Vol.51, n. 1 : pp. 49-56, January-February 2008
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF
BIOLOGY AND TECHNOLOGY
A N I N T E R N A T I O N A L J O U R N A L

Lysine Requirement of Starting Barrows from Two Genetic Groups Fed on Low Crude Protein Diets

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ABSTRACT

A trial was carried out to determine the lysine requirement for starting barrows fed on ideal protein concept-based diets. Thirty-two pigs from a commercial crossbred genetic group (CCGG, BW=15.9 ± 1.4 kg) and 32 pigs from a dam line one (DLGG, BW= 14.8 ± 1.0 kg) were used. Pigs were allotted to 4 treatments with diets containing increasing levels of total lysine (0.80, 1.00, 1.20 and 1.40%). Methionine+cystine, threonine and tryptophan were adjusted according to ideal protein profile. Data from performance, plasma urea nitrogen (PUN) and carcass composition were analyzed. CCGG showed higher daily feed intake, daily weight gain, PUN and protein:fat ratio in carcass, while DLGG showed higher fat carcass content and nitrogen retention. Fat content and protein:fat ratio in carcass for CCCGG and PUN and crude protein carcass content for DLGG showed quadratic response to increasing total lysine levels. Derivations of the quadratic equations indicated the total lysine requirement for CCGG starting barrows is 1.15% and for DLGG starting barrows is 1.09%.

Key words: Carcass composition, crystalline amino acids, nitrogen excretion, nutrition, lean meat

INTRODUCTION

Environmental pollution is an increasing concern in the pig production, mainly due to nitrogen in the slurry. Low crude protein diets formulated with crystalline amino acids are an effective way to decrease nitrogen excretion from the pigs (Canh et al., 1998, Moreira et al., 2004, Oliveira et al., 2004). According to the ideal protein concept, animals are fed on the exact amino acid amounts required by them, or rather, with no excess or lack of amino acids in the diet (Baker, 1996). When a diet is formulated according to ideal protein concept, the requirement of essential amino acid is obtained according to lysine requirements. Amino acids requirements are shown as amino acid to lysine ratio (Penz Junior, 1996). Genetic factors, gender, body weight and environmental conditions influence lysine requirement. There are different lysine requirement values of starting pig in the literature. In a review Ferreira et al. (1996) found 1.09% as an average requirement, while Benati (1996) reported 1.15% as the average lysine level used by the Brazilian pig industry. International (National Research Council, 1998) and Brazilian (Rostagno et al., 2005) requirement indicate 1.05 and 1.13% respectively.

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The aim of this study was to determine the dietary total lysine requirement of starting barrows from two genetic groups, fed on low crude protein diets, formulated according to the ideal protein concept.

MATERIALS AND METHODS

Animals and housing

Sixty-four barrow pigs (thirty-two from each genetic group) were used. Groups consisted of a commercial crossbred genetic group (CCGG), formed by the Duroc boar x [Landrace x Large-White crossbreed sow] crossbreeds (15.9 ± 1.4 kg; 45 to 73 d of age), and a dam line genetic group (DLGG), formed by crossbreeds (14.8 ± 1.0 kg; 44 to 72 d of age) from a swine improvement company. Thus, DLGG resulted from a selection process from dam line while CCGG was not from improvement process. Two pigs/pen were housed in an open-sided house. Pens were equipped with two self-feeders and two drinker nipples. The Food and the water were given *ad libitum*. Mean temperature inside the building ranged from 19.0 ± 2.9 to 30.5 ± 3.3°C during the trial.

Experimental diets

As shown in Table 1, four experimental diets were used: one basal diet with 0.8% total lysine and three diets with increasing lysine levels (1.0, 1.2 and 1.4% total lysine).

Table 1 - Centesimal, chemical and energetic composition of experimental diets containing graded levels of lysine (as-fed basis)

Item	Total lysine levels (%)			
	0.80	**1.00**	**1.20**	**1.40**
Ingredients (%)				
Yellow corn	78.55	78.55	78.55	78.55
Soybean meal	13.09	13.09	13.09	13.09
Soybean oil	3.16	3.16	3.16	3.16
Dicalcium phosphate	1.46	1.46	1.46	1.46
Limestone	0.73	0.73	0.73	0.73
Salt	0.40	0.40	0.40	0.40
Vitamin and mineral premix †	0.50	0.50	0.50	0.50
Growth promoter ‡	0.10	0.10	0.10	0.10
Corn starch	1.70	1.16	0.63	0.09
L-lysine HCl (78.8%)	0.182	0.436	0.690	0.994
DL- methionine (99%)	0.053	0.168	0.282	0.396
L- threonine (98%)	0.096	0.229	0.360	0.492
L-tryptophan (98%)	0.000	0.038	0.074	0.112
Total	**100.00**	**100.00**	**100.00**	**100.00**
Nutrients				
Digestible energy (kcal/kg)	3,400	3,408	3,416	3,424
Crude protein (%)	13.13	13.56	13.99	14.42
Calcium (%)	0.65	0.65	0.65	0.65
Total phosphorus (%)	0.55	0.55	0.55	0.55
Na + K - Cl§ (meq/kg)	116.3	102.5	89.0	75.2
Lysine (%)	0.80	1.00	1.20	1.40
Methionine + cystine (%)	0.453	0.566	0.679	0.792
Threonine (%)	0.517	0.647	0.776	0.905
Tryptophan (%)	0.145	0.182	0.218	0.255

† The vitamin and trace mineral premix supplied per kg of diet: Vit. A - 10.000 UI; Vit. D3 - 2.000 UI; Vit. E – 25.0 UI; Vit K3 – 2.0 mg; Vit. B1 – 2.0 mg; Vit B2 – 6.0 mg; Vit. B6 – 3.0 mg; Vit. B12 – 30.0 μg; Niacin – 30.0 mg; Pantothenic acid – 12.0 mg; Biotin - 0.1 mg; Folacin - 1.0 mg; Selenium - 0.3 mg; Choline - 150.0 mg; Lysine - 1.170.0 mg; Growth promoter - 50.0 mg; Antioxidant – 100 mg; Iodine - 1.5 mg; Cobalto – 1.0 mg; Cooper – 175.0 mg; Zinc – 100.0 mg; Iron – 100.0 mg; Manganese – 40.0 mg.

‡ Tylosin phosphate + sulfamethazine (10% each).

§ Values calculated by Mongin and Sauveur (1977) formula, using the feed values indicated by Rostagno et al. (2005).

Crystalline L-lysine HCl, DL-methionine, L-threonine and L-tryptophan were added to diets, at the expense of corn starch, to maintain a similar amino acid pattern (lysine 100: methionine+cystine 57: threonine 65: tryptophan 18), as indicated by NRC (1998) for barrows with 300 g of daily lean gain, 22.5 kg body weight and 3,400 kcal of DE/kilogram of diet.

The yellow corn and soybean meal used in the experimental diets were previously analyzed for the crude protein and gross energy. Values of digestible energy and amino acid content of these ingredients were calculated according to feedstuffs composition (crude energy digestible coefficient and amino acids proportion) indicated by Empresa Brasileira de Pesquisas Agropecuárias (1991).

Experimental protocols

Pigs and feed were weighed on 0 and 28 days of the trial to calculate daily feed intake (DFI), daily weight gain (DWG) and feed: gain ratio (FG). Pigs were bled by vena cava cranialis in heparinized tubes at the beginning and the end of the experiment. Plasma urea concentrations were determined by the enzymatic method (Kit Ecoline 25 MERCK®). Values of plasma urea concentration were multiplied by 0.467 (Newman and Price,1999) to calculate the plasma urea nitrogen (PUN). The initial PUN (pretreatment period) was used as a covariate to correct the final PUN for the individual animal differences.

Three pigs from each genetic group were slaughtered at the beginning of the trial to determine initial body composition. At the end of the trial, two pigs from the each treatment were slaughtered. Pigs were fasted for 24 h with access to water for 6 h before slaughter. Half carcasses from each slaughtered pig were frozen (-12^{o}C), and then ground by electrical grinder, powered by a 1700-rpm engine, with a 4 mm-round hole perforated plate. Samples of approximately 1.0 kg were taken and stored at -12^{o}C for chemical analysis later.

Approximately 200 g of each sample was defrosted, pre-dried during 72 h and the fat was pre-extracted for 4 h by "Soxlhet" extractor. Pre-dried and pre-fat extracted samples were ground with "ball" grinder and then kept refrigerated until the analysis (Association of Official Analytical Chemists, 1975). Carcasses were analyzed for the protein, water, fat and ash contents. Values obtained during the pre-drying and pre-fat extraction were used for calculating values in whole carcasses. Deposition of protein and fat by pigs and the retention percentage of intake nitrogen were also estimated by the following formula:

Daily Protein Accretion = $(AP_{EC} - AP_{IC}) / EP$,

where, AP_{EC} and AP_{IC} were respectively the amount (gram) of protein in the carcass at the end and at the beginning of the trial; EP was the experimental period (days). AP_{EC} was obtained by multiplying the carcass weight of one particularly pig by its respective crude protein content, while AP_{IC} was obtained by multiplying the body weight of this respective pig by the average carcass dressing and the crude protein content of its genetic group (average of three pigs slaughtered at the beginning of the trial).

Daily Fat Accretion = $(AF_{EC} - AF_{IC}) / EP$,

where AF_{EC} and AF_{IC} were respectively the amount (gram) of fat in the carcass at the end and at the beginning of the trial; EP was the experimental period (in days). AF_{EC} and AF_{IC} were obtained as AP_{EC} and AP_{IC}, considering the fat content values.

Nitrogen Retention =
(nitrogen acretion / nitrogen intake) x 100,

where nitrogen accretion and nitrogen intake were, respectively, daily protein accretion / 6.25 and DFI x nitrogen % of the diet, in grams.

Statistical analysis

Pigs were blocked by the body weight and allotted to 4 x 2 factorial treatment arrangement (four lysine levels 0.80, 1.00 1.20 and 1.40% and two genetic groups) in a randomized block design. The eight treatments were replicated four times and two pigs per experimental unit were used. Data were submitted to polynomial regression analysis, according to the following statistic model:

$$Y_{ijk} = \mu + G_i + b_1(L_j - L) + b_2(L_j - L)^2 + e_{ijk},$$

where:

Y_{ijk} = observed value of variables, referring to each *k* pig, fed on *j* lysine level, within *i* genetic group;

μ = general constant;

G_i = genetic group effect on variable Y, i =1, 2;

b_1 = linear regression coefficient of lysine level on variable Y;

b_2 = quadratic regression coefficient of lysine level on variable Y;

L_j = lysine levels in the experimental diets, with j = 0.80; 1.00; 1.20 and 1.40%;

L= average lysine level (1.1) of experimental diets;

e_{ijk} = error in each replicate.

Initial values of PUN and slaughtered weight were used as covariates in the analysis of data from PUN and carcass composition, respectively. Exponential equations obtained for variables with quadratic response were derived to estimate lysine requirement.

RESULTS AND DISCUSSION

Performance and PUN data of two genetic groups fed on increasing lysine levels are given in Table 2 and carcass composition in Table 3. Lysine estimating equations are shown in Table 4. About performance traits, there were differences (P<0.05) between the genetic groups: the CCGG had higher feed and nitrogen intake, weight gain and PUN than the DLGG. Probably the lower feed intake was the reason for other differences (nitrogen intake, weight gain and PUN values) of the DLGG. According to Moreira (1998), modern pig genotypes generally show lower feed intake, when compared with pigs not submitted to selection programs.

Feed intake decreased for the CCGG with the increase of lysine levels (P<0.05). However, when contrast test was made comparing 0.80 plus 1.00 against 1.20 plus 1.40% of total lysine content, difference (P<.05) for the CCGG and for the DLGG (P=0.055) was found. This observation revealed the negative effect of high levels of crystalline lysine-HCl over the consumption by the pigs. Decrease of DFI caused by increasing lysine levels could be explained by decreasing in Na+K-Cl value, owing to L-lysine HCl inclusion, although the decrease in the Na+K-Cl value in this trial was from 116 to 75 meq/kg (from 0.80 to 1.40% of total lysine diet) and this range was not higher than the range (341 to 0 meq/kg) proposed by Patience et al. (1987) as necessary to reduce the feed intake. The DLGG showed linear improve (P<.05) for feed conversion with the increase of lysine levels. The PUN, the result of amino acid catabolism, indicates the capacity of utilization of intake nitrogen by the animal (Brown and Cline, 1974). It's used for amino acid requirement determinations (Coma et al., 1995). In this trial, the DLGG showed quadratic response of the PUN (P=0.05). The derivation of the polynomial regression indicated 1.09 as the best level of total lysine for the lowest PUN value, or for the minimum nitrogen excretion by the urine. Although the CCGG showed a high numerical reduction in PUN values with the increasing lysine levels, no statistical difference (P>0.1) was observed among the diets.

PUN generally shows a high variance (Coma et al., 1995) and in some studies, PUN was not efficient to determine the lysine requirement (Fontes et al,.1999; Gasparotto et al., 2001; Hannas et al., 2000; Moreira et al., 2002, Moreira et al., 2004). In this trial, the CCGG showed greater values of standard deviation for PUN than DLGG (Table 2). Negative and positive regression coefficients were found (P<0.05) among the slaughtered weight and water content and the slaughtered weight and fat content of carcasses, respectively. The CCGG had higher water content (P=0.05) and protein:fat ratio than DLGG, while the DLGG had higher nitrogen retention and fat content. Dam line selection programs include both reproductive and performance traits and feed efficiency is one of the most import performance criteria (Ollivier, 1998). The DLGG showed higher capacity to convert feed nitrogen in tissues nitrogen in carcass. On the other hand, maternal abilities include the age at puberty, a characteristic influenced by fat content of sows (den Hartogh and Vesseur, 1994), hence these pigs selected for maternal abilities can develop an earlier fat deposition for an earlier reproductive age than not selected pigs. Pigs from the CCGG showed quadratic response for the fat and protein:fat ratio contents and linear decrease for the daily protein accretion and the retention of nitrogen in the carcass. The derivation of the quadratic equations indicated 1.14 and 1.11% of total lysine content for minimum fat content and maximum protein:fat ratio. On the other hand, pigs from the DLGG showed quadratic response for the crude protein content and linear decrease for the fat content. The derivation of quadratic equation

indicated 1.08% of total lysine content for the maximum protein content of the carcass.
Based on the averages of the values of total lysine indicated by the polynomial equations, the CCGG and DLGG requirements of total lysine found in this trial were 1.15 and 1.09 %, respectively.

Table 2 – Performance and nitrogen urea values of starting barrow pigs from two genetic groups fed increasing total lysine levels

Item	Total lysine levels, %									
	Commercial crossbred genetic group[1]					Dam line genetic group				
	0.80	1.00	1.20	1.40	Effect[2]	0.80	1.00	1.20	1.40	Effect
Daily feed intake, kg	1.34 ± .03	1.30 ± .05	1.21 ± .12	1.20 ± .11	L	1.11 ± .08	1.12 ± .04	1.05 ± .06	1.06 ± .09	NS
		μ = 1.26 ± .04[a]					μ = 1.08 ± .03[b]			
Daily weight gain, kg	.65 ± .03	.68 ± .03	.61 ± .07	.61 ± .05	NS	.54 ± .03	.58 ± .02	.53 ± .04	.57 ± .03	NS
		μ =.64 ± .02[a]					μ =.55 ± .02[b]			
Feed conversion	2.05 ± .06	1.91 ± .04	2.01 ± .05	1.96 ± .01	NS	2.05 ± .05	1.94 ± .06	2.02 ± .05	1.85 ± .05	L
		μ = 1.98 ± .02					μ = 1.97 ± .03			
Daily nitrogen intake, g	28.0 ± .5	28.2 ± 1.2	27.1 ± 2.8	27.6 ± 2.5	NS	23.3 ± 1.7	24.4 ± .8	23.4 ± 1.4	24.4 ± 2.1	NS
		μ = 27.7 ± .9[a]					μ = 23.9 ± .7[b]			
PUN, mg/dL	6.5 ± 1.5	6.1 ± 1.7	5.7 ± 1.1	4.6 ± 1.2	NS	5.3 ± .8	5.0 ± 1.0	2.9 ± .8	6.4 ± 1.4	Q.
		μ = 5.8 ± .7[a]					μ = 4.9 ± .6[b]			

[1] Means with different superscripts ([a,b]) within a row differ (P<0.05) between groups. [2] NS - Not significant; L – Linear effect of total lysine levels (P<0.05); Q – Quadratic effect of total lysine levels (P=0.05).

Considering the genetic difference between the groups, the distance of the optimal lysine levels observed for them was smaller than could be expected. Thus, an effect of the crude protein reduction of the experimental diets could be thought. For the protein synthesis, the animals require not only a correct amount of essential amino acids, such as lysine, but they are necessary non-essential amino acids too (Baker, 1996). High reduction on the crude protein content of diets added synthetic amino acids can limit the availability of non-essential amino acids for the animal protein synthesis. For finishing pig diets, the limit of this reduction is around 4.0 points (Tuitoek et al., 1997; Canh et al., 1998; Kendall et al. 1998).
In this trial, the crude protein content of the basal diet (0.80% total lysine content) was 5.6 points below of the indicated by NRC (1998) when a corn-soybean meal is used. Consequently, the requirements determined in this study could be limited by the lack of some essential or non-essential amino acids that could limit other amino acid utilization, making lysine (and other adjusted amino acids) surplus. Exceeding amino acids were degraded and led to quadratic PUN response for the DLGG.
However, Ferreira et al. (1996) suggested 1.09% of total lysine as requirement for barrow pigs from 15 to 30 kg of body weight. Additionally, NRC (1998) indicated 1.07% for medium lean growth barrows (325 g/d of lean deposition). In Brazil, Rostagno et al. (2005) suggested 1.13% for high lean growth pigs. The requirements determined in this trial were close to the literature values for medium genetic potential that characterizes the CCGG. The DLGG showed a performance not better than a medium genetic potential, hence probably these levels reflected the real capacity of these animal to develop.
Results suggest that starting barrows from the commercial crossbred genetic group fed on low crude protein diets (13.8%) formulated according to ideal protein concept, require 1.15% of total lysine, while barrows from dam line genetic group require 1.09% of total lysine.

Table 3 – Carcass composition and nutrients deposition of starting barrow pigs from two genetic groups fed increasing total lysine levels

Item	Total lysine levels, %									
	Commercial crossbred genetic Group[1]					Dam Line Genetic Group				
	0.80	1.00	1.20	1.40	Effect[2]	0.80	1.00	1.20	1.40	Effect
Slaughter weight, kg	31.0 ± .5	31.0 ± .8	29.8 ± 2.9	28.8 ± .9	NS	29.3 ± 2.0	30.2 ± 1.4	28.9 ± 1.0	29.5 ± 1.2	NS
		μ = 30.1 ± .7					μ = 29.5 ± .6			
Water, %	65.1 ± .1	65.6 ± .7	66.4 ± .2	65.1 ± .9	NS	63.8 ± .9	64.0 ± .5	65.2 ± .9	64.7 ± .1	NS
		μ = 65.6 ± .3					μ = 64.4 ± .3			
Crude protein, %	15.4 ± .6	15.6 ± .5	15.6 ± .6	15.6 ± .2	NS	15.4 ± .4	15.9 ± .3	15.7 ± .4	15.4 ± .5	Q*
		μ = 15.5 ± .2					μ = 15.6 ± .2			
Fat, %	16.7 ± .9	15.4 ± 1.3	14.9 ± .9	16.6 ± .6	Q	18.0 ± 1.4	17.8 ± 1.9	16.3 ± .6	16.7 ± .7	NS
		μ = 15.9 ± .5[b]					μ = 17.2 ± .5[a]			
Ash, %	3.3 ± .1	3.5 ± .0	3.3 ± .1	3.2 ± .1	NS	3.5 ± .2	3.0 ± .3	3.5 ± .5	3.5 ± .3	NS
		μ = 3.3 ± .0					μ = 3.4 ± .1			
Protein:fat ratio	.93 ± .09	1.03 ± .12	1.06 ± .10	.94 ± .02	Q	.87 ±.09	.90 ± .07	.96 ± .06	.93 ± .09	NS
		μ =.99 ± .04[a]					μ =.91 ± .03[b]			
Daily protein acretion, g	59 ± 1	67 ± 11	68 ± 2	72 ± 0	L*	67 ± 7	75 ± 6	70 ± 4	68 ± 0	NS
		μ = 66 ± 3					μ = 70 ± 2			
Daily fat acretion, g	97 ± 11	89 ± 22	91 ± 11	107 ± 4	NS	107 ± 17	109 ± 15	94 ± 11	96 ± 7	NS
		μ = 96 ± 6					μ = 102 ± 6			
Nitrogen retention, %	33.2 ± .5	37.7 ± 6.0	40.2 ± 1.1	41.9 ± .2	L	46.3 ± 4.8	48.9 ± 4.0	48.1 ± 2.6	44.4 ± 0.0	NS
		μ = 38.2 ± 1.7[b]					μ = 46.9 ±1.4[a]			

[1] Means with different superscripts ([a,b]) within a row differ (P<0.05) between groups. [2] NS - Not significant; L – Linear effect of total lysine levels (P<0.05), L* - (P=0.07); Q – Quadratic effect of total lysine levels (P=0.05), Q* - (P=0.08)

Table 4 - Quadratic equations according to the effects indicated on Table 3

Variable	b_0	b_1	b_2	R^2	Best lysine level, %
Commercial crossbred genetic group					
Fat content	17.6	-4.5	+1.9	.944	1.18
Protein:fat ratio	2.6	-3.0	+1.4	.971	1.11
Dam line genetic group					
Plasma urea nitrogen	68	-110	+51	.717	1.09
Crude protein content	10.2	+10.5	-4.9	.895	1.08

ACKNOWLEDGEMENTS

The authors would like to thank AJINOMOTO BIOLATINA for supplying the amino acids; to RAÇALTO BRASIL AGROPECUÁRIA LTDA for providing the animals; to Ms. Marlene Leiko Doi Sakuno for urea analysis and to CNPq-Brazil for scholarships given to authors.

RESUMO

Foi realizado um trabalho com o objetivo de determinar a exigência em lisina para suínos castrados em fase inicial, alimentados com dietas formuladas de acordo com o conceito de proteína ideal. Trinta e dois suínos provenientes de cruzamento comercial (CC, PV = 15,9 kg) e 32 suínos provenientes de linhagem materna (LM,

PV= 14,8 kg) foram alimentados com quatro dietas contendo níveis crescentes de lisina total (0,80; 1,00; 1,20 e 1,40%). Metionina + cistina, triptofano e treonina foram adicionados às dietas para manter constante o padrão de proteína ideal. Foram analisados dados de desempenho, nitrogênio da uréia plasmática (NUP) e carcaça. Suínos do grupo CC apresentaram maior consumo diário de ração, ganho diário de peso, NUP e relação proteína: gordura na carcaça, enquanto que os animais do grupo LM apresentaram maiores teores de gordura na carcaça e retenção de nitrogênio. Teor de gordura e relação proteína:gordura na carcaça para o grupo CC e NUP e teor de proteína bruta na carcaça para o grupo LM apresentaram resposta quadrática aos níveis de lisina. Derivações das equações indicaram a exigência de lisina total de suínos machos castrados do grupo cruzamento industrial de 1,15% e do grupo linhagem materna de 1,09%.

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Received: October 18, 2005;
Revised: October 04, 2006;
Accepted: July 25, 2007.