Effects of Phase Feeding and Sugar Beet Pulp on Growth Performance, Nutrient Digestibility, Blood Urea Nitrogen, Nutrient Excretion and Carcass Characteristics in Finishing Pigs

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ABSTRACT : This experiment was conducted to investigate effects of phase feeding and sugar beet pulp (SBP) on growth performance, nutrient digestibility, nitrogen excretion, blood urea nitrogen (BUN) concentration and carcass characteristics in finishing pigs. A total of 128 pigs were allotted at 53.9 kg BW to 8 replicates in a 2×2 factorial arrangement in a randomized complete block (RCB) design. The first factor was phase feeding (2 or 3 phase feeding) and SBP (SBP: 0% or 10%) was the second factor. Ten percent SBP supplement groups showed lower average daily feed intake (ADFI) than 0% SBP supplement groups ($p<0.05$). However, there were no significant difference in average daily gain (ADG) and feed:gain ratio among treatments during overall experimental period. Nutrient digestibility was not affected by phase feeding or SBP supplementation. Urinary nitrogen excretion in 10% SBP supplement group was lower than that in 0% SBP supplement group ($p<0.05$) and total nitrogen excretion was lower in SBP supplement group than in the group without SBP. Urinary and total nitrogen were numerically decreased in three phase feeding compared to two phase feeding. The BUN concentration in three phase feeding groups was lower than two phase feeding groups at 47 and 63 day ($p<0.05$). Consequently, results of this experiment demonstrated that three phase feeding was more acceptable than two phase feeding for finishing pigs. And sugar beet pulp could be supplemented in finishing pig diet for decreasing urinary nitrogen excretion without retardation in growth performance of pigs. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 8 : 1150-1157)***

Key Words : Phase Feeding, Sugar Beet Pulp, Growth Performance, Nitrogen Excretion, Finishing Pigs

INTRODUCTION

Last 50 years, productivity in swine industry has been the main issue so advanced managements and new ingredients were widely used to improve it. However, in recent years, with increase in herd size in swine farms and high concern about environmental problems, swine manure has become one of the most important environmental pollutant. Especially nitrogen was regarded the main material in contamination of water and soil.

Many nutritional approaches, such as reducing dietary crude protein level, synthetic amino acid supplementation, enzyme supplementation, the use of high available corn, advanced formulation based on nutrient requirements for the apparent ileal digestibility and sex-spilt feeding were adapted in swine industry. To decrease environmental pollutant in swine production, increase of nutrients availability in animal body, was considered which resulted in decreasing pollutant excretion through feces and urine. In swine industry, phase feeding was suggested to decrease nutrient excretion. Phase feeding may supply more accurate level of dietary nutrients to meet requirements that could be changed very frequently during growing period.

Currently, three phase feeding in weaning pig showed a tendency to improve growth performance and was economically beneficial to pig producer due to reduction of the feed cost (Ko et al., 2003). Two phase feeding was suggested for finishing pigs (NRC, 1998) and it was generally used in commercial swine farm. Although the requirement of protein and amino acid was changed rapidly during finishing period, the efficiency of nutrient utilization was dramatically decreased after about 90 kg body weight. Thus, multi phase feeding system has to be considered for finishing pigs.

According to recent researches, when sugar beet pulp (SBP) was supplemented in finishing pigs diet, urea was shifted from blood to lumen and then urinary and total nitrogen excretion was decreased (Canh et al., 1997, 1998). This nitrogen partitioning effect by SBP supplementation was due to non-starch polysaccharide (NSP) such as cellulose.

Thus, the objectives of this experiment was to investigate the effect of multi phase feeding and SBP supplementation in finishing pigs on growth performance, nutrient availability, blood urea nitrogen and carcass characteristics in of pigs.

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MATERIALS AND METHODS

Experimental animals and diet

One hundred and twenty-eight pigs [(Landrace×Large

Table 1. Formula and chemical composition of experimental diets

Ingredients	0% SBP			10% SBP		
	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Corn	74.31	79.29	84.30	63.80	68.69	73.65
Soybean meal (44%)	22.11	17.05	12.00	21.85	16.83	11.86
Sugar beet pulp	0.00	0.00	0.00	10.00	10.00	10.00
Animal fat	1.00	1.00	1.00	1.90	1.95	1.95
TCP	1.40	1.55	1.64	1.46	1.60	1.75
Limestone	0.37	0.27	0.25	0.16	0.08	0.00
L-Lysine·HCl	0.14	0.16	0.17	0.11	0.13	0.14
Methionine+cystine	0.05	0.03	0.00	0.08	0.06	0.01
Threnine	0.02	0.05	0.04	0.04	0.06	0.04
Vit.-min. premix[a]	0.28	0.28	0.28	0.28	0.28	0.28
Antibiotics	0.06	0.06	0.06	0.06	0.06	0.06
Choline cloride	0.06	0.06	0.06	0.06	0.06	0.06
Salt	0.20	0.20	0.20	0.20	0.20	0.20
Chemical composition[b]						
ME (kcal/kg)	3,341.71	3,348.06	3,354.31	3,293.29	3,301.48	3,307.67
CP (%)	16.03	14.03	12.00	16.00	14.01	12.00
Lysine (%)	0.92	0.80	0.67	0.92	0.80	0.67
Ca (%)	0.70	0.70	0.70	0.70	0.71	0.71
P (%)	0.60	0.60	0.60	0.60	0.60	0.60
NDF (%)	10.1	9.9	9.7	13.3	13.1	12.9
ADF (%)	4.2	3.8	3.5	6.5	5.9	5.6

[a] Provided the following per kilogram of diet : vitamin A, 8,000 IU; vitamin D_3, 1,600 IU; vitamin E, 32 IU; d-biotin, 64 μg; riboflavin, 3.2 mg; calcium pantothenic acid, 8 mg; niacin, 16 mg; vitamin B_{12}, 12 μg; vitamin K, 2.4 mg; Se, 0.1 mg; I, 0.3 mg; Mn, 24.8 mg; Cu, 54.1 mg; Fe, 127.3 mg; Zn, 84.7 mg; Co, 0.3 mg.

[b] Calculated value.

White)×Duroc] averaging 53.96 kg BW were allotted in 4 treatments by body weight and sex. Experimental design was 2×2 factorial arrangement in a randomized complete block (RCB) design in 8 replicates with 4 pigs per pen. The first factor was feeding regimes (2 or 3 feeding regimes) and sugar beet pulp (SBP: 10% supplementation or not) was the second factor. In experimental diet, total six experimental diets were formulated and supplied according to phase feeding programs. Diet 1 and 4 contain 16% of crude protein and 0.92% lysine, diet 2 and 5 contained 14% crude protein and 0.80% lysine, diet 3 and 6 contained 12% crude protein and 0.67% lysine, respectively. Sugar beet pulp was supplemented by 10% in diet 1, 2 and 3. All other nutrients met or exceeded requirements of NRC (1998). The formula and chemical composition of experimental diet was presented in Table 1.

Housing and blood sampling

All pigs were housed in a plastic woven floored pen, equipped with a feeder and a nipple waterer, and allowed *ad libitum* access to feed and water throughout the whole experimental period. Body weight and feed intake were recorded three-week interval and average daily gain (ADG), average daily feed intake (ADFI) and feed/gain ratio were recorded.

Blood samples with vacuum tube contained $EDTA_3$ were collected from anterior vena cava of the same pigs weekly during the whole experimental period for blood urea nitrogen (BUN) analysis. All samples were quickly centrifuged for 15 min at 3,000 rpm and 5°C, plasma samples were obtained and stored at -20°C until BUN analyses. Total BUN concentration was analyzed using blood analyzer (Ciba-Corning model, Express Plus, Ciba Corning Diagnostics Co.).

Metabolic trial

Twenty four in different body weight group averaging 65, 85 and 100 kg body weight, were housed in an individual metabolic crate in a 6 replicates. Diets contained 16 or 14% CP were supplied at 65 and 85 kg body weight pigs, respectively. For 100 kg body weight finishing pigs, 14% (for two phase feeding) and 12% (for three phase feeding) CP diet was provided. Pigs were fed experimental diets twice daily on 4, 3 and 2.7% of body weight at each body weight. After 5 days of adaptation period, 3 d collection period was followed. The total amount of feed consumed and excreta produced were recorded daily during the metabolic trial. Collected excreta from each pig were pooled, sealed in plastic bags, and dried in a forced air drying oven at 60°C for 72 h and ground to 1 mm in a Wiley Mill for chemical analyses.

Urine was collected daily and filtered through 8 μm glass wool into 5 L collection vessels containing 50 ml of 0.5 N HCl to prevent fermentation. The total amount of urine was weighed and sub-samples were taken for chemical analyses.

Table 2. Effect of phase feeding and SBP on growth performance in finishing pigs[a]

Feeding regimen	Two phase feeding		Three phase feeding		PSE[c]	Probability		
SBP[b]	0%	10%	0%	10%		PF[d]	SBP[e]	PF×SBP
ADG (g)	885	853	884	853	13.49	NS[f]	NS	NS
ADFI (g)	2,676	2,425	2,617	2,515	56.64	NS	0.0318	NS
Feed/gain	3.04	2.83	2.95	2.97	0.06	NS	NS	NS

[a] Initial body weight: average 54.0 kg and final body weight: 108.8 kg.
[b] Sugar beet pulp. [c] Pooled standard error. [d] Phase feeding effect. [e] SBP effect. [f] Not significant.

Chemical analysis

Analysis of the experimental diets and excreta was conducted according to the methods of the AOAC (1995). The amino acid were determined after acid hydrolysis with 6 N HCl at 110°C for 24 h (Mason, 1984), using an amino acid analyzer (Biochrom 20, Pharmacia Biotech, England). Mineral contents were measured using an Atomic Absorption Spectrophotometer (Shimadzu, AA6145F, Japan).

Statistical analysis

Data in this experiment was anaylzed as a randomized complete block (RCB) design using the ANOVA procedure of SAS (1992), and treatment means were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance

The effects of phase feeding and sugar beet pulp (SBP) supplementation on growth performance in finishing pigs were presented in Table 2. There was no significant difference in growth performance among treatments except for average daily feed intake (ADFI). Average daily feed intake was lower in pigs fed diet containing SBP than in pigs fed diet without SBP ($p<0.05$), but the interaction between phase feeding and SBP was not shown in all criteria.

As expected, the growth performance was not affected by phase feeding system. This result was agreed with reports by Lee et al. (2000) and Hines et al. (1993) demonstrated that there were no significant differences in growth performances between three phase feeding and two or one phase feeding during finishing period. Cromwell et al. (1993) reported that 0.58% dietary lysine was sufficient for maximum growth rate of finishing barrows weighing 47 to 103 kg. Dritz et al. (1997) suggested that total lysine requirement of barrows and gilts weighing 90 to 115 kg was about 0.61% for maximal growth performance and carcass traits. Yen et al. (1986b) reported that optimal growth performance and carcass characteristics were observed in gilts fed a total daily lysine intake of 21.2 g/d. Also Hahn et al. (1995) reported that early finishing gilts weighing 50 to 95 kg required 0.75% or 21.2 g/d total lysine and late finishing gilts weighing 90 to 110 kg required 0.61% or 20.4 g/d total lysine. Loughmiller et al. (1998) reported that total lysine requirement for gilts from 91 to 113 kg gilts was approximately 0.60% total lysine in diet, which corresponds to approximately 18 g/d lysine intake. Based on previous results, the finishing pigs weighing 50 to 90 kg should be supplied over 20 g/d total lysine for maximal growth performance, followed by about 18 g/d total lysine from 90 to 110 kg. In the present study, the pigs fed on two phase feeding system were supplied average 22.5 g/d (23.6 g for 0-4.5 weeks and 21.4 g for 4.5-9 weeks) of total lysine during experimental period. The pigs fed on three phase feeding system were supplied average 22.0 and 17.1 g/d total lysine for 0-6 and 7-9 weeks, respectively. Consequently, three phase feeding could supply sufficient lysine for maximal growth performance for finishing pig, and then the growth performance in three phase feeding was not impaired.

Generally, inclusion of 10% sugar beet pulp to diet has not resulted in decreasing growth performance of growing pigs (Longland and Low, 1988). However, in the present study, ADG was numerically decreased in SBP treatment, although it was not significant difference between 0 and 10% SBP treatment. The slight reduction of ADG in 10% SBP treatment was due to decrease in average daily feed intake (ADFI), consequently feed conversion ratio was not reduced in 10% SBP treatments. Generally soluble NSP had hydration properties which were characterized by the swelling capacity, solubility, water holding capacity and water binding capacity (Knudsen, 2001). The first part of the solubilization process of NSP would be swelling in which incoming water spreads the macromolecules until they are fully extended and dispersed then, those were solubilized (Thibault et al., 1992). In the present study, above process might be occurred continually in stomach of pigs fed diet containing 10% SBP, due to the fact that the diet was supplied *ad libitum*. Thus, duration time of satiety might be long relatively in 10% SBP treatment, and ADFI might be reduced in 10% SBP treatment.

Nutrient digestibility

Table 3 showed effects of phase feeding and SBP on nutrient digestibility in finishing pigs. There were no significant differences in all nutrient digestibilities among treatments. However, calcium digestibility was numerically decreased when SBP was provided. Table 4 showed effects

Table 3. Effect of phase feeding and SBP on fecal nutrient digestibility in finishing pigs

Feeding regimen	Two phase feeding		Three phase feeding		PSE[b]	Probability		
SBP[a]	0%	10%	0%	10%		PF[c]	SBP[d]	PF×SBP
Dry matter (%)	90.23	88.01	89.38	88.47	0.69	NS[e]	NS	NS
Crude ash (%)	65.87	56.80	53.92	56.27	3.41	NS	NS	NS
Crude protein (%)	87.95	85.14	87.78	86.82	1.10	NS	NS	NS
Crude fat (%)	87.24	85.61	85.48	88.54	1.94	NS	NS	NS
Calcium (%)	72.70	46.57	70.61	59.68	5.84	NS	NS	NS
Phosphorus (%)	61.34	53.69	56.64	55.34	2.89	NS	NS	NS
Gross energy (%)	88.68	86.33	87.99	87.04	0.82	NS	NS	NS

[a] Sugar beet pulp. [b] Pooled standard error. [c] Phase feeding effect. [d] SBP effect. [e] Not significant.

Table 4. Effect of feeding regimen and NSP on amino acids digestibility in finishing pigs

Feeding regimen	Two phase feeding		Three phase feeding		PSE[b]	Probability		
SBP[a]	0%	10%	0%	10%		PF[c]	SBP[d]	PF×SBP
Threonine	83.33	81.91	86.23	83.30	1.12	NS[e]	NS	NS
Valine	79.30	78.92	81.78	80.17	0.98	NS	NS	NS
Isoleucine	83.82	83.08	83.98	83.59	0.58	NS	NS	NS
Leucine	86.70	85.22	88.13	86.96	0.77	NS	NS	NS
Phenylalanine	85.96	84.89	88.22	85.62	0.71	NS	NS	NS
Lysine	86.35	83.92	87.55	87.47	1.16	NS	NS	NS
Histidine	90.73	89.76	90.94	90.63	0.34	NS	NS	NS
Arginine	90.13	90.59	92.47	91.69	0.75	NS	NS	NS
EAA[f]	85.79	84.79	87.41	86.18	0.58	NS	NS	NS
Aspartate	86.75	87.55	90.15	88.82	0.98	NS	NS	NS
Serine	86.94	87.94	88.72	89.14	0.83	NS	NS	NS
Glutamate	91.23	91.39	92.63	92.61	0.66	NS	NS	NS
Proline	91.06	88.73	92.92	89.30	0.70	NS	0.0358	NS
Glysine	81.48	78.88	83.68	80.20	1.09	NS	NS	NS
Alanine	83.54	81.73	85.00	82.65	0.92	NS	NS	NS
Tyrosine	85.85	83.92	88.92	84.30	0.96	NS	NS	NS
NEAA[g]	86.69	85.73	88.86	86.71	0.79	NS	NS	NS
Total AA[h]	86.24	85.26	88.14	86.45	0.68	NS	NS	NS

[a] Sugar beet pulp. [b] Pooled standard error. [c] Phase feeding effect. [d] SBP effect.
[e] Not significant. [f] Essential amino acid. [g] Non-essential amino acid. [h] NEAA+EAA.

of phase feeding and SBP on amino acid digestibility in finishing pigs. There was no significant difference in all amino acids digestibility among treatments except for proline. When pigs were fed SBP contained diet, proline digestibility was decreased ($p<0.05$).

Previous studies demonstrated that dietary protein (Le Bellego and Noblet, 2002) or lysine level (Lawrence et al., 1994; Bae et al., 1998) showed no effect on nutrient digestibility in growing-finishing pigs, which suggested that the reduction of dietary protein or lysine level did not impair nutrient absorption in growing-finishing pigs. In the present study, no effect of phase feeding system on nutrient digestibility could be explained by results from previous studies, because dietary protein and lysine levels in phase feeding system was lowered with increase in body weight of pigs. The result from present study demonstrated that nutrient digestibility in finishing pigs should not be impaired by three phase feeding. Lee et al. (2000) also observed that multi phase feeding did not affect nutrient digestibility in finishing pigs.

Generally, non-starch polysaccharide (NSP) in diet decrease ileal digestibility of nutrients, although it depended upon the kind and amount of NSP, diet composition and the age of pig. However many researches showed NSP inclusion in diet did not affect fecal digestibility of nutrients (Graham et al., 1986; Longland and Low, 1988; Shi and Noblet, 1993; Jørgensen et al., 1996; Lizardo et al., 1997; Freire et al., 2000). Increment of nutrient digestibility could be interpreted by microbial fermentation in large intestine although it was not clearly known how much nutrients absorbed from large intestine. In the present study, no difference in fecal nutrient digestibility by SBP supplementation was observed.

On the contrary of the present study, Mosenthin et al. (1994) reported that dietary pectin, one of the main components of NSP in sugar beet pulp, reduced the apparent ileal and fecal amino acid digestibilities. However, den Hortog et al. (1988) observed pectin in diet did not effect on amino acid digestibilities Mosenthin et al. (1994) demonstrated that this contradictory results might be due to differences in the composition of the basal diets used in addition to the dose effect. Den Hartog et al. (1988)

Table 5. Effect of phase feeding and SBP on N excretion and N retention in finishing pigs

Feeding regimen	Two phase feeding		Three phase feeding		PSE[b]	Probability		
SBP[a]	0%	10%	0%	10%		PF[c]	SBP[d]	PF×SBP
N intake (g/d)	60.26	61.15	60.59	61.08	0.89	NS[e]	NS	NS
Fecal N excretion (g/d)	7.13	9.03	7.29	7.88	0.59	NS	NS	NS
Urinary N excretion (g/d)	23.85	18.92	21.82	18.21	1.01	NS	0.0389	NS
Total N excretion (g/d)[f]	30.98	27.95	29.11	26.09	1.00	NS	NS	NS

[a] Sugar beet pulp. [b] Pooled standard error. [c] Phase feeding effect. [d] SBP effect. [e] Not significant.

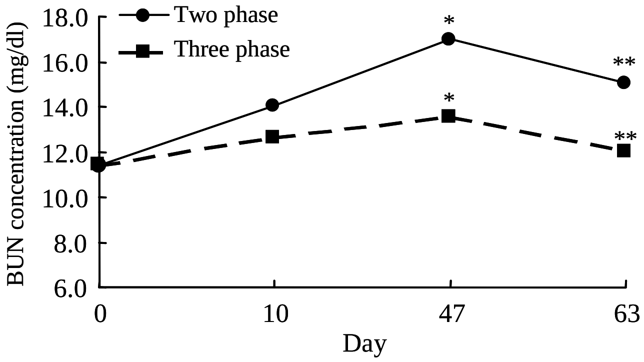

Figure 1. Effects of phase feeding on BUN concentration in finishing pigs (* p<0.05, ** p<0.01).

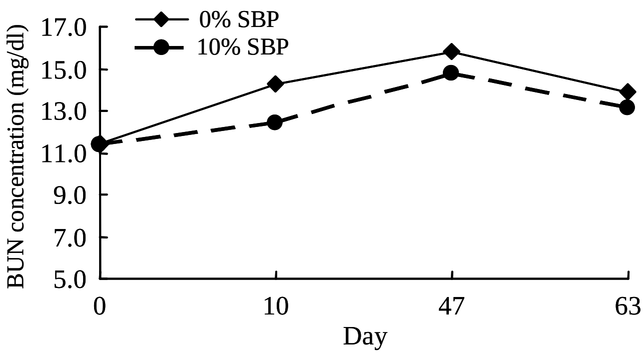

Figure 2. Effects of SBP on BUN concentration in finishing pigs.

provided a basal diet composed of natural fiber-containing ingredients such as corn, barley and soybean meal, whereas Mosenthin et al. (1994) used a highly digestible semi-purified cornstarch-based diets, which were much more sensitive to the additional supply of pectin. In the present study, natural fiber-containing corn-soybean basal diet was used. Thus amino acid digestibility might not be impaired by SBP supplementation, although proline digestibility was decreased by SBP supplementation exceptionally.

Nitrogen excretion

Table 5 showed the effects of phase feeding and SBP on nitrogen excretion in finishing pigs. Urinary and total nitrogen excretion in three phase feeding was decreased by 6.4 and 6.3%, respectively compared to two phase feeding, even though it was not significant. Urinary nitrogen excretion was reduced 18.7% in pigs fed diets containing 10% SBP treatment compared to 0% SBP treatment (p<0.05). Total nitrogen excretion in 10% SBP treatment also was numerically reduced 10.1% compared to 0% SBP treatment.

It has been well known that nitrogen excretion could be reduced by phase feeding without impairment of growth performance (Jongbloed and Lenis, 1992; Paik et al., 1996). Phase feeding system might reduce urinary N because phase feeding system did not affect nutrient digestibility, although a few researches showed a reduction of fecal N excretion by phase feeding system (Lee et al., 2000). In the present study, urinary N excretion was decreased by phase feeding system, but nutrient digestibility is not affected by phase feeding system.

10% SBP supplementation clearly reduced urinary N excretion in the present study. This result agreed with findings by Canh et al. (1997, 1998), who found high fecal N excretion and low urinary N excretion in pigs fed a diet containing 30% sugar beet pulp. Canh et al. (1997) demonstrated that decreased urinary N excretion by SBP supplementation was due to a high secretion of urea from the blood to digestive tract and a high microbial growth in the large intestine. Fermentable carbohydrates could be utilized as an energy source for microflora in the large intestine (Canh et al., 1997; Fuller and Reeds, 1998). The amount of urea secreted from blood into the large intestine increases when dietary fiber level was increased (Low, 1985), resulting in a reduction of urea and ammonia content in the portal plasma (Malmlöf, 1985).

In the present trial, like previous studies, fecal N excretion was not affected by phase feeding system and urinary N excretion was slightly decreased in three phase feeding system. However, urinary N excretion was clearly reduced and total N excretion was slightly reduced by 10% SBP supplementation. These results suggested that 10% SBP supplementation in finishing pig diet caused reduction of urinary N and subsequent reduced urinary N excretion might contribute to low ammonia emission of slurry.

Blood urea nitrogen

The effect of phase feeding and SBP supplementation on blood urea nitrogen (BUN) concentration was presented in Figure 1 and 2. As shown in Figure 1, while BUN concentration in two phase feeding was increased linearly with increase in age of pigs, however BUN in three phase feeding was almost not changed. Blood urea nitrogen

Table 6. Effect of phase feeding and SBP on carcass characteristics in finishing pigs

Feeding regimen	Two phase feeding		Three phase feeding		PSE[b]	Probability		
SBP[a]	0%	10%	0%	10%		PF[c]	SBP[d]	PF×SBP
Final body weight (kg)	113.0	116.0	116.9	112.7	1.18	NS[e]	NS	NS
Carcass weight (kg)	85.42	86.70	87.58	88.21	0.92	NS	NS	NS
Carcass percentage (%)	75.77	74.87	74.86	78.59	0.65	NS	NS	NS
Backfat thickness (mm)[f]	2.81	2.88	3.31	3.08	0.09	0.0315	NS	NS

[a] Sugar beet pulp. [b] Pooled standard error. [c] Phase feeding effect. [d] SBP effect. [e] Not significant. [f] 10th backfat thickness.

concentration in three phase feeding was significantly lower than that in two phase feeding at 47 days ($p<0.05$) and 63 days ($p<0.01$). There was no significant difference in BUN concentration between 0% SBP treatment and 10% SBP treatment.

It was well known that BUN concentration could be pretty good indicator for the determination of protein and amino acid utilization by pigs (Eggum, 1970). High level of BUN represented that excessive amino acids were metabolized and circulated in the blood during before the excretion. Yen et al. (1986a) demonstrated that BUN concentration of pigs was higher when dietary lysine and protein levels were increased above the pig's requirements. Chiba et al. (1991) also demonstrated that BUN concentrations of pigs fed diets containing different levels of protein were increased linearly with an increase of dietary lysine level. In the present study, BUN concentration in two phase feeding system was higher than that in three phase feeding system from 47 days, which represented that 14% protein and 0.8% lysine level in the two phase feeding might be too excessive for late finishing pigs. During overall experimental period, BUN concentration in three phase feeding was maintained in plateau at lower level than that in two phase feeding, which suggested that more adequate level of protein and lysine could be supplied because nutrient requirement was changed with age and body weight of the pig.

It was expected that lower level of BUN concentration was shown in three phase feeding and 10% SBP treatment, because of nitrogen partitioning effect of SBP into lumen from blood. However, there were no interaction between phase feeding and SBP supplementation, which was due to no effect of SBP supplementation on BUN nitrogen concentration (Figure 2). In the present study, sugar beet pulp may not affected BUN concentration in circulating system, although low urea content was reported in the portal plasma by Malmlöf (1985).

Carcass characteristics

The effects of phase feeding and SBP supplementation on carcass characteristics were presented in Table 6. There were no significant differences in carcass weight and carcass percentage among all treatments. However backfat thickness was decreased significantly in two phase feeding system compared to three phase feeding system ($p<0.05$). No interaction was found in all carcass characteristics between phase feeding system and SBP supplementation.

Lee et al. (2000) reported that 10th rib backfat thickness was reduced with increase in feeding regimen and shown the lowest thickness in four phase feeding regimens during finishing period. In the present study, however, backfat thickness of pigs fed on two phase feeding system was thinner than those fed on three phase feeding system. Chen et al. (1999) suggested that the pigs fed high-protein diet utilized energy less efficiently, consequently backfat thickness of finishing pigs increased when dietary protein and lysine was increased to certain level. The pigs fed high-protein diets required extra energy for metabolizing excessive amounts of protein (amino acid), therefore less energy would be available for growth (Chen et al., 1999). In their study, BUN concentration was also decreased with increase in dietary protein and lysine level. In the present study, when more protein and lysine would be supplied by two phase feeding compared to three phase feeding system during last 3 weeks, oversupplied protein and lysine were degraded to urea (Figure 1), and then more energy might be used for the protein and amino acid degradation. However, Lee et al. (2000) demonstrated that there was no significant difference in backfat thickness between two and three phase feeding system.

Generally, high dietary fiber limited energy density of diet, which resulted in decreased body fat content. However, in the present study, SBP supplementation did not affect bacfat thinkness. This result might be explained by high fermentation of dietary SBP in large intestine. Sugar beet pulp mainly consisted of fermentable NSP, such as soluble NSP (Knudsen, 2001). Consequently, fermentable NSP allowed high microbial fermentation in large intestine, which increased volatile fatty acid (VFA) production (Freire et al., 2000). Increased VFA could be used as energy source for portal vein-drained organs such as small and large intestine (Yen et al., 1989) and thus energy was utilized for growth.

IMPLICATION

Three phase feeding system did not show any adverse effect on growth performance in finishing pigs compared to two phase feeding system. The BUN concentration in three phase feeding group was lower and maintained in plateau for overall experimental period compared to that in two phase feeding group. Also urinary nitrogen excretion was lowed in three phase feeding group. Based on these results, three phase feeding is more acceptable than two phase feeding for finishing pigs. Sugar beet pulp supplementation did not affect ADG, although ADFI was decreased. Although BUN concentration was not affected by SBP supplementation, SBP reduced urinary nitrogen excretion.

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