Effects of Phase Feeding on Growth Performance, Nutrient Digestibility, Nutrient Excretion and Carcass Characteristics of Finishing Barrow and Gilt[a]

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ABSTRACT : A total of 120 finishing crossbred pigs (Landrace×Large White×Duroc) with equal numbers of barrows and gilts weighing 58.5 kg body weight were used in a feeding trial, and 6 pigs (three of each sex) were used in a metabolic trial to investigate the effect of phase feeding. Finishing period was divided into two phases and 4 different diets were fed for those periods. Growth performance was not significantly different among treatments within the same sex. This result showed that 16% crude protein for early finishing period and 14% crude protein diet for late finishing period should be optimum. During the early finishing period, only feed intake was significantly different between sexes ($p<0.01$), but in late finishing period daily weight gain ($p<0.0001$) and feed intake ($p<0.01$) of barrows were significantly higher than those of gilts. During the early finishing period, digestibilities of dry matter, protein and phosphorus were significantly higher in gilts than in barrows ($p<0.05$). However, there was no treatment effect within same sex during the early and late finishing period. During early finishing period, excretion of N of pigs fed 16% CP diet in early and 14% CP diet in late-finishing period was less than that of pigs fed 17% CP diet in early and 15% CP diet in late-finishing period ($p<0.05$), but the difference was not significant. During the late finishing period, N excretion with two phase feeding was reduced by 8.5% compared with single feeding. In gilts, total cost reduction by two phase feeding compared to single feeding was 9.1%, but in barrows it was just 3.19%. Relative margin increased with two phase feeding by 2.5% in gilts and 0.2% in barrows. There was a tendency that backfat thickness at 10th rib of gilts was thinner than that of barrows ($p>0.05$). Within the same sexes, there was no treatment effect on back fat thickness ($p>0.05$). Carcass grade was improved by two phase feeding compared to single feeding. Carcass grade of gilts was significantly better than that of barrows ($p<0.001$). From this results, it is concluded that finishing pigs could be fed two-phase diets to improve profit and reduce pollution. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 6 : 802-810)*

Key Words : Phase Feeding, Pigs, Nutrient Digestibility, Fecal Nutrient Excretion, Sex, Barrows, Gilts, Carcass Characteristics

INTRODUCTION

In a current feeding systems, pigs are fed a single diet for the whole finishing period. In such feeding systems, finishing pigs are often oversupplied and a lot of nutrients are wasted in feces and urine. An attempt to meet the change in the animal's nutrient requirements over time, with increasing body weight and degree of maturity, is made by changing the composition of the feed. The more frequent the changes, the more exactly the requirements can be met. However, since handling a large number of feeds is not easy to practice in the farm, there is inevitably a compromise between the requirements of individuals, or of the herd, and the number of feeds used. Pigs are usually given access to two or three types of feeds from weaning to market weight and the differences between genotypes, sexes and states are often ignored.

Also, a great deal of attention is now being given to reduce pollutant excretions from livestock all over the world. By far, the most feasible ways to reduce animal excreta are to improve digestibility of nutrients with biologically active substances, such as enzymes or yeast (Kwon et al., 1995a, b; Noh et al., 1995; Park et al., 1994; Han and Min, 1991), and to reduce crude protein content in the diet using synthetic amino acids (Han et al., 1978, 1995; Chae et al., 1988; Daghir, 1983; Heo et al., 1995; Jin et al., 1997).

Some researchers suggested phase feeding as an alternative method to reduce the amount of animal excreta (Honeyman, 1996; Paik et al., 1996). Phase feeding is to use diets tailored to stage of production. This avoids over-feeding and the excretion of unwanted nutrients in the manure (Paik et al., 1996). Jongbloed and Lenis (1992) and Paik et al. (1996) suggested that with phase feeding, nitrogen and phosphorus excretion could be reduced by 2 to 10%. Honeyman (1996) also suggested that nitrogen and phosphorus excretion could be decreased by phase feeding. Since the amino acids requirements of a pig

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change as it grows, phase feeding could be introduced as a desirable method to reduce animal excreta without sacrificing animal growth performance.

To determine optimum market weight is very important for maximizing profit of swine farmers. Optimum market weight can be determined by several factors such as follows: (1) projected price trend; (2) carcass value relative to feed price; (3) whether carcass grades for light weight pigs are maintained as they reach heavy weight; and (4) price discounts for carcasses outside the optimum weight range (Grimes and Carlisle, 1977). Traditionally, the major limitation to increasing slaughter weights has been high carcass fat levels observed at heavier weights and the associated deterioration in feed efficiency. These two factors have moderated the rate of increase of slaughter weights over time. However, the genetic potential of commercial pigs has changed dramatically over recent years, particularly in terms of lean growth rates. Cisneros et al. (1996) reported that modern genotypes of pigs can be slaughtered at live weights up to 160 kg with limited impact on growth performance, commercial meat yields, or meat quality characteristics.

Currently, the optimum live weights specified by many packers fall between 100 and 115 kg weight, and market discounts can be more severe for light weight pigs than for heavier weight pigs outside the optimum range.

These experiments were performed to investigate 1) effects of multiphase feeding on growth performance, nutrient digestibility and excretion, and carcass characteristics of finishing barrows and gilts, 2) optimum market weight.

MATERIALS AND METHODS

A total of 120 finishing crossbred pigs (Landrace × Large White × Duroc) with equal numbers of barrows and gilts averaging 58.5 kg body weight was allocated to different treatments to investigate the effect of phase feeding on growth performance, nutrient digestibility, nutrient excretion and carcass characteristics of finishing barrows and gilts.

Corn and soybean meal were mixed to prepare experimental diets of 4 different protein and lysine levels (table 1). Finishing period was divided into two phases, early and late growing period, to investigate the effects of multiphase feeding on finishing pigs. Four different experimental diets were fed to pigs for the whole finishing periods. During the early finishing period, 16% crude protein (0.8% lysine) and 17% crude protein (0.85 lysine) diets were fed to pigs. During late finishing period, three different diets, 16% crude protein (0.8% lysine), 15% crude protein (0.75% lysine) diets and 14% crude protein (0.7% lysine) were fed to pigs. Major limiting amino acids except lysine were added to diets according to ideal amino acids patterns suggested by Baker and Chung (1992). The formula and chemical composition of experimental diets are presented in table 1.

Table 1. Formula and chemical composition of the experimental diets

Protein level (%)	17	16	15	14
Ingredients (%):				
Corn	50.24	55.23	55.99	58.81
Wheat	15.00	13.70	15.00	15.00
Corn germ meal	2.00	1.15	2.00	2.00
Soybean meal (dehulled)	20.40	19.35	15.35	12.70
Canola meal	4.00	3.00	4.09	4.00
Animal fat	1.65	1.30	1.25	1.00
Molasses	4.00	4.00	4.00	4.00
Limestone	0.50	0.50	0.50	0.50
Tricalciumphosphate	1.05	1.05	1.10	1.15
Salt	0.25	0.25	0.25	0.25
L-Lysine-HCl	0.00	0.00	0.04	0.07
Threonine	0.40	0.00	0.00	0.00
Premix[1]	0.52	0.52	0.52	0.52
Total	100.00	100.00	100.00	100.00
Chemical composition[2]:				
ME (Mcal/kg)	3.24	3.26	3.25	3.24
Crude protein (%)	17.00	16.00	15.00	14.00
Lysine (%)	0.85	0.80	0.75	0.70
Met.+Cys. (%)	0.58	0.56	0.53	0.51
Threonine (%)	0.82	0.59	0.55	0.51
Tryptophan (%)	0.20	0.19	0.18	0.16

[1] Supplied per kg of diet: vitamin A 5,500 IU, vitamin D_3 550 IU, vitamin E 27 IU, menadione sodium bisulfate 2.5 mg, pantothenic acid 27 mg, niacin 33 mg, riboflavin 5.5 mg, vitamin B_{12} 0.04 mg, thiamin 5 mg, pyridoxine 3 mg, biotin 0.24 mg, folic acid 1.5 mg, choline chloride 700 mg, selenium 0.15 mg, manganese 0.03 g, zinc 0.1 g, iron 0.1 g, iodine 0.5 mg, magnesium 0.1 g.

[2] Calculated value.

Pigs were housed in a concrete floored pen, with a feeder and a nipple waterer, and allowed *ad libitum* access to feed and water through five weeks experimental period. The temperature within the house was maintained at 18~22℃.

To determine the nutrients digestibilities, total fecal collection method was used. Nutrient digestibility was measured two times during early and late finishing periods. For early finishing pigs, 6 pigs (3 barrows and 3 gilts) averaging 62 kg body weight were housed in individual metabolic crates. For late finishing, 6 pigs (3 barrows and 3 gilts) averaging 83 kg body weight were kept in an individual metabolic crates,

Table 2. Effects of phase feeding on growth performance of finishing barrows and gilts[1]

	Barrows			Gilts			SE[2]	Contrast Barrow vs Gilt
CP (%)	16-16	16-14	17-15	16-16	16-14	17-15		
58 to 76 kg								
ADG (kg)	0.699	0.688	0.675	0.659	0.651	0.662	0.0097	0.1314
ADFI (kg)	2.136[a]	2.106[a]	1.958[ab]	1.975[ab]	1.898[b]	1.886[b]	0.0343	0.0049
F/G	3.02	3.04	2.90	2.91	2.88	2.83	0.0531	0.0950
76 to 103 kg								
ADG (kg)	0.955[a]	0.891[a]	0.934[a]	0.905[a]	0.812[b]	0.788[b]	0.0151	0.0001
ADFI (kg)	2.368[ab]	2.529[a]	2.318[ab]	2.308[ab]	2.155[b]	2.200[b]	0.0395	0.0039
F/G	2.49[c]	2.84[a]	2.48[c]	2.56[bc]	2.65[abc]	2.80[ab]	0.0446	0.4232
58 to 103 kg								
ADG (kg)	0.836[a]	0.797[a]	0.813[a]	0.791[ab]	0.737[bc]	0.730[c]	0.0101	0.0006
ADFI (kg)	2.347[ab]	2.417[a]	2.230[bc]	2.233[bc]	2.112[c]	2.130[c]	0.0353	0.0008
F/G	2.81[ab]	3.03[a]	2.75[b]	2.83[ab]	2.87[ab]	2.92[ab]	0.0388	0.9754

[a,b] Means with different superscripts in a row differ ($p<0.05$).
[1] A total of 120 pigs; average initial body weight 58.5 kg and final body weight was 103.9 kg, four pigs/replicate, five replicates/treatment.
[2] Pooled standard error.
Abbreviations: 16-16% CP=16% CP diet in early and late-finishing period; 16-14% CP=16% CP diet in early and 14% CP diet late-finishing period; 17-15% CP=17% CP diet in early and 15% CP diet late-finishing period.

and a digestibility trial used a latin square design.

For early and late finishing period, experimental diets were provided to the pigs on a weekly rotation basis. After four days of adaptation period, total excreta were collected through three consecutive days. The amount of feed consumed and total excreta were recorded daily during the metabolic trial. Collected excreta were pooled and dried in an air-forced drying oven at 60℃ for 72 hours and then ground with 1 mm Wiley mill for chemical analyses. Analyses of proximate nutrients of the experimental diets and excreta were conducted according to the methods of AOAC (1990). Amino acids contents were determined, following by acid hydrolysis with 6N HCl at 110℃ for 16 hours (Mason, 1984), using an amino acid analyzer (Biochrom 20, Pharmacia Biotech. England). To evaluate effects of phase feeding on carcass characteristics, a total of 96 pigs (excluding the fifth replicate in each treatment) were slaughtered at the end of feeding trial. To evaluate effect of slaughter weight on carcass characteristics, 8 pigs (4 barrows and 4 gilts) at each 95, 100, 110 and 120 kg body weight were compared. Statistical analysis was carried out to compare means using Duncan's multiple range test (Duncan, 1955), by General Linear Model (GLM) procedure of SAS (1985) package program with the main effect of sex and feeding program.

RESULTS AND DISCUSSION

Growth performance

Table 2 shows effects of phase feeding on growth performance of finishing barrows and gilts. During the early finishing period (58 to 76 kg body weight), average daily gain was not significantly different among treatments. Feed intake of barrows was significantly higher than that of gilts ($p<0.001$). But there was no significant difference among treatments within the same sexes. There was a trend that feed efficiency of gilts was better than that of barrows ($p>0.05$). Barrows and gilts fed 17% CP diet in early and 15% CP diet in late-finishing (17-15% CP) showed better feed efficiency than pigs fed on 16% CP diets, but the difference was not significant.

During the late finishing period (76 to 103 kg body weight), average daily gain of barrows was significantly higher than that of gilts ($p<0.001$). As for barrows, there was no significant difference among treatments in average daily gain. But, average daily gain of gilts fed on 16% CP diet was significantly higher than that of those fed on 14% CP and 15% CP diet ($p<0.05$). This means that protein and amino acids requirements of gilts were higher than barrows, and the response of gilts to a dietary supplement of protein and amino acids was greater than that of barrows. This agreed with the report by Yen et al. (1986b) that when eight levels of lysine ranging from 0.56% to 1.24% were offered to 50 to 90 kg body weight of pigs, boars and gilts showed a greater response than barrows to increase in dietary protein. Watkins et al. (1977) reported similar results that gilts required more protein than barrows. There was no significant difference in feed intake within the same sexes. But feed intake of barrows was significantly higher than that of gilts ($p<0.01$). For barrows, feed efficiency (F/G) of barrows fed on 14% CP diet was worse than that of barrows fed on 16% and 15% CP diets ($p<0.05$), but feed efficiency was not significantly different among treatments in gilts.

Throughout the whole finishing period (58 to 103

Table 3. Effects of phase feeding on nutrient digestibility of experimental diets (%)[1]

	Barrows			Gilts			SE[2]	Contrast
CP (%)	16-16	16-14	17-15	16-16	16-14	17-15		Barrow vs Gilt
58 to 76 kg								
Dry matter	90.95[ab]	91.49[ab]	89.03[b]	92.46[a]	92.99[a]	92.55[a]	0.46	0.0179
Crude protein	87.73	88.75	87.05	90.30	90.80	91.04	0.56	0.0200
Crude ash	70.29[ab]	72.97[a]	59.21[b]	75.19[a]	78.05[a]	73.46[a]	1.93	0.0142
Crude fat	76.93[b]	80.94[ab]	86.58[ab]	82.69[ab]	85.68[ab]	91.90[a]	1.84	0.1502
Phosphorus	64.87	67.75	60.50	72.07	74.20	74.10	2.02	0.0348
76 to 103 kg								
Dry matter	90.59	91.48	88.67	90.86	89.23	90.78	0.45	0.9607
Crude protein	88.07	87.39	84.45	88.43	84.20	87.35	0.68	0.8510
Crude ash	61.45	57.15	53.11	60.85	46.86	61.31	2.34	0.9873
Crude fat	94.15	94.03	92.80	94.55	93.31	93.55	0.29	0.8140
Phosphorus	69.26	71.58	65.67	73.29	66.82	71.36	1.51	0.6183

[a,b] Means with different superscripts in a row differ ($p<0.05$).
[1] For early finishing period, 3 barrows and 3 gilts averaging 62 kg body weight were used to measure digestibility; for late finishing period, 3 barrows and 3 gilts averaging 83 kg body weight were used. The digestibility trial latin square design.
[2] Pooled standard error.
Abbreviations: See table 2.

kg body weight), average daily gain was not significantly different among treatments within barrows, while gilts fed 17-15% CP diet grew slower than gilts fed on 16-16% CP diet ($p<0.05$). Regarding sex effects on average daily gain, barrows grew faster than gilts ($p<0.001$) during the whole finishing period. Feed intake of barrows was significantly higher than that of gilts ($p<0.001$), but there was no significant difference in feed intake within the same sexes ($p>0.05$). Throughout the whole finishing period, feed efficiency of barrows fed on 17-15% CP was significantly better than that of barrows fed on 16-14% CP, but there was no significant difference in feed efficiency. Castel et al. (1985) reported similar results that among crossbred (Hampshire × (Landrace × Yorkshire)) boars, gilts and barrows, barrows grew 12% faster than gilts, due to greater feed intake.

In this experiment, growth performance was not significantly different among treatments within the same sex. It appeared that 16% crude protein for early finishing period and 14% crude protein for late finishing period was appropriate for normal growth. Increasing nutrient density (protein and amino acids content) above 16% CP for early finisher and 14% CP for later finisher could cause nutrient wastage without further improving growth performance. This observation was similar to the report of Han et al. (1998) that over 14% of crude protein diets for late finishing pigs did not necessarily guarantee high growth rate. Meeting the animal's need for amino acids without excess is more important. As pigs do not have an ability to control protein intake to meet their requirements (Owen et al., 1994; Gourley et al., 1994; Nam and Aherne, 1995), supplying nutrients above requirement results in nutrients wastage without improving growth performance.

Concerning sex effects on growth performance, effect by sex increased with increasing body weight. During early finishing period, only feed intake among criteria was significantly different between sexes ($p<0.01$), but in late finishing period, average daily gain ($p<0.0001$) and feed intake ($p<0.01$) of barrows were significantly higher than that of gilts. This showed that gilts had a better growth response to dietary protein level than barrows. Sexe did not influence feed efficiency throughout the whole finishing period. This suggested that, for the finishing period, barrows and gilts should be fed different diets. Watkins et al. (1977) reported that performance difference between gilts and barrows was large with a low protein diet (14% CP), while gilts gained weight closer to the barrows on the higher protein diets. This supported the theory that leaner gilts respond more to higher protein levels than fatter barrows, and gilts have a higher protein requirement than do barrows. Campbell and Taverner (1988) and Stahly et al. (1991) suggested that boars and gilts require greater lysine intake to facilitate protein accretion. Furthermore, gilts have decreased feed intake, indicating a need for more lysine per kilogram of diet for optimal protein accretion.

Nutrient digestibility

Table 3 summarizes the effects of phase feeding on proximate nutrient digestibility of finishing barrows and gilts. Nutrient digestibility was measured two times, early finishing period (3 barrows and gilts averaging 62 kg body weight) and late finishing period (3 barrows and gilts averaging 83 kg of body weight). During the early finishing period, digestibilities of dry matter, protein and phosphorus by gilts were significantly higher than barrows ($p<0.05$). Though fat digestibility of gilts was higher than that of barrows, the difference was not significant. Within the same sex, there was no treatment effect on nutrient digestibility except ash. The ash digestibility of barrows fed on 17% CP diet was significantly lower than that of barrows fed on 16% CP diet ($p<0.05$). During the late finishing period there was no significant differences among treatments.

Table 4 and 5 show the effect of phase feeding on amino acid digestibilities in finishing barrows and gilts. During early finishing period, digestibilities in gilts were significantly higher than in barrows ($p<0.05$), though the differences in digestibilities of methionine, phenylalanine and histidine were not significant. This trend was observed with protein digestibilities. Within same sexes, there was no difference among treatments. During the late finishing period, there was no sex effect on amino acid digestibility. The valine digestibility of pigs fed on 15% CP diets was significantly lower than that of pigs fed on 14% CP diets ($p<0.05$). Except valine, amino acids digestibilities within the same sex were not significantly different ($p>0.05$).

Fecal nutrient excretion

Table 6 shows the effect of phase feeding on fecal nutrient excretion of finishing barrows and gilts. During early finishing period, barrows excreted more fecal dry matter, nitrogen and phosphorus than gilts. In gilts, excretion of fecal nitrogen by pigs fed 16-14% CP diet was less than that by pigs fed 17-15% CP diet ($p<0.05$), but there was no significant difference. Fecal N excretions of barrows and gilts fed 17% CP diet was higher than that of pigs fed 16% CP diet. These results indicated that high protein diet cause higher fecal nitrogen excretion. During late finishing period, the fecal excretions of nitrogen in pigs fed 16-14% and 17-15% CP diet were lower than that of pigs fed 16-16% CP diet. These results indicated that two phase feeding reduce fecal nitrogen excretion. Comparing 16-16% (single feeding) and 16-14% CP diet (two phase feeding), of two phase feeding was reduced fecal N excretion by 8.5%, but fecal P excretion did not a show consistant trend. In barrows, fecal P excretion was lower in pigs fed two phase feeding diet (16-14%) than pigs fed single phase feeding diet (16-16%). But fecal P excretion of pigs fed 16-14% CP diet in gilts was higher than that of pigs fed 16-16% CP diet. A much bigger proportion of the pigs' fecal N excretion appears in the urine, mainly as a result of degradation of superfluous amino acids which cannot be used for body protein deposition (Lenis, 1989; Jongbloed and Lenis, 1992). Also protein digested in the hindgut is excreted mostly as urinary N (Lenis, 1989). Thus, it is desirable to provide nutrients in each growth stage in amounts that not only improve growth rate but also minimize environmental problems of pig production.

Carcass characteristics

Table 7 shows the effect of phase feeding on carcass characteristics of finishing pigs. For evaluating effects of phase feeding on carcass characteristics, a total of 92 pigs were used. The 10th rib back fat thickness of gilts tended to be thinner than that of barrows, without significant difference ($p>0.05$). Within the same sexes, there was no treatment effect on thickness ($p>0.05$). Carcass grade of gilts was significantly better than that of barrows ($p<0.001$). This results were similar to several reports (Siers, 1975; Watkins et al., 1977; Bereskin, 1983; Yen et al., 1986b). Jonsson (1956, 1959) also reported that barrows gained faster and were fatter than gilts when pigs were fed in groups of three or four littermates. Differences in leanness among sex groups could provide a foundation for differences in nutritional requirements. It has long been established that castrated male pigs have a lower capacity for protein deposition and thus require less dietary protein and amino acids to support maximum growth than entire males or females (Prescott and Lamming, 1967; Newell and Bowland, 1972; Taverner et al., 1977; Cresswell et al., 1975; Williams et al., 1984; Yen et al., 1986a, b). There was no treatment and sex effect on loin eye area. Loin eye area of gilts was almost the same as that of barrows. This disagreed with other reports. Yen et al. (1986b) reported that loin eye area of gilts was 3% greater than that of boars and 14% greater than that of barrows.

Feed costs

Table 8 summarized the effect of phase feeding on production cost of finishing pigs. Comparing single and two phase feeding, there was a trend for total feed cost of two phase feeding (16-14% and 17-15% CP) to be lower than that of single phase feeding, but the difference was not significant. The difference in total feed cost was bigger in gilts than barrows. In gilts, total cost reduction of two phase feeding (16-14% CP) compared to single phase feeding (16-16% CP) was 9.1%, but that of barrows was only 3.2%. These results are similar to Han et al. (1998) who reported that feeding low nutrient feed during the late finishing period reduced total feed cost. Feed cost per kg weight gain of gilts was decreased (2.7%) by two phase feeding compared to single phase feeding,

Table 4. Effects of phase feeding on amino acid digestibilities of experimental diets during early finishing period (58 to 76 kg)[1]

CP (%)	Barrows 16-16	Barrows 16-14	Barrows 17-15	Gilts 16-16	Gilts 16-14	Gilts 17-15	SE[2]	Contrast Barrow vs Gilt
Essential amino acids (%)								
Threonine	86.21	88.11	88.17	89.65	90.99	92.51	0.82	0.0396
Valine	87.59	88.95	87.00	90.86	92.13	92.37	0.77	0.0136
Methionine	81.99	84.00	84.07	85.79	87.35	89.35	1.10	0.0877
Isoleucine	87.45	89.12	86.02	90.45	91.82	91.77	0.79	0.0201
Leucine	90.51^{ab}	91.20^{ab}	88.73^{b}	92.69^{ab}	93.75^{a}	93.42^{a}	0.60	0.0088
Phenylalanine	87.44	90.64	85.34	91.10	91.17	89.48	0.93	0.1561
Histidine	89.81^{ab}	70.14^{a}	82.82^{b}	91.79^{a}	92.81^{a}	88.49^{ab}	1.12	0.1196
Lysine	85.84	88.40	85.95	89.63	91.14	91.21	0.86	0.0304
Argine	93.53^{ab}	94.09^{ab}	92.69^{b}	94.84^{ab}	95.51^{a}	95.18^{ab}	0.35	0.0141
Submean	87.82	87.18	86.76	90.76	91.85	91.53	0.88	0.0328
Non-essential amino acids (%)								
Aspartate	88.31	90.17	88.97	91.38	92.47	93.14	0.70	0.0333
Serine	90.59	91.46	90.29	93.07	93.83	93.88	0.57	0.0197
Glutamine	93.61	93.92	92.91	95.12	95.60	95.62	0.37	0.0112
Proline	92.78^{ab}	92.79^{ab}	90.81^{b}	95.01^{a}	94.69^{ab}	94.45^{ab}	0.55	0.0233
Glycine	87.60	88.93	87.02	90.73	91.93	91.88	0.74	0.0190
Alanine	86.05^{ab}	87.53^{ab}	84.74^{b}	89.80^{ab}	91.31^{a}	91.23^{a}	0.86	0.0070
Tyrosine	88.11	89.54	89.86	91.61	92.26	94.24	0.82	0.0425
Submean	89.58	90.62	89.23	92.39	93.16	93.49	0.63	0.0164
Total	88.60	88.71	87.86	91.48	92.43	92.40	0.75	0.0222

[1] For early finishing period, 3 barrows and 3 gilts averaging 62 kg body weight were used to measure digestibility.
[2] Pooled standard error. [a,b] Means with different superscripts in a row differ ($p<0.05$). Abbreviations: See table 2.

Table 5. Effects of phase feeding on amino acid digestibilities of experimental diets during late finishing period (76 to 103 kg)[1]

CP (%)	Barrows 16-16	Barrows 16-14	Barrows 17-15	Gilts 16-16	Gilts 16-14	Gilts 17-15	SE[2]	Contrast Barrow vs Gilt
Essential amino acids (%)								
Threonine	89.26	87.93	85.47	88.26	84.20	86.14	0.84	0.4475
Valine	89.08^{ab}	93.08^{a}	84.15^{b}	87.92^{ab}	90.77^{a}	83.52^{b}	1.01	0.3498
Methionine	83.20	85.95	80.52	82.16	83.74	83.16	1.40	0.9509
Isoleucine	89.71	90.12	85.37	89.33	87.01	86.58	0.76	0.6157
Leucine	91.96	92.20	88.82	91.85	90.05	90.10	0.57	0.7845
Phenylalanine	90.31	86.96	85.50	89.30	84.08	86.57	1.15	0.7069
Histidine	93.13^{a}	88.41^{ab}	86.86^{ab}	91.96^{ab}	85.21^{b}	85.03^{b}	1.09	0.2905
Lysine	89.25^{a}	87.35^{ab}	85.57^{ab}	88.72^{ab}	82.72^{b}	85.77^{ab}	0.84	0.3023
Argine	94.96	93.99	92.48	94.62	82.47	92.06	0.46	0.4055
Submean	90.10	89.55	86.08	89.35	86.69	86.55	0.75	0.5042
Non-essential amino acids (%)								
Aspartate	91.96	90.66	87.88	90.82	87.46	88.33	0.72	0.3783
Serine	92.94	91.85	89.89	92.34	89.21	90.12	0.62	0.4314
Glutamine	94.73	94.40	91.81	94.10	92.77	93.46	0.34	0.4437
Proline	94.48	93.70	91.65	93.29	92.17	93.99	0.57	0.9176
Glycine	89.57	88.61	85.73	89.52	85.42	86.93	0.74	0.6525
Alanine	89.83	88.62	84.35	89.01	84.86	86.59	0.80	0.6080
Tyrosine	91.61	90.44	88.77	90.77	88.21	89.30	0.74	0.6100
Submean	92.16	91.19	88.73	91.41	88.58	89.82	0.60	0.5383
Total	91.01	90.28	87.26	90.26	87.53	88.00	0.68	0.5152

[1] For late finishing period, 3 barrows and 3 gilts averaging 83 kg body weight were used to measure digestibility.
[2] Pooled standard error. [a,b] Means with different superscripts in a row differ ($p<0.05$). Abbreviations: See table 2.

Table 6. Effects of phase feeding on fecal nutrient excretion of finishing barrows and gilts (g/day)[1]

Treatment	Barrows			Gilts			SE[2]	Contrast Barrow vs Gilt
	16-16% CP	16-14% CP	17-15% CP	16-16% CP	16-14% CP	17-15% CP		
58 to 76 kg								
Dry matter	188.57	186.81	192.54	165.48	163.82	188.31	6.71	0.2776
Nitrogen	7.90	7.85	8.61	6.44	6.42	7.25	0.30	0.0223
Phosphorus	6.07	5.36	6.99	4.80	4.42	4.68	0.36	0.0520
76 to 103 kg								
Dry matter	191.47	176.46	181.97	197.90	177.11	186.79	8.03	0.8344
Nitrogen	7.93	7.22	7.24	7.88	7.25	7.23	0.31	0.9939
Phosphorus	4.65	4.03	4.98	4.09	4.24	4.25	0.20	0.5393

[1] For early finishing period, 3 barrows and 3 gilts averaging 62 kg body weight were used to measure digestibility. And for late finishing period, 3 barrows and 3 gilts averaging 83 kg body weight were used.
[2] Pooled standard error.
[a,b] Means with different superscripts in a row differ (p<0.05). Abbreviations: See table 2.

Table 7. Effects of phase feeding on carcass characteristics of finishing pigs[1]

Treatment	Barrows			Gilts			SE[2]	Contrast Barrow vs Gilt
	16-16% CP	16-14% CP	17-15% CP	16-16% CP	16-14% CP	17-15% CP		
CWT (kg)[4]	78.7[ab]	77.7[b]	81.2[a]	79.5[ab]	81.0[ab]	80.3[b]	0.76	0.2349
CR (%)	75.7[ab]	74.8[b]	78.4[a]	76.6[ab]	78.0[ab]	77.3[ab]	0.47	0.2842
Length (cm)	85.2[a]	84.0[ab]	83.3[ab]	81.1[ab]	80.4[ab]	79.4[b]	0.91	0.0223
BF (mm)	26.0[a]	25.1[ab]	25.5[a]	24.1[b]	24.8[ab]	25.3[ab]	0.30	0.1496
Grade[3]	1.88[ab]	1.79[ab]	2.16[a]	1.49[b]	1.24[b]	1.50[b]	0.078	0.0003
LEA (cm^2)	28.1	29.4	30.9	27.5	30.6	30.4	0.99	0.9831

[1] Total 96 pigs (16 pigs per treatment) were killed at the end of test and measured for carcass characteristics.
[2] SE : Pooled standard error. [3] Grade : A=1, B=2, C=3.
[4] Means of CWT, CR, Length, BF, Grade and LEA were corrected based on lean final slaughter weight as a covariate. CWT=carcass weight; CR=carcass ratio; Length=carcass length; Grade=carcass grade; LEA=loin eye area; BF=back fat thickness at 10th rib.
[a,b] Means with different superscripts in a row differ (p<0.05). Abbreviations: See table 2.

Table 8. Effects of different feeding regimen on production cost of finishing pigs[1]

Treatment	Barrows			Gilts			SE[2]	Contrast Barrow vs Gilt
	16-16% CP	16-14% CP	17-15% CP	16-16% CP	16-14% CP	17-15% CP		
TWG (kg)	48.5[a]	46.2[a]	47.2[a]	45.9[ab]	42.7[b]	42.3[b]	0.62	0.0008
TFC (₩)	28,144[a]	27,246[ab]	27,351[ab]	26,808[ab]	24,370[b]	26,134[ab]	420.16	0.0309
FCG (₩)	573.4	570.4	581.2	588.2	565.8	557.2	4.91	0.6396
Price (₩)	236,027	236,041	232,762	264,390	265,535	263,773	1,669.6	0.0001
RMG (₩)[3]	100	100.23	97.83	126.16	129.25	126.16	1,772.1	0.0001

[1] Feed production costs for each diet were 263.3 ₩/kg for 17% CP, 214.7 ₩/kg for 16% CP, 206.8 ₩/kg for 15% CP, 200.1 ₩/kg for 14% CP, respectively.
[2] Pooled standard error.
[3] Relative margin per pig was calculated on the basis of total management cost suggested by NLCF (1998).
TWG, Total weight gain; TFC, Total feed cost; FCG, Feed cost/kg weight gain; Price, Price of pigs; RMG, Relative margin per pig (RMG=Price−TFC).
[a,b] Means with different superscripts in a row differ (p<0.05). Abbreviations: See table 2.

but that of barrows was almost similar between 16-16% and 16-14 CP diet. These results suggested that the effect of phase feeding during the finishing period was higher in gilts than barrows. Margin was calculated by feed cost for finisher and price of pig. Margin was increased by two phase feeding. The increase in relative margin by phase feeding was 2.5% in gilts, and 0.2% in barrows. Total feed costs of barrows were significantly higher than that of gilts ($p<0.05$). This was caused by differences in feed intake and weight gain. Therefore, we suggest that two phase feeding during the finishing period could save feed costs compared to single phase feeding without decreasing growth performance.

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