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Requirement of Ileal Digestible Lysine for European Growing and Finishing Pigs under Tropical Conditions

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ABSTRACT

Thirty crossbred barrows averaging 24 kg body weight (BW) were used to investigate the ileal digestible lysine requirement of growing (20-40 and 40-65 kg BW) and finishing pigs (65-90 kg BW). Basal diets based on broken rice, rice bran and peanut meal were fortified with four incremental additions of L-lysine-HCl with an interval of 0.15 %. The dietary lysine contents ranging from 0.65 to 1.25 % for period 20-40 kg, 0.55 to 1.15 % for period 40-65 kg and 0.50 to 1.10 % for period 65-90 kg. Conventional control diets, containing 18.8, 16.4 and 13.8 % crude protein (CP) were also included. Daily gain, N retention , plasma urea nitrogen (PUN) during each of the 17 day balance were measured. Increasing dietary lysine content improved daily gain and protein deposition significantly ($p < 0.05$) for the growing periods but did not significantly affect in the finishing period. Conversely, the concentration of PUN decreased as dietary lysine concentration increased. Broken-line regression analysis determined the total dietary lysine requirements needed to optimize the daily gain, N retention and PUN as being 11.1, 16.8 and 20.0 g/d for the three stages of growth, respectively. Based on the ileal digestible lysine in feedstuffs and the total lysine contents found to optimize performance, the ileal digestible lysine requirements of European growing and finishing pigs under tropical conditions were 9.9, 15.2 and 17.0 g/d, respectively.

Key words: requirement, European pigs, ileal digestible lysine, tropical conditions

INTRODUCTION

The population of European pigs which provide a leaner carcass has increased in recent years in Thailand. Due to the differences in environmental conditions, the recommended lysine requirement from published data may not ensure the maximal performance of these pigs. It's therefore necessary to determine the lysine requirement for the growing and finishing period under tropical conditions. As the requirements are affected by a number of factors, feeding differences in digestibility or availability of lysine among feedstuffs also may be responsible for some of the variation among trials (ARC, 1981), the use of ileal digestibility to estimate the optimal lysine intake could provided a better prediction of the lysine utilization in pigs (Martinez and Knabe, 1990). The objective of this research was to determine the digestible lysine requirement of European pigs under tropical conditions.

MATERIALS AND METHODS

Animals and Housing

Thirty crossbred (Danish Landrace-

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Largewhite sows x Pietrain boars) barrows averaging 24 kg BW were used to investigate the optimal lysine level for the two stages of growing period (20-40 and 40-65 kg BW) and finishing period (65-90 kg BW). The animal was housed individually in metabolic cage and was randomized to six groups to feed the experimental diets. The room temperature during the experiment varied from 24.4 to 33.0 °C and the relative humidity ranged from 56 to 96 %.

Experimental Diets

The basal diets for each stage of growth were formulated based on broken rice, ricebran and peanut meal and containing 18.5, 16.0 and 13.6 % CP by analyzed, respectively (Table 1). Corresponding dietary lysine content were 0.65, 0.55 and 0.50 %. Basal diets were fortified with four incremental additions of L-lysine-HCl with an interval of 0.15 % to provide dietary lysine contents ranging from 0.65 to 1.25 % for the period 20-40 kg, 0.55 to 1.15 % for the period 40-65 kg and 0.50 to 1.10 % for the finishing period. Crystalline essential amino acids were added to provide the optimal ratios of essential amino acids (Wang and Fuller, 1990) to the highest lysine level for each period. Conventional control diets containing 18.8, 16.4 and 13.8 % CP were also included. Mineral and vitamins were added to meet the requirement of pigs (NRC, 1988).

Method

To avoid the effects of feed intake to N utilization, the pigs were fed twice daily at a daily dietary level of 100 g/kg of the expected metabolic body weight ($BW^{0.75}$) for the middle of each period. Water was mixed with the feed prior to feeding to provide a 1 : 1.5 feed : water ratio. Additional water was offered 1.5 liter after each feeding. N balance studies were conducted to determine the optimal lysine requirements of the three periods of growth. Each period consisted of a 7-d adaptation period to the dietary treatment and a 10-d collection period to collect total feces and urine. Samples were collected twice a day and stored at -20 °C until analyzed.

At the end of each collection period, blood sampling was carried out from each of animal by anterior vena cava puncture 1 to 2 h after feeding. Plasma was seperated by centrifugation and stored at -20 °C until it was analyzed. The PUN concentrations were determined by colori-metrically measuring the product formed in the direct reaction of urea and diacetyl monoxime (Test set: Life Science Dynamics Laboratory, Nr. 10302).

Feedstuffs and diets were analyzed for dry matter, CP, crude fat, crude fibre (AOAC, 1984), GE (adiabatic bomb calorimeter, Parr Instrument Moline IL). For amino acid analysis, samples were hydrolyzed in 6 n HCl for 12 h at 110 °C. Hydrolyzate was filtered through membrane filter (∅ 0.45 µ) to eliminate particulate matter. Filtered hydrolyzate was dried for two times under liquid N_2 and derivatived with Phenylisothiocyanate (PITC) to form Phenylthiocarbamyl amino acids. Amino acid hydrolyzates were analyzed using HPLC (Waters, Milford Massachusetts USA) as method described by Waters (1989). Amino acids were seperated by reverse-phase columm (Pico-Tag columm; Waters Nr. 88131) and detected by UV detector with 254 nm. Tryptophan content was not determined. Nitrogen content of feces and urine samples was determined by the Kjeldahl procedure (AOAC, 1984).

Statistical analysis

All data were analyzed by ANOVA appropriate for completly randomized designs (SPSS for windows, Version 6.0.1). The one-slope, broken-line regression model described by Robbins *et al*. (1979) was used to estimate an inflection point for the ADG and N retention (NR) response curves to increasing lysine, whereas a two-slope, broken-line model was used to calculate an inflection point for the PUN concentration response curve.

RESULTS AND DISCUSSION

In the growing periods (20-40 and 40-65 kg BW), increasing dietary lysine content caused

Table 1 Composition of basal and control diets for the three experimental periods (%).

Component	Period 20-40 kg		Period 40-65 kg		Period 65-90 kg	
	Basal	Control	Basal	Control	Basal	Control
Broken rice	54.33	56.35	62.44	62.75	66.99	67.75
Ricebran	10.00	10.00	10.00	10.00	10.00	10.00
Peanut meal	30.20	-	22.10	-	17.90	-
Soybean meal	-	25.10	-	19.70	-	15.90
Fishmeal	-	5.00	-	4.00	-	3.00
Dicalciumphosphate	3.40	2.70	3.25	2.70	2.80	2.50
$CaCO_3$	0.10	-	0.10	-	0.10	-
NaCl	0.35	0.35	0.35	0.35	0.35	0.35
DL-Methionine	0.20	-	0.20	-	0.20	-
L-Tryptophan	0.03	-	0.05	-	0.05	-
L-Threonine	0.32	-	0.33	-	0.33	-
L-Isoleucine	0.20	-	0.21	-	0.22	-
L-Leucine	0.17	-	0.22	-	0.26	-
L-Valine	0.20	-	0.20	-	0.23	-
L-Histidine	-	-	0.05	-	0.07	-
Vitaminpremix [1]	0.25	0.25	0.25	0.25	0.25	0.25
Mineralpremix [2]	0.25	0.25	0.25	0.25	0.25	0.25
Analyzed composition						
Crude protein (%)	18.50	18.75	15.95	16.39	13.64	13.83
Lysine (%)	0.66	1.05	0.55	0.94	0.49	0.79
Methionine (%)	0.43	0.34	0.42	0.26	0.40	0.29
Threonine (%)	0.88	0.74	0.78	0.65	0.74	0.61
Calcium (%)	1.04	1.03	0.93	0.92	0.81	0.81
Phosphorus (%)	0.81	0.82	0.75	0.77	0.66	0.69
GE (MJ/kg)	15.02	15.13	14.89	15.09	15.10	15.38
ME (MJ/kg) [3]	13.81	14.10	14.06	14.19	14.20	14.26

1. Vitamin premix (per kg diet): 16000 IU vitamin A; 1340 IU vitamin D3; 20 mg vitamin E; 1.4 mg menadion; 2 mg thiamine; 4 mg riboflavin; 2.6 mg pyridoxine; 0.024 mg cobolamine; 10 mg d-calcium-pantothenate; 20 mg niacin; 0.5 mg folic acid; 0.2 mg d-biotin; 300 mg choline chloride
2. Trace element premix (per kg diet): 0.2 mg Se; 80 mg Fe; 50 mg Mn; 100 mg Zn; 150 mg Cu; 0.2 mg Co; 0.5 mg I
3. Calculated from crude nutrients (GfE, 1987)

daily gain, feed conversion ratio (Table 2 and 3) to improve ($p < 0.05$). Dietary lysine concentration did not alter the amount of N lost via feces, whereas the urinary N excretion decreased significantly ($p < 0.05$) with increasing dietary lysine. Therefore, N retention increased significantly ($p < 0.01$). The maximum daily gain (495 and 811 g/d) and protein deposition (99 and 146 g/d) were reached at the level of 1.25 % lysine in period 20-40 kg BW and 1.0 % lysine in period 40-65 kg BW. During finishing period the growth performance and N retention (Table 4) of pigs were increased only in tendency ($p = 0.12$) as the dietary lysine increased. At lysine level of 0.95 % in the diet, the growth performance and protein deposition were maximized with 795 g/d and 136 g/d, respectively. Performance of pigs fed the control diets (1.05 % lysine for period 1, 0.94 % lysine for period 2 and 0.79 % lysine for period 3) were similar to performance of pigs fed the peanut meal based diets containing 1.25 %, 1.0 % and 0.95 % lysine, respectively.

Similar growth performance were reported by Phanacharoensawat *et al*. (1995), whereas the average daily gain of 669 g/d that was determined by Coma *et al*. (1995) in growing pigs (25-30 kg BW) with high genetic potential for lean growth and 1,079 g/d in finishing pigs (50-90 kg BW) reported by Hahn *et al*. (1995) showed the better performance. The protein deposition in each period of growth are agree well with the purpose for the pigs by GfE (1987). However, these values are lower than the average protein deposition capacity of castrated with high potential for lean gain between growing period from 20 to 100 kg BW of 171 g/d reported by van Lunen and Cole (1996). Properly, because the feed intake of animals under tropical environment decreased to reduce the body heat production. Additively the metabolism of animals could be also affected. Christon (1988) reported

Table 2 Growth performance and N retention of pigs (20-40 kg BW) by increasing dietary lysine level.

Groups Lys. Supplementation (%)	I -	II 0.15	III 0.30	IV 0.45	V 0.6	Control diet
% dietary lysine	**0.65**	**0.80**	**0.95**	**1.10**	**1.25**	**1.05**
Initial weight (kg)	23.7	23.4	23.7	24.1	23.8	23.7
Final weight (kg)[3/]	27.7[a]	29.9[ab]	30.6[ab]	32.3[b]	32.4[b]	32.0[b]
ADG (g)[3/]	236[a]	344[b]	400[b]	478[c]	494[c]	480[c]
Feed intake (kg/d)	0.93	0.95	0.99	1.00	1.00	1.00
FCR[3/]	4.05[a]	2.82[b]	2.51[bc]	2.14[bc]	2.06[c]	2.12[bc]
N balance data						
N intake (g/d)	27.8	28.4	29.7	30.4	30.3	29.9
N excretion (g/d)						
fecal excretion	6.1	6.2	6.4	6.5	6.6	5.7
renal excretion[3/]	13.6[a]	11.9[b]	10.6[b]	8.9[c]	7.9[c]	8.6[c]
N retention (g/d)[3/]	8.2[a]	10.3[b]	12.7[bc]	15.0[cd]	15.8[d]	15.5[cd]
PUN (mg/dL)[3/]	20.9[a]	19.3[ab]	15.2[abc]	13.5[bc]	12.3[c]	13.1[c]

[1/] $p < 0.05$; [2/] $p < 0.01$; [3/] $p < 0.001$

Mean values in the same row with different superscripts are significantly different by Scheffe' test ($p < 0.05$)

Table 3 Growth performance and N balance data of pigs in period 2 (40-65 kg BW).

Groups Lys. supplementation (%)	I -	II 0.15	III 0.30	IV 0.45	V 0.6	Control diet
% dietary lysine	**0.55**	**0.70**	**0.85**	**1.00**	**1.15**	**0.94**
Initial weight (kg)	44.6	45.2	44.2	44.8	44.8	44.6
Final weight (kg) [1/]	55.6^{a}	57.9^{ab}	58.0^{b}	59.4^{b}	59.2^{b}	58.6^{b}
ADG (g) [1/]	612	704	768	812	800	778
Feed intake (kg/d)	1.78	1.82	1.81	1.83	1.83	1.79
FCR	2.92	2.63	2.40	2.27	2.32	2.32
N balance data						
N intake (g/d)	45.4	46.7	47.0	47.9	48.3	46.9
N excretion (g/d)						
fecal excretion	8.04	8.40	8.50	8.62	8.72	7.56
renal excretion	20.2	18.0	17.4	16.0	16.5	17.0
N retention (g/d)[1/]	17.2^{a}	20.3^{ab}	21.1^{ab}	23.3^{b}	23.1^{b}	22.4^{ab}
PUN (mg/dL)	16.7	16.1	14.6	13.9	15.0	15.3

[1/] $p < 0.05$; [2/] $p < 0.01$; [3/] $p < 0.001$
Mean values in the same row with different superscripts are significantly different by Scheffe' test ($p < 0.05$)

that with the constant feed intake (90 g/kg BW$^{0.75}$) the growth performance and nitrogen retention of pigs kept under tropical temperature (22-32 °C) were lower and renal N excretion was higher than that from pigs under optimal temperature (14-21 °C).

The PUN concentrations decreased as the dietary lysine increased and showed a negative correlation with the N retention. Eggum (1970) demonstrated that the quality of dietary protein was inversely correlated with PUN concentrations. By supplementation with the first-limiting amino acid (Lys) to improve the amino acid balance of diet, the concentrations of PUN were reduced. Therefore, as the dietary requirement of the first limiting amino acid was met, N deposition maximized and at the same time the PUN concentration showed the minimal value. Dietary amino acid concentration greater than the requirement result in an excess of amino acids that must be catabolized and in consequence the greater PUN concentration are found. A similar pattern was observed by Coma *et al.* (1995) in growing and finishing pigs.

Estimated lysine requirement

Derived from broken-line regressions, the lysine requirement to maximize daily gain for the three stages of growth was slightly lower than that required to maximize N retention. The estimated lysine requirements using PUN concentrations supported the estimation using N retention as the response criterion (Figure 1). Coma *et al.* (1995) and Markert *et al.* (1993) also reported that the lysine requirement by using both criteria was close to another. To optimize ADG, N retention and PUN concentrations, the estimated requirements of total lysine were 1.14, 0.93 and 0.82 % in the diet for the three stages of growth, respectively. The

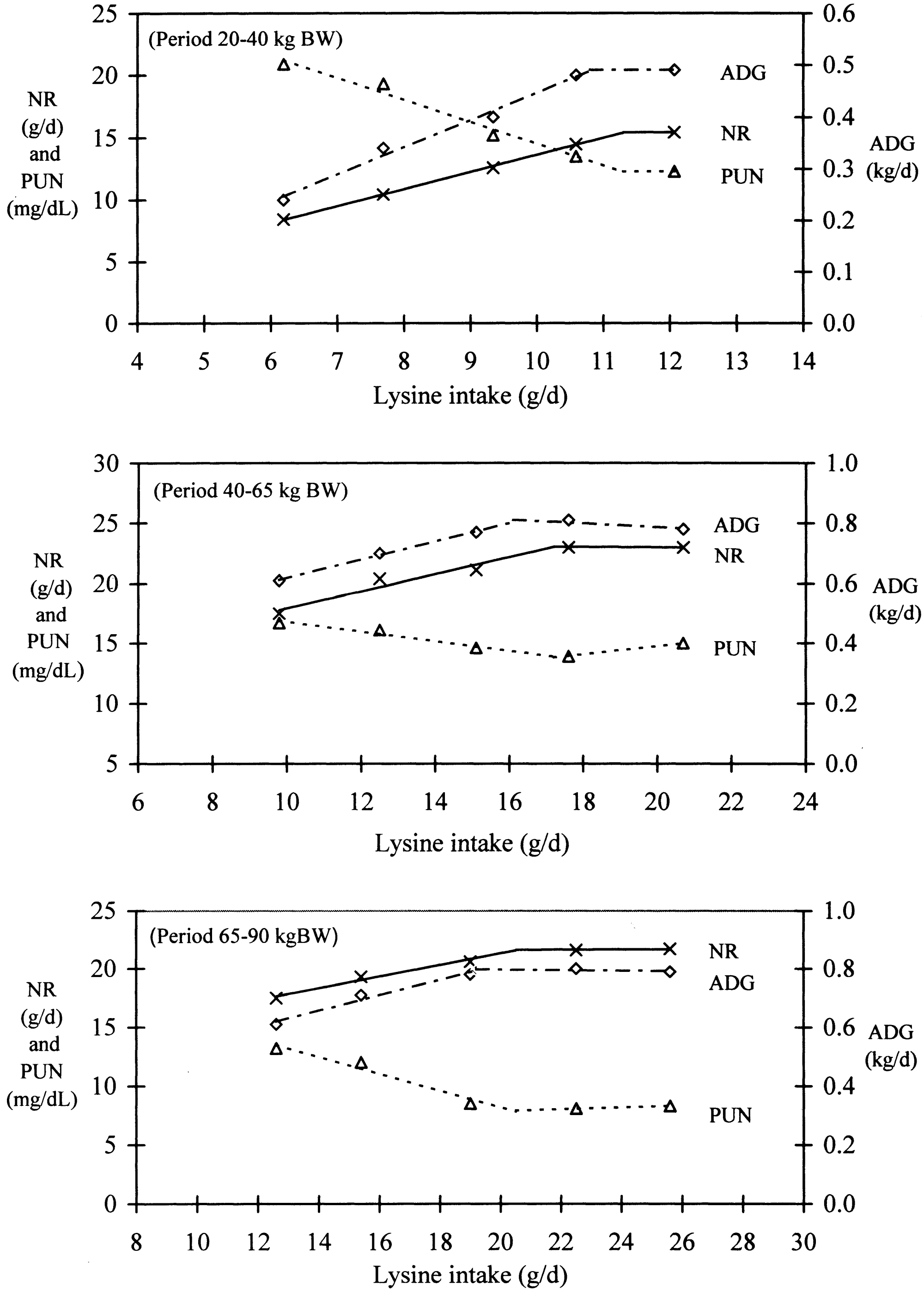

Figure 1 Estimated lysine requirement for the three periods of growth of pigs by broken-line regression model from the response criteria average daily gain (ADG), nitrogen retention (NR) and plasma urea nitrogen concentration (PUN).

corresponding daily lysine intake were 11.1, 16.8 and 20.0 g. Based on the ileal digestibility values of lysine in feedstuffs, 79.9% for broken rice, 71.8% for ricebran and 78.6 % for peanut meal, that were determined in digestion trials with growing pigs fitted with an ileal T-cannula (Paraksa, 1998) and the ileal digestibility of crystalline lysine was assumed to be 100 % (Martinez and Knabe, 1990), the calculated ileal digestible lysine requirements for the three periods of growth were 1.02, 0.84 and 0.70 % in the diet or 9.9, 15.2 and 17.0 g/d, respectively. To compare with the values proposed by NRC (1998), the digestible lysine requirement in these studies is slightly lower in growing period and somewhat higher in the finishing period, that presumably reflects differences in genetic capacity for protein deposition between the experimental animals and conditions, such as feed intake and environmental conditions.

CONCLUSION

Because of the variation of the digestibility in feedstuffs, the requirement based on ileal digestible amino acids may provide the optimal supply of the amino acids for the maximal performances. The ileal digestible lysine requirements for European growing and finishing pigs under tropical environment, such as in Thailand, are 9.9, 15.2 and 17.0 g/d for the period 20-40, 40-65 and 65-90 kg BW, respectively.

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Table 4 Growth performance and N balance data of the finishing pigs by increasing dietary lysine concentration.

Groups Lys. Supplementation (%)	I -	II 0.15	III 0.30	IV 0.45	V 0.6	Control diet
% dietary lysine	**0.50**	**0.65**	**0.80**	**0.95**	**1.10**	**0.79**
Initial weight (kg)	71.2	71.0	70.8	70.6	72.4	69.2
Final weight (kg)	81.6	83.1	84.0	84.1	85.8	82.6
ADG (g)	614	712	780	794	794	788
Feed intake (kg/d)	2.45	2.44	2.40	2.42	2.43	2.35
FCR	4.11	3.47	3.14	3.12	3.25	3.03
N balance data						
N intake (g/d)	53.4	53.3	52.8	53.4	54.1	52.0
N excretion (g/d)						
fecal excretion [2/]	8.30[ab]	8.50[a]	8.20[ab]	8.70[a]	8.72[a]	7.10[b]
renal excretion	27.9	25.7	24.2	23.2	23.7	23.6
N retention (g/d)	17.2	19.2	20.4	21.6	21.7	21.4
PUN (mg/dL) [3/]	13.2[a]	12.0[ab]	8.50[bc]	8.1[c]	8.3[bc]	8.5[bc]

[1/] $p < 0.05$; [2/] $p < 0.01$; [3/] $p < 0.001$

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