Estimation of Protein Deposition Rate of Growing-Finishing Pigs Reared in Commercial Conditions in Korea[a]

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ABSTRACT : A total of 9,540 pigs were evaluated for their growth performance to provide information on the development of different feeding strategies to support maximum rate of protein deposition (PD). Large variations in growth performance and protein deposition rate were found in the population used in this study (ADG from 701 to 974 g/day; ADFI from 1,726 to 2,498 g/day; Feed/gain from 2.10 to 2.90; Backfat thickness from 12.4 to 20.5 mm and PD rate from 103 to 153 g/day). It was found that ADG was positively correlated to PD (R^2=0.9362, p<0.0001) while FCR was negatively correlated to PD (R^2=0.4031, p<0.0001). Backfat thickness was negatively correlated to PD (R^2=0.7024, p<0.0001) and to ADG (R^2=0.5096, p<0.0001). The estimated lysine requirement based on PD rate also showed large variation (12.37 to 18.38 g/day true ileal digestible lysine on average between 25 and 100 kg), thus strongly indicated the need of separate feeding strategies for each group of pigs. When pigs were divided into three categories according to estimated whole body PD rate, the group of pigs with the highest PD rate grew faster by 6.3 and 13.9% than pigs with intermediate and low PD rate, respectively. Feed utilization was also more efficient in pigs with a high PD rate. It appeared that pigs with high PD rate maintained higher PD rate especially in the later stage of their life. Pigs with high PD rate require an extra amount of 1.2 and 2.4 g/true digestible lysine per day and 0.4 and 0.8% more lysine in the diet than pigs with intermediate and low PD rate during the growing-finishing period respectively. Results of this study suggest that there is a need for separate feeding strategies for individual group of pigs with different PD rate. It should be noted that average value for each group presented in this report is not the adequate amount for an animals potential for maximum PD rate. With recent development in growth modeling and access to computer technologies to facilitate computation, pork producers can easily estimate pigs protein deposition rate and thus can make their own feeding strategies. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 8 : 1147-1153*)

Key Words : Pigs, Protein Deposition, Lysine, Genetic Potential, Feeding Strategies

INTRODUCTION

It is very important to consider the pig's genetic potential for protein accretion for cost-effective feeding strategy of individual groups of growing-finishing pigs (de Vries and Kanis, 1994). Most studies in the review of de Vries and Kanis (1994) showed an annual improvement over last three decades of about 1 per cent for feed conversion ratio, and 1-2 per cent for growth rate and backfat thickness. Modern pigs consequently would require greater quantities of nutrients due to genetic improvement as well as advances in nutrition, health and management. Numerous studies (Campbell et al., 1984, 1988; Rao and McCracken, 1990; Yen et al., 1986; Friesen et al., 1994a, b; Friesen et al., 1995) showed the differences in nutrient requirements of pigs with different growth potential. Stalhy et al. (1988) reported that 2 to 4 g/d more dietary lysine requirements for high-lean growth barrows compared to medium-lean growth barrows fed from 22 to 109 kg. Friesen et al. (1994a, b) and Campbell et al. (1988) also suggested that the greater lysine requirements for high-lean growth gilts were needed to support a higher rate of protein gain. Some researchers (Bereskin et al., 1976; Davey, 1976; Whittemore, 1986; Campbell, 1988; Stalhy et al., 1991) have showed that the genetic potential of the pig for lean tissue growth does determine amino acid requirements.

For many pork producers in Korea, it is unlikely that the genetic potential for lean growth is adequately considered in the development of feeding strategies. Each producer should consider cost-effective feeding strategies to support the maximum expression of their pigs' genetic potential. Thus the present study was conducted to evaluate the genetic potential of pigs reared in commercial setting in Korea and provide information for individual feeding strategies for the maximum lean growth of the pigs.

MATERIALS AND METHODS

A total of 53 swine farms were involved to evaluate their pigs' potential for protein accretion in

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the present study. In each farm, the feeding trials were undertaken with three body weight categories of 25 kg, 50 kg, and 85 kg. Sixty pigs were employed in the feeding trial in each body weight range, which resulted in 180 pigs per farms and a total of 9,540 pigs as experimental subjects in the whole study. A commercial grower ration was fed to all pigs in the experiment. The experimental diet was formulated to contain 3,630 kcal/kg DE, 22.90% crude protein, 1.37% total lysine and 0.82% methionine+cystine (table 1). Pigs had *ad libitum* access to the experimental diet. All the pigs were on test for 2 weeks in each body weight categories. Weight gain and feed intake were measured. Based on performances of pigs of 25 kg, 50 kg, and 85 kg, the growth performance during 25 to 100 kg growth phase was estimated. Last rib backfat thickness was measured at slaughter using ultrasonic equipment (Renco, USA) and converted to a value of 100 kg pigs. Protein deposition (PD) was calculated by the following equation suggested by NRC (1998).

Fat-free lean index=
50.767+(0.035×Hot carcass weight, lb) - (8.979 ×Last rib midline backfat thickness on hot carcass, in)
Carcass fat-free lean (lb)=
Fat-free lean index×Hot carcass weight (lb)
Initial fat-free lean (lb)=
0.95×{-3.65 + (0.418 X live weight, lb)}
Carcass fat-free lean gain (lb/day)=
{Final carcass fat-free lean (lb) Initial carcass fat-free lean (lb)}/Days from initial to final
Lean gain (g/day)=Lean gain (lb/day)×0.454
Whole body PD=Lean gain (g/day)/2.55

Table 1. Nutrients composition of the experimental diet[a]

Nutrients	Concentration in the diet
Digestible energy (kcal/kg)	3,630
Crude protein (%)	22.9
Crude fat (%)	6.9
Crude ash (%)	4.4
Lysine (%)	1.37
Methionine+Cystein (%)	0.82
Threonine (%)	0.84
Tryptophan (%)	0.27
Calcium (%)	0.72
Phosphorus (%)	0.66

[a] Typical commercial diet (air dry basis).

Calculated average PD rate was regressed against ADG, FCR and BF. Backfat thickness was also regressed against ADG. Lysine requirement for these pigs was estimated by the method of NRC (1998).

Lysine required for maintenance=$0.036\times BW^{0.75}$
True ileal digestible lysine for gain (g/day)=
0.12×whole body protein gain

To show the example of the difference among groups with different PD rate, the entire population was divided into three subgroups: High PD rate (H: upper 30%), intermediate PD rate (I: middle 40%) and low PD rate (L: lower 30%). Growth performance and estimated lysine requirement of these groups were statistically analyzed using GLM procedure of SAS (1985) and mean value for each group was compared using least square mean. Each farm was used as an experimental unit.

RESULTS

Growth performance, backfat thickness and protein deposition rates are presented in table 2. There was a large difference in growth rate among the pigs evaluated in this study. Average daily gain of the pigs ranged from 701 g/day to 974 g/day with a mean value of 840 g/day. Average daily feed intake of the pigs was ranged from 1,726 g/day to 2,498 g/day with a mean value of 2,076 g/day. Feed/gain varied from 2.10 to 2.90 with a mean value of 2.48. Backfat thickness ranged from 12.4 mm to 20.5 mm with a mean value of 15.86 mm. PD rate ranged from 103 g/day to 153 g/day with a mean value of 129 g/day. The relationships between PD and ADG or FCR are presented in figure 1. Average daily gain was positively correlated to PD (R^2=0.9362, $p<0.0001$) while FCR was negatively correlated to PD (R^2=0.4031, $p<0.0001$). Backfat thickness was regressed against PD or ADG (figure 2). Backfat thickness was negatively correlated to PD (R^2=0.7024, $p<0.0001$) and ADG (R^2=0.5096, $p<0.0001$).

The mean values of each criteria of those three groups (High (H): upper 30%, Intermediate (I): middle 40% and Low (L): lower 30%) are presented in table 2. Pigs in H group grew 6.3% faster than those in M and 13.9% faster than L group, respectively ($p<0.05$). For the ADFI, no significant difference was found between pigs in H or M group, but pigs in L group consumed significantly less feed ($p<0.05$) than pigs in H group. Animals of H group utilized feed 6.7% more efficiently for their body growth than those of L group ($p<0.05$). The difference in feed/gain (F/G) between H and M group was not significant. Backfat thickness was significantly different among H, M and L group. H group reached at 100 kg body weight from 25 kg 5 and 11 days faster than M and L group, respectively ($p<0.05$).

The estimated growth performance during 25 to

Table 2. Growth performance of pigs with different rate of protein deposition

	Mean	Protein deposition rate			SEM
		High	Intermediate	Low	
ADG (g/day)	840	893[a]	838[b]	790[c]	6.87
ADFI (g/day)	2076	2125[a]	2082[ab]	2021[b]	16.92
Feed/gain	2.48	2.38[a]	2.49[a]	2.57[b]	0.02
Backfat (mm)	15.86	13.97[a]	15.66[b]	18.00[c]	0.29
Protein depositon (g/day)[1]	129.0	139.2[a]	129.2[b]	118.8[c]	1.28
Days required from 25 kg to 100 kg	89.5	84.1[a]	89.2[b]	95.2[c]	0.73

[1] Mean protein deposition rate between 25 to 100 kg body weight.
[a,b,c] Means with different superscripts in the same row differ at $p<0.01$.

100 kg growth phase of pigs with different PD rate are shown in figure 3. For ADG, obvious difference were found among pigs with different PD for whole growing-finishing period ($p<0.01$). H group consistently showed high ADG between 25 to 100 kg growth phase. However, ADFI and F/G did not follow the same pattern with ADG. During the phase of 25 to 100 kg, ADFI of H and M groups was not significantly different, though H pigs consumed more feed. L group consumed significantly less feed during 25 to 90 kg growth phase than H group ($p<0.01$). For 90 to 100 kg growth phase, no significant difference was found in ADFI. Until 50 kg body weight, F/G was not different among pigs with different protein deposition rates. As pigs grow, H group utilized feed more efficiently than L or M group. However, no difference was found in F/G between M and L group, although M group showed better feed utilization than L group. H group consistently showed better F/G during finishing period (60 to 100 kg growth phase) than L group.

The lean gain curve was derived from mean lean gain value by multiplying the factor for each weight category suggested by NRC (1998). The lean gain curve and lysine requirements for pigs with different PD rates are shown in figure 4. The difference for lean gain rate is about 10 g/day among pigs with different PD rate all over the duration of observation. As a result, pigs of H group require about 1.2 g more lysine per day than pigs in I group and I group require about 1.2 g more lysine than pigs in L group. Using the ADFI obtained in this study, lysine requirement is expressed as per cent of diet (table 3). H group require 0.4% and 0.8% more lysine than I and L group during growing-finishing period.

DISCUSSION

The better growth performance of pigs with high lean gain potential has been shown by several publications (Davey and Morgan, 1969; Campbell et al., 1984, 1988; Rao and McCracken, 1990; Yen et al., 1986; Friesen et al., 1994a, b; Friesen et al.,

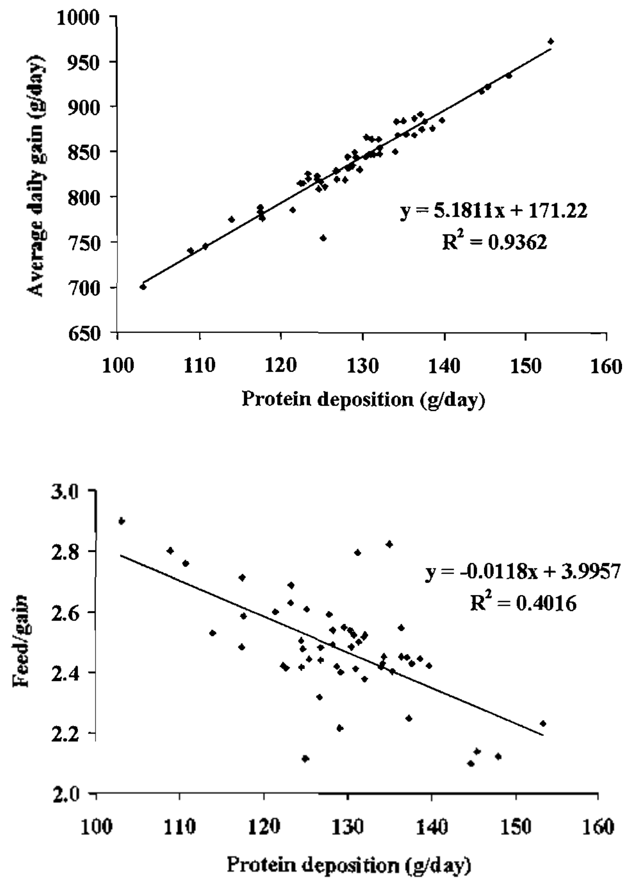

Figure 1. Relationship between protein deposition and weight gain or feed efficiency* (* The mean values for each farm were included in the equation)

1995). Although the genetic background of pigs was not individually investigated in this study, the marked difference in growth rate found among pigs indicates that intensive selections have been occurred in pig breeding in Korea.

The ADG of H group was consistently high during 25 to 100 kg growth phase, while ADFI was not significantly different during the same growth phase between H and I group. Feed/Gain was also not significantly different until 70 kg between H and I

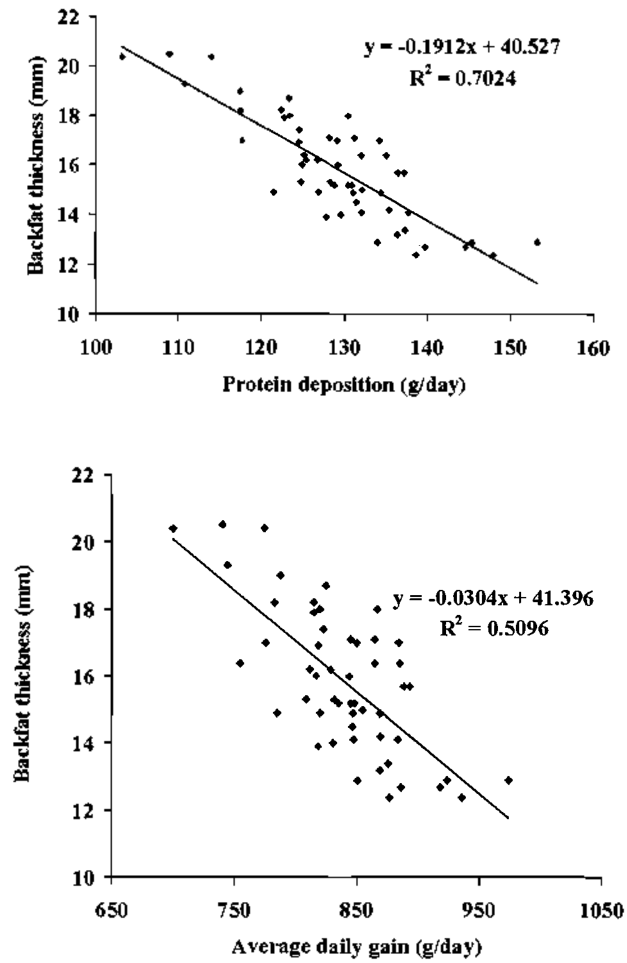

Figure 2. Relationship between backfat thickness and average daily gain or protein deposition* (* The mean values for each farm were included in the equation)

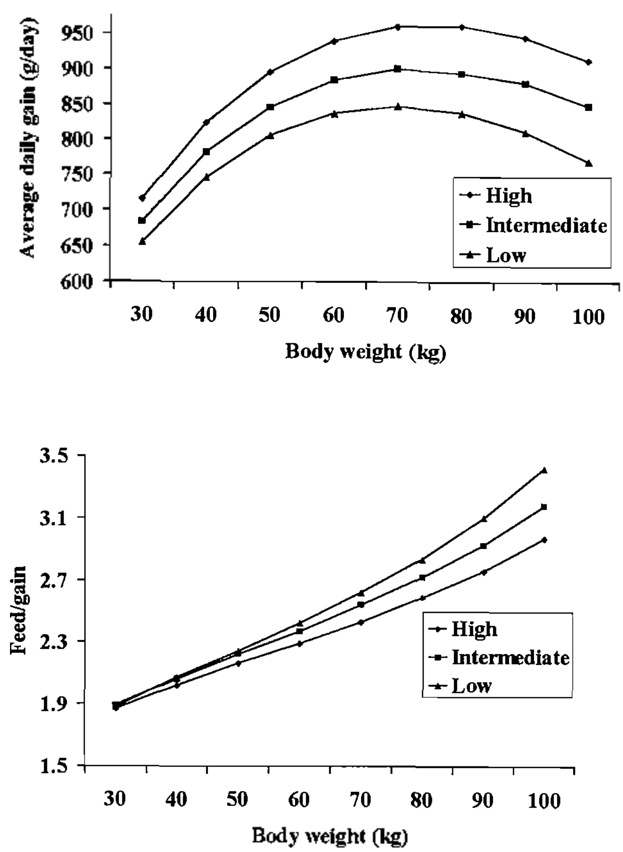

Figure 3. Growth performance of pigs with different protein deposition rate

group. The higher ADFI of H and I group appeared to be the main reason for better growth performance than pigs in L group. Previous reports have shown that feed consumption is associated positively with gain and negatively with F/G (Headley, 1946; Bereskin et al., 1975), which is in agreement with our data.

The differences in growth rate and feed utilization between pigs with high and low PD rate became larger in later growth phase. This might be a reflection of genetic potential for lean deposition. Schinckel and de Lange (1996) suggested that generally high protein accretion genotypes maintain higher protein accretion rates at heavier weights than low or average protein accretion genotypes. In addition, McPhee et al. (1991) suggested that the difference between pigs with different growth potential is enhanced under a high energy and lysine diet. In this study, the diet containing 22.9% crude protein, 1.37% lysine diet was obviously higher than the requirements of average finishing pigs, as a consequence the larger difference found in later growth phase might be associated with the finding of McPhee et al. (1991). Friesen et al. (1994a) also reported that high-lean gilts had greater magnitude of response to increased dietary lysine than medium-lean type gilts. The higher crude protein level of the experimental diet might not be adequate for the pigs with low growth potential. Christian et al. (1980) suggested that young pigs seemed to eat to meet protein need, while in later stages, the relative importance of energy increased. Baird et al. (1975) also indicated that a pig eat to meet a nutrient or energy requirement rather than to fill its stomach. Thus, the low appetite found in the L group might be associated with its protein or energy requirement, indicating that the nutrient requirement is different among pigs with different protein deposition rates (Stalhy et al., 1988; Friesen et al., 1994a, b; Campbell et al., 1988; NRC, 1998).

Backfat thickness was significantly different among pigs with different PD rate and negatively correlated with ADG and PD (figure 2). It has been shown from rats, lambs and pigs that, when protein is supplied in excess of the amount needed for maximal protein accretion, heat production is increased and the

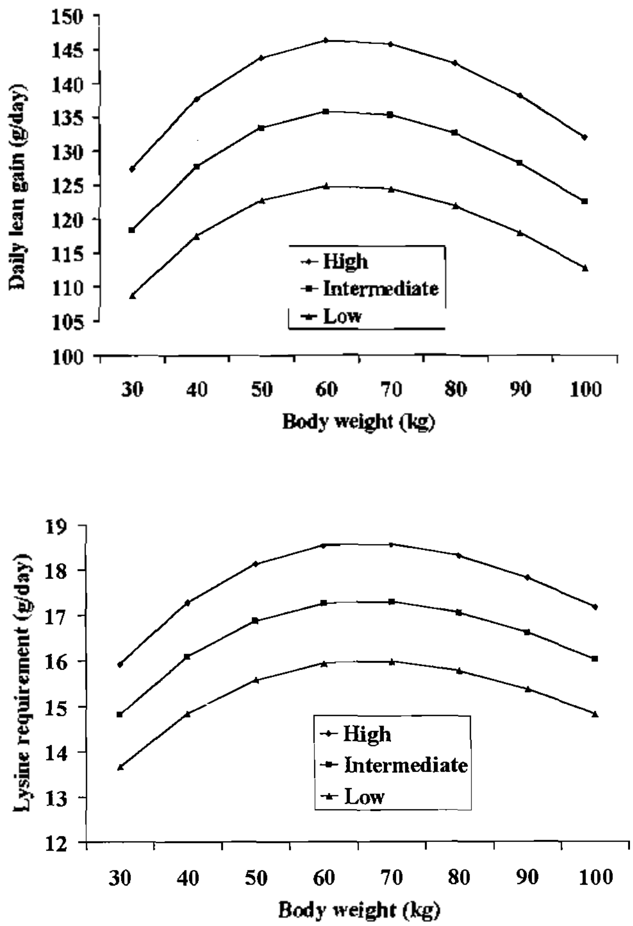

Figure 4. Estimated lean gain curve and lysine requirement

Table 3. Estimated lysine requirement of pigs with different protein deposition rate

Body weight (kg)	Lysine requirement (% of diet)[1]		
	High	Intermediate	Low
30	1.20	1.16	1.12
40	1.04	1.00	0.97
50	0.94	0.90	0.87
60	0.87	0.83	0.79
70	0.80	0.76	0.73
80	0.74	0.70	0.67
90	0.69	0.65	0.62
100	0.64	0.60	0.57

[1] True digestible basis.

efficiency of energy utilization is reduced (Walker and Norton, 1971; Holmes et al., 1980; Campbell et al., 1985). Under these circumstances lipogenesis is reduced and initially the fat:protein ratio in the gain falls below that of animals fed a better-balanced diet (Campbell, 1988). Campbell (1988) suggested that the decline in protein deposition was more rapid than the associated decline in lipogenesis, particularly in castrated males, females and genetically inferior animals, resulting in the fat:protein ratio of gain, and thus body fat content, rising to considerably higher levels than those of animals fed better-balanced diets. Thus, higher backfat value of pigs with lower PD rate indicated that they consumed excessive protein and energy from the diet used in this study.

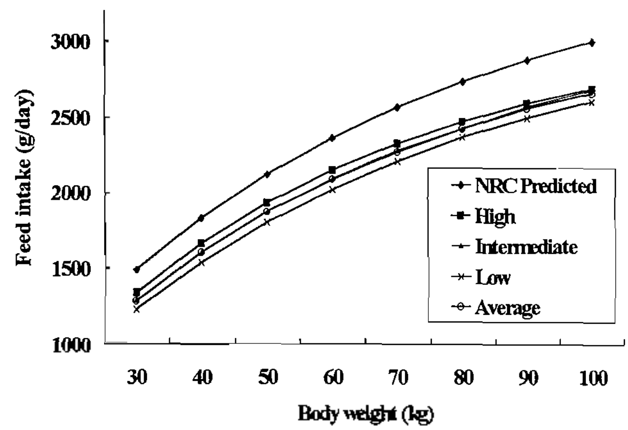

Figure 5. Average feed intake of pigs fed the experimental diet

Recently, the NRC (1998) suggested an equation to estimate whole body protein deposition from backfat thickness and/or loin eye area. Because lysine requirement is directly related to whole body protein deposition, lysine requirement can also be easily estimated. From the mean protein deposition rate and default equation suggested by NRC (1998), we estimated the lean gain curve during growing-finishing period and lysine requirement for each body weight category (figure 4 and table 3). The estimated lysine requirement strongly suggests a need for different feeding scheme for pigs with different growth potential. Pigs in H group required more than 2 g lysine per day to support its protein deposition rate compared to pigs in L group. This result supports the finding of Stahly et al. (1988) who found that high-lean growth barrows would require 2 to 4 g/d greater dietary lysine than for medium-lean growth barrows fed from 22 to 109 kg. Friesen et al. (1994a, b) and Campbell et al. (1988) also suggested that the higher lysine requirements for high-lean growth gilts were needed to support the greater rate of protein gain. Other amino acids requirements can be easily estimated using ideal amino acids patterns (NRC, 1998) based on the estimated lysine requirement. Estimated lysine requirement was a little higher than the current NRC (1998) recommendation when expressed in % of diet (table 3). This was due to a relatively low feed intake observed in this study (figure 5) as a general trend for modern animals.

It should be noted that average values for each group are not an adequate description of an animal's potential for lean growth (Schinckel, 1994). In the present study, growth performance within the same group varied considerably among individual values, especially for pigs with high or low growth potential. ADG of pigs in H group varied from 867 to 974 g/day and that of pigs in L group varied from 701 to 819 g/day. Differences in feed intake, growth performance and carcass characteristics can be found between breeds, between distinct genetic lines within a breed, and between individuals within a line (Ellis et al., 1997). Friesen et al. (1994a) also reported a within genotype difference between sex. The within line selection practiced by each stock supplier is much more important than the breed composition (Schinckel, 1994).

Pork producers should be interested in the growth potential of their pig, since pigs with high protein deposition rate are more efficient in converting feed and protein to weight gain. The results of the present study clearly showed the better feed utilization of pigs with high PD rate. This relationship exists because the energetic cost of fat deposition is approximately four times greater than that for lean growth. At 100 kg live weight, fat tissue is approximately 88% lipid, 3% protein and 9% water and lean tissue is approximately 76% water, 20% protein and 4% lipid. This allows lean pigs to be more efficient in converting feed to weight gain (Schinckel, 1994).

IMPLICATION

In the commercial setting, pigs showed large variation in their growth rate. This might be a result of the differences in improvement of genetic, nutrition, health and management depending on the production units and intensive selection occurred in commercial conditions. Pigs with high PD rate maintained higher growth rate at heavier growth stage indicating higher nutrients need in the later growth phase than pigs with average or low growth potential. The present study confirmed the previous findings that there should be different feeding strategies for the pigs with different PD rate and the data presented in this report will be of great help to Korean pork producers for developing their feeding strategies. More studies are required to set the nutrient requirements, management system and environmental conditions for realizing the maximum expression of growth potential of pigs.

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