0.05$). Percentage of piglets weaned out of total piglets born was 98.98 %, 98.78 % and 98.23 % for T1, T2 and T3, respectively, without any significant differences among treatments.

6. Effects on blood profiles of piglets

The effects of feeding the experimental diets containing three different origins of soybean meals to gilts from gestation to lactation on the blood profile of piglets are shown in Table 9.

Analysis of blood of piglets randomly selected from each treatment showed that total protein contents were 5.32 g/dl, 5.36 g/dl and 5.37 g/dl in the order of T1, T2 and T3, respectively, without any significant differences among treatments.

Albumin contents of blood were 3.02 g/dl, 3.03 g/dl and 3.03 g/dl in the order of T1, T2 and T3, respectively, similarly without significant differences among treatments.
WBC (Whilte Blood Cell) concentrations were $16.42\times10^3/mm^3$, $15.98\times10^3/mm^3$ and $16.01\times10^3/mm^3$ for T1, T2 and T3, respectively, indicating that T1 was highest among treatments ($P<0.05$).

Lymphocyte contents were determined to be 71.60 %, 71.45 % and 71.40 % in the order of T1, T2 and T3, respectively, but no significant differences were observed among treatments even though T1 appeared to be highest.

Monocyte contents of T1, T2 and T3 were determined to be 6.23 %, 5.78 % and 5.77 %, respectively, demonstrating that T1 has the highest value (P<0.05).

Table 9. Effects of feeding the experimental diets containing U.S. dehulled meal, Indian and Argentine non-dehulled meal to gilts during gestation and lactation on blood profile of piglets

Items	T1	T2	T3
Total protein (g/dl)	5.32±0.02	5.36±0.06	5.37±0.12
Albumin (g/dl)	3.02±0.04	3.03±0.13	3.03±0.08
WBC($10^3/mm^3$)	16.42±0.02^a	15.98±0.02^b	16.01±0.03^b
Lymphocyte(%)	71.60±0.17	71.45±0.16	71.40±0.27
Monocyte(%)	6.23±0.14^a	5.78±0.11^b	5.77±0.36^b

$^{a-b}$Means±SD in the same row with different superscripts differ significantly(p<0.05).
T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

In general, it has been well recognized that the differences in blood profiles of pigs are induced by not only animal factors such as age, body weight, sex, breed, health status and growth rate but also environmental factors such as season, temperature, time of measuring, etc. and the methods to collect blood (Swenson et. al., 1995). Considering these factors, the differences in blood profile observed in this study seemed to be caused by some of the factors listed above, or other unidentified factors.

7. Analysis of economical efficiency

Table 10 shows the production (feed) costs per piglet generated from gilts fed the three experimental diets containing different origins of soybean meals (U.S., India and Argentina) for the duration from gestation to lactation.

Feed costs of U.S. dehulled meal-containing diet (T1), Indian non-dehulled meal-containing diet (T2) and Argentine non-dehulled meal-containing diet (T3) were estimated at 182.71 won/kg, 177.47 won/kg and 177.19 won/kg for gestation, respectively. Those of T1, T2 and T3 for lactation were calculated 200.89 won/kg, 195.00 won/kg and 195.23 won/kg, respectively.

Feed intakes during gestation were 298.60 kg, 305.60 kg and 303.60 kg for T1, T2 and T3, respectively, and feed intakes during lactation were 67.62 kg, 68.25 kg and 68.04 kg for T1, T2 and T3, respectively. Feeding duration of gestation was 114 days and that of lactation was 21 days.

Feed costs for the duration of gestation were calculated 54,557won, 54,234won and

53,794won for T1, T2 and T3, respectively, and those for the duration of lactation were calculated 13,584won, 13,308won and 13,283won for T1, T2 and T3, respectively, showing that T1 was the most expensive diet among them.

Table 10. Comparison of economical efficiency of three experimental diets containing U.S., Indian and Argentine origin of soybean meal fed to gilts during gestation and lactation

Items		T1	T2	T3
Feed cost (won/kg)	Gestation	182.71	177.47	177.19
	Lactation	200.89	195.00	195.23
Feed intake (kg)	Gestation	298.60	305.60	303.60
	Lactation	67.62	68.25	68.04
Total		366.22	373.85	371.64
Feed intake (won/kg)	Gestation	54,557.21	54,234.83	53,794.88
	Lactation	13,584.18	13,308.75	13,283.45
Total		68,141.39	67,543.58	67,078.33
No. of weaned piglets		9.79	8.11	7.75
Production costs(won/piglet)		6,960	8,328	8,655
Production costs (won/kg)		5,254	6,283	6,413
Relative savings in costs (%)		18.07	16.38	0

T1 : US. dehulled soybean meal
T2 : Indian non-dehulled soybean meal
T3 : Argentine non-dehulled soybean meal

Total feed costs summing both gestation and lactation duration were estimated at 68,141won, 67,543won and 67,078won for T1, T2 and T3, respectively.

Number of piglets weaned per litter were 9.79, 8.11 and 7.75 in the order of T1, T2 and T3, respectively, and feed costs per piglet of each litter were calculated 6,960won, 8,328won and 8,655won, respectively. It demonstrated that the diet containing U.S. dehulled meal (T1) was lowest among treatments in terms of feed costs required to produce one piglet.

Feed costs per 1 kg of piglet were estimated at 5,254won, 6,283won and 6,413won in the order of T1, T2 and T3, respectively, showing that T1 was lowest among treatments.

In consequence, the feed costs of T1 required to produce 1 kg of piglet was 18.07% lower than T3 and 16.38% lower than T2, suggesting that U.S. dehulled meal could be more desirable than Indian and Argentine non-dehulled meals in saving the production costs of piglets although the diet cost per 1 kg was most expensive among the three diets.

Ⅳ. Summary

This study was carried out to evaluate the effects of feeding three experimental diets containing U.S. dehulled soybean meal (T1), Indian non-dehulled soybean meal (T2) and Argentine non-dehulled soybean meal (T3) as a major protein ingredient to gilts from

gestation to lactation on their reproductive performances and economical efficiency.

The feeding trial lasted 160 days from April 2006 to September 2006 including 3 weeks of mating for artificial insemination, 17 weeks of gestation and 2 weeks of farrowing, nursing and weaning. The feeding trial was conducted at a commercial farm specially raising American Berkshire breeds, which is located in Hamyang, Gyeongsangnam-do province. A total of 60 American Berkshire replacement gilts were assigned to 3 treatments with 20 replications.

Total feed intake of gilts was lowest in T1 among treatments, but no significant differences were found in average daily feed intake accounting for 114 days of gestation. Feed conversion was lowest in T1 among treatments ($P<0.05$).

There were no significant differences in body weights measured at mating, and body weight measured on the day 100 after mating was greater in T1 than T2 and T3 ($P<0.05$). The changes (kg) in body weight between the day of mating and the day 100 after mating were greatest for T1 ($P<0.05$).

No significant differences in back fat thickness (mm) were found among treatments.
Average daily feed intake of gilts for the duration of lactation was not significantly different among treatments..

Body weights of gilts measured on the day 100 after mating were significantly greater in T1 than T2 and T3, and body weights of gilts measured on the day of weaning was also greater in T1 than T2 and T3 ($P<0.05$).

The differences in back fat thickness between the day 100 after mating and the day of weaning were greatest for T1, and lowest for T3 among treatments ($P<0.05$).

Numbers of gilts reached re-estrus 1 to 3 days and 4 to 6 days after weaning were highest in T1 among treatments, but number of gilts reached re-estrus 7 to 9 days after weaning was 11 for both T2 and T3, which was higher than T1.

Therefore, the days required to reach re-estrus were lowest for T1 fed the diets containing U.S. dehulled meal among treatments.

Litter size was significantly highest in T1 fed U.S. dehulled meal among treatments ($P<0.05$). Number of piglets born dead was lowest in T3 fed Argentine non-dehulled meal without any significant differences among treatments, and number of piglets culled before weaning was lowest in T1 without significant differences among treatments.

Litter weight was significantly higher in T1 than both T2 and T3 ($P<0.05$). Number of piglets per litter survived before weaning was highest in T1 among treatments ($P<0,05$), but survival rates (%) of piglets per litter were not significantly different among treatments..

Litter weight was highest in T1 fed U.S. dehulled meal among treatments ($P<0.05$), but body weight of individual piglet per litter was not significantly different among treatments.

Litter weight at weaning was significantly highest in T1 fed U.S. dehulled meal ($P<0.05$), but body weight of individual piglet weaned was not significantly different among treatments.

Number of piglets weaned per litter (heads/litter) was highest in T1 fed U.S. dehulled meal among treatments ($P<0.05$), and weaning rate (%) was not significantly different among treatments although minor differences were observed.

Analysis of blood of piglets randomly selected from each treatment showed no significant differences in total protein and Albumin contents among treatments. WBC concentrations were significantly highest in T1 fed U.S. dehulled meal among treatments ($P<0.05$).

Calculated by multiplying total feed intake (kg) by the diet cost per kg, feed costs for the duration of gestation were 54,577 won, 54,234 won and 53,794 won in the order of T1, T2 and T3, respectively, and feed costs for the duration of lactation were 13,584 won, 13,308 won and 13,283 won in the same order as above, respectively, indicating that T1 diet was most costly for both gestation and lactation.

Summing the feed costs for both gestation and lactation duration, T1, T2 and T3 were estimated at 68,141 won, 67,534 won and 67,078 won, respectively, also showing that T1 fed U.S. dehulled meal was most costly among treatments.

However, the production costs termed as feed costs required to produce one piglet or produce 1 kg of piglet from a gilt was lowest in T1 fed U.S. dehulled meal among treatments. The relative production costs of T1 to produce 1 kg of piglet was estimated 18.07 % cheaper than T3 and 16.38 % cheaper than T2, implying that U.S. dehulled meal could be the most desirable soybean meal for feeds for gestation and lactation gilts or sows.

Ⅴ. Literature Cited

A.O.A.C. 2005. Official method of analysis, Association of Offical Agricultural Chemists. Washington, D. C.

Aherne, F. X. and Krikwood, R. N. 1985. Nutrition and sow prolificacy. J. Reprod. Fertil. Suppl. 33:169.

Boyd, R. D., Moser, B. D., Peo, L. R. Jr. and Cunningham, P. J. 1978. Effect of energy source prior to parturition and during lactation on piglet survival and growth and on milk lipids. J. Anim. Sci. 47:883-892.

Bushman, D. H. and Lee. S. H. 1998. Dehulled soybean meal, non-fish meal diets and parametric formulation for increased profit with broilers. A draft paper obtained from ASA, Seoul.

Cast, W. R. 1977. Tarrow, Choline and tyroprotein additions to the gestation-lactation diet of swine. M.S. thesis, Library, University of Nebraska-L incoin.

Christain, L. L. 1992. Breeding swine evaluation, 1992-1993. Winter Swine Series, Breeding, Feeding, and Marketing Lean Pork. Iowa State University.

Chung, K. K., Lee, B. D. and Park. H. S. 1988. Effects of feeding dehulled soybean meal and full fat soybean on the performance and profitability of broilers. Korean Journal of Animal Nutrition and Feed 12:292-297.

Close, W. H. and Cole, D. J. A. 2000. Nutrition of sows and boars. Nottingham Univ. Press. p. 5.
Cronin. G. M., Simpson, G. J. and Hemsworth, P. H. 1996. The effects of the gestation and farrowing environments on sow and piglet behaviour and piglet survival and growth in early lactation. Appl. Anim. Behav. Sci. 46:175-192.

D. H. Kim, J. Y. Park and J. H. Woo. 2003. Effect of gestation housing and parity on the farrowing performance and behaviour of sows during the pregnancy, farrowing and lactation. J. Anim Sci.

Technol. Kor.. 45(6):1067-1078.

D. S. Son, J. H. Lee, S. H. Choe, S. H. Yeon, I. S. Ryu, G. H. S대, T. Y H대, S. J. Park, G. H. Jo, C. H. Yu, N. C. Kim and C. S. Park. 2003. Studies on early selection of excellent gilts for improvement of reproductive efficiency.

Dourmad, J. Y., Etienne, M., Prunier, A. and Noblet, J. 1994. The effect of energy and protein intake of sows on their longvity : A review. Livest. Prod. Sci. 40:87.

Etienne, M., Noblet, J. and Desmoulin. 1985. Mobilisation des reserves coporelles chez la truie primipare en lactation. Reprod. Nutr. Develop. 25:341.

Graham, P. L., Mahan, D. C. and Shields, R. G. Jr. 1981. Effect of starter diet and length of feeding regimen on performance and digestive enzyme activity of 2-week old weaned pigs. J. Anim. Sci. 53:299.

Gyeongnam Advanced Swine Research Institute. 2004. 경남 흑돈 계통조성에 관한 연구. 모돈 생산성 유전능력평가. 2005년도 연구설계사업 심의 자료. pp9-10.

Gyeongnam Advanced Swine Research Institute. 2005. 경남 흑돈 계통조성 및 브랜드화. 후보 종빈돈의 등지방 두께가 번식에 미치는 영향. 2005년도 연구사업 추진현황, 2006년도 연구 설계사업 심의 자료. pp9-12.

Gyeongnam Advanced Swine Research Institute. 2005. 경남 흑돈 계통조성에 관한 연구. 경남 양돈 모돈의 생산성 유전능력 평가. 2005년도 연구결과발표자료, pp6-11.

Hwang, K. Y. 2000. Effect of different originated-soybean meal inclusion in gestation diets on sow and litter performance. Paper obtained from Korea University.

Kim, C. W., Jin, S. K. and Kim. D. H. 1995. Effects of mating type, parity and weaning age on sow`s body condition and reproductive traits in swine. Korean J. Anim. Sci. 37(5)467-474.

King, R. H. and Dunkin, A. C. 1986. The effect of nutrition on the reproductive preformance of frist-litter sows 3. The response to graded increase in food intake during lactation. Anim. Prod. 42:19.

Maeng, W. J., Kim, Y. J. and I. Choi. 1998. Effects of animal fat in the gestation diets on the birth weight and survival rate of piglets and days of estrus return of sows after postweaning. Korean J. Anim. Sci., 30(5) 297-300.

Min, B. J., Kwon, O. S., Hong, J. W., Son, K. S. and Kim, I. H. 2005. Effects of herbal plant mixture (Miracle®) supplementation on the productivities of lactating sows and growth performance and hematological characteristics of piglets. J. Anim. Sci & Technol. (Kor.) 47(3) 371-378.

Morrison, F. B. 1956. Feed and Feedings(22nd Ed). Morrison Pub. Co., Ithaca, N. Y.

Moser, B. D. and Lewis, A. J. 1980. Adding fat to sow diets. Feedstuff. 52:36.

Newton, E. A., and Mahan, D. C. 1993. Effect of initial breeding weight and management system using a high-producing sow genotype on resulting reproductive performance over three parities. J. Anim. Sci. 71:1177-1186.

Okai, D. E., Aherne, F. X. and Hardin, R. T. 1977. Effects of sow nutrition intake and gestation on the body composition and survival of the neonatal pig. Can. J. Anim. Sci. 57:439.

Pettigrew, J. E. 1978. Supplemental fat in sow diets. Proc. Pacific Northwest pork exposition. Washington State University, Pullman. Nov. 14-17.

Quiniou, N. and Noblet, J. 1999. Influence of high ambient temperatures on performance of multiparous lactating sows. J. Anim. Sci. 77:2124-2134.

Robinson, J. J. 1990. Nutrition in the reproduction of earn animals. Nutr. Res. Rev. 3:253.

Rozeboom, D. W., Pettigrew, J. E., Moser, R. L., Cornelius, S. G. and Kandelgy, S. M. El. 1996. Influence of gilt age and body composition at first breeding on sow reproductive performance and longevity. J. Anim. Sci. 74:138-150.

SAS. 1999. SAS user's Guide:Statistics, SAS Inst. Ins, Cary, NC.

Seerley, R. W. 1981. High fat rations for sows can benefit piglets. Feedstuff. March.

Seerley, R. W., Maxwell, J. S. and McCambell, H. C. 1978. A comparison of energy sources for sows and subsequent effect on piglets. J. Anim. Sci. Vol. 47:1114-1120.

Seerley, R. W., Pace, T. A. Folry, C. W. and Scarth, R. D. 1974. Effect of energy intake prior to parturition on milk lipids and survival rate, thermostability and carcass composition of piglets. J. Anim. Sci. 38:64-70.

Swenson, M. J., D. D. Goetsh and G. K. L. Underbieges. 1995. The effect of the sow's tation on the hematology of the newborn pig proc book, AVWA. 36:159-161.

Swick, R. A. 1995. Selection and use of soybean meal in swine feed. ASA Technical Bulletine. MITA NO. 083/12/94. ASA, Singapore.

Swick, R. A. 1998. Soybean meal: present quality and future trends. ASA Technical Bulletine. MITA(P)NO. 096/11/97. AN14-1998. ASA, Singapore.

T. S. Koh, K. C. Lee, C. L. Choi, M. C. Chang, B. S. Parkand S. Y. Kim. 1999. Influence of supplemental microbial phytrase on the utilization of energy and protein of soybean meals from domestic, brazil, china and india in layer. Kor. J. Anim. Nutr. Feed.. 23(2):99-110.

Teaque, H. S. and Rutledge. E. A. 1960. Soybean oil meal as a protein source for successive generations of swine. J. Anim. Sci. 19:902-909.

Tokach, M. D., Goodband, R. D., Nelssen, J. L. and Kats, L. J. 1992. Influence of weaning weight and growth during the first week postweaning on subsequent pig performance. Kansas State University Swine Day. 1992. p. 15.

Van Kempen, G. J. M., Geerse, C., Verstengen, M. W. A. and Mesu, J. 1995. Effect of feeding level on milk production of sow during four weeks of lactation. Neth. J. Agric. Sci. 33:23.

Whittemore, C. T. 1996. Nutrition reproduction interaction in primiparous sows. Livest. Prod. Sci. 46:65-83.

Young, L. G., King, G. J., Walton, J. S., Mc Millan, I. and Klevorick, M. 1990. Age, weight, backfat and time of mating effects on performance of gilts. Can. J. Anim. Sci. 70:469-481.

김춘수, 김인호. 1998. 최신 양돈사료와 영양. 신광종합출판. 서울.

김형관, 박유헌, 김희성, 이형석, 신인수, 황광연. 2000. 대두박의 원산지와 사료의 조단백질 수준이 육계의 성적에 미치는 영향. 축산분야종합학술대회 2000 (Proceedings of the 9th annual congress) Vol. Ⅱ :p149.

박흥석. 1998. 육성-비육돈에 대한 세가지 대두박 자원의 사료 및 경제적 가치 비교. American Soybean Association/ Korea.