Vol.48, n. 5 : pp. 729-737, September 2005
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

Metabolizable Energy Requirement for Starting Barrow Pigs (15 to 30 kg) Fed on the Ideal Protein Concept Based Diets

Gisele Cristina de Oliveira, Ivan Moreira*, Alessandro Luís Fraga, Marianne Kutschenko, Iolanda Maria Sartori

Departamento de Zootecnia; Universidade Estadual de Maringá; Av. Colombo, 5790; 87.020-900 -Maringá -PR - Brasil

ABSTRACT

The objective of this study was to determine the metabolizable energy (ME) requirement for starting barrow pigs. Forty-three animals, selected for their high lean gain, were allotted in a completely randomized block design, divided in four treatments with five blocks and two animals in each experimental unit. The diet in Treatment 1 consisted of 3,264 kcal of ME/kg containing 0.96% of digestible lysine, 0.55% of digestible methionine+cystine, 0.60% of digestible threonine, and 0.188% of digestible tryptophan reaching the ideal protein pattern. The diets in Treatments 2, 3, and 4 were similar to the diet in Treatment 1; nevertheless, the levels of ME in Treatments 2, 3, and 4 were 2, 4, and 6% higher than those in Treatment 1. The lysine:ME ratio, was mantained the same (2.82 g) in all treatments. The daily feed intake (DFI) and the feed:gain ratio (F:G) were not affected by the levels of ME. There was a linear increase of daily weight gain (DWG) and of daily energy intake (DEI). Later, a linear reduction in carcass protein percentage (CPP) and a linear increase of fat content and daily fat accretion (DFA) occurred. Results suggested that the required ME was of 3,264 kcal/kg or less for improved barrows (15 to 30 kg), of the dam line, fed with diets containing 0.96% of digestible lysine, formulated according to the ideal protein concept.

Key words: Synthetic amino acids, carcass, performance, plasma urea nitrogen, energy requirements

INTRODUCTION

Genetically improved pigs have a high daily demand of nutrients, mainly energy and amino acids, in order to achieve their genetic potential. Since they have low feed intake, diets with high nutritional density are needed to attend such demands. Through genetic selection, pigs have been proved capable of processing food more efficiently, then, developing carcasses with a higher proportion of muscle and less fat; thus, these animals require a diet with a high concentration of digestible amino acids in order to achieve their genetic potential for lean meat accretion (Chen et al., 1995).

Constant progress in management, health, environment, and genetic improvement leads to a permanent need for reevaluation and updating of studies on nutritional requirements (Caldara et al., 2001). Along with this need, the environmental concern should be taken more seriously since pig farming produces a large amount of manure that pollutes the environment. Nutritionists could interfere more often in the process and, through the state-of-the-art revising in nutrition and food,

* Author for correspondence

help to reduce swine manure production and to maximize nutrient utilization (Penz Junior, 1999).
The concept of the ideal protein suggests the utilization of diets with lower levels of protein supplemented with synthetic amino acids; thus, the animals are fed with a profile of amino acids close to nutritional requirements, while the emission of pollutants in the soil is reduced (Baker, 1996). This study determined the metabolizable energy requirement of barrows (15 to 30 kg) fed on an ideal protein concept based diet.

MATERIAL AND METHODS

A performance trial was carried out during summer with average low temperatures of 20.2 ± 1.5°C and average high temperatures of 32.9 ± 3.4°C. Forty-three hybrid barrows (Large White x Landrace/Large White) SEGHERS® of the dam line, with genetic potential for a high lean accretion and average initial weight 15.6 ± 1.4 kg, were used. These were housed in a two-room concrete nursery. Each room was divided into ten pens, separated by a central corridor. The pens were equipped with self-feeders in the front part and a drinking nipple at the back. The floor was elevated by 1/3 with a plastic drained floor. The pigs were allotted in a completely randomized block design, with two pigs per experimental unit, with four treatments and five replicates. Ancestry and initial body weight were taken into account at the formation of the blocks and the experimental units.
Corn and soybean meal were analyzed for crude protein and gross energy (Table 1). The containing lysine (23.4%) in vitamin and mineral premix was taken into account. Table 2 shows the ideal protein pattern used in the formulation of the diet.

Table 1 - Composition of yellow corn and soybean meal (as-fed basis)

Item	Yellow corn	Soybean meal
Gross energy [1], kcal/kg	3,908	4,201
Metabolizability coefficient [2]	0.847	0.766
Metabolizable energy, kcal/kg	3,310	3,218
Crude protein [1], %	8.2	44.9
Digestible lysine [3], %	0.19	2.4
Digestible methionine+cystine [3], %	0.312	1.12
Digestible threonine [3], %	0.25	1.49
Digestible tryptophan [3], %	0.05	0.57

[1] Values were determined on Feed and Animal Nutrition Laboratory of UEM.
[2] Metabolizability coefficient of energy of yellow corn and soybean meal from Rostagno et al. (2000).
[3] Adjusted according to the content indicated by Rostagno et al. (2000) and to the analyzed crude protein.

Table 2 - Ideal ratio of amino acids for barrows in the starting phase (15-30 kg BW)

Amino acid	Ideal pattern [1] (% of lysine)	%
Digestible lysine	100	0.96
Digestible methionine+cystine	57	0.55
Digestible threonine	63	0.60
Digestible tryptophan	19	0.18

[1] Calculated by NRC software (1998), considering barrows with 22.5 kg (averaging between 15 and 30 kg) of body weight, 3,264 Kcal ME/kilogram of diet and 325 g of daily lean gain.

The treatments consisted of four practical diets (Table 3) based on yellow corn, soybean meal, soybean oil, limestone, dicalcium phosphate, salt (NaCl), vitamin, and mineral premix. Treatment 1 consisted of a diet containing 0.96% of digestible lysine (Fraga, 2002). The levels of digestible amino acids (lysine, methionine+cystine, thryptophan, and threonine) met the ideal ratio of amino acids (Table 2).
Treatments 2, 3 and 4 consisted of diets similar to Treatment 1; the levels of energy were 2, 4, and 6% higher than those in Treatment 1. In the same way, the levels of amino acids followed proportionally lysine:ME ratio in Treatment 1. The

levels of calcium and available phosphorus in all treatments were corrected proportionally with the ME content. Table 4 shows the chemical and energetic compositions of the experimental diets.

Experimental protocols. The pigs were given *ad libitum* access to the diets and water. Both, pigs and feed were weighed at the start on the 14th day and at the end of the trial. Feed intake (DFI), daily weight gain (DWG), and feed:gain ratio (F:G) were calculated daily. Pigs were bled in the morning, after feeding, according to Cai et al. (1994). Blood samples were collected in heparinized tubes, via vena cranialis puncture, at the start and at the end of the experiment. Approximately 10 mL of blood was collected and centrifuged at 3000 rpm, for 15 minutes, in order to obtain the plasma, which was frozen at -20º C, for further analysis of plasma urea nitrogen (PUN).

Table 3 - Composition (%) of experimental diets fed to barrows, containing increasingly graded levels of metabolizable energy (ME) (as-fed basis)

Ingredients	ME levels (kcal /kg)			
	3,264	**3,329**	**3,395**	**3,460**
Yellow corn	68.19	66.51	64.80	63.13
Soybean meal	27.45	27.67	27.89	28.10
Soybean oil	1.46	2.82	4.20	5.56
Dicalcium phosphate	1.12	1.16	1.21	1.25
Limestone	0.68	0.69	0.69	0.70
NaCl	0.40	0.40	0.40	0.40
Vitamin and mineral premix[1]	0.50	0.50	0.50	0.50
Growth promoter[2]	0.10	0.10	0.10	0.10
DL-methionine, 99,0%	0.02	0.04	0.05	0.07
L-lysine, 78,4%	0.06	0.08	0.11	0.13
L-threonine, 98,0%	0.02	0.04	0.05	0.07

[1] Provided mg/kg complete diet: retinol 3.0; cholecalciferol 0.05; DL alpha tocopherol acetate 25; menaphthone 2.0; thiamin 2.0; riboflavin 6.0; nicotinic acid 30.0; pantothenic acid 12.0; pyridoxine acid 3.0; cyanocobalamin 0.03; biotin 0.10; folic acid 1.0; choline 150.0; Iodine 1.5; Cobalt 1.0; Copper 175.0; Zinc 100.0; Iron 100.0; Manganese 40.0; Selenium 0.3; Antioxidant 100.0; Lysine 1,170.0.

[2] Provided mg/kg complete diet: tylosin phosphate 100.0; sulfamethazine 100.0.

Table 4 - Chemical and energetic composition of experimental diets fed to barrows, containing graded levels of metabolizable energy (ME) (as-fed basis)

Item	ME levels (Kcal /kg)			
	3,264	**3,329**	**3,395**	**3,460**
Analyzed Crude Protein[1], %	18.67	19.11	18.9	18.76
Calculated values [2]				
Crude Protein, %	18.00	18.00	18.00	18.00
Metabolizable energy, kcal/kg	3,264	3,329	3,395	3,460
Calcium, %	0.650	0.663	0.676	0.689
Available phosphorus, %	0.270	0.275	0.281	0.286
Digestible lysine, %	0.960	0.979	0.998	1.018
Digestible methionine+cystine, %	0.550	0.561	0.572	0.583
Digestible threonine, %	0.600	0.612	0.624	0.636
Digestible tryptophan, %	0.188	0.189	0.189	0.190
Lysine:CP ratio	5.3	5.4	5.5	5.7
Lysine:DE ratio	2.82	2.82	2.82	2.82

[1] Values were determinate on Feed and Animal Nutrition Laboratory of UEM;

[2] Calculated values with basis in the Tables 1 and 3.

The PUN dosage was analyzed by the enzymatic method, by MERCK® Diasys kit. The urea level rate was multiplied by 0.467, which represents the nitrogen fraction in the urea molecule (Newman

and Price, 1999). Initial PUN (pretreatment period) was used as a co-variable to correct final PUN (treatment period), for individual animal differences.

Three pigs were slaughtered at the beginning of the trial in order to determine the initial body composition, and three pigs from each treatment were slaughtered at the end of the trial; the pigs underwent feed fast for 24 hours and water fast for six hours before slaughter. At the end of the experiment, liver, kidneys, heart, pancreas, stomach, spleen, and lungs of the slaughtered animals were weighed. The absolute and relative weights of the organs were analyzed; the relative weight was calculated by dividing the absolute weight of each organ by the body weight of the pigs before slaughtering.

Half-carcasses from each slaughtered pig were frozen (-12°C) and ground by an electrical grinder, powered by a 1700-rpm engine, with a four mm-round hole perforated plate. Samples of approximately 1.0kg were taken and stored at -12°C for later chemical analysis. Approximately 200g from each sample were defrosted, pre-dried during 72 hours, and fat pre-extracted during four hours by the "Soxlhet" extractor. Pre-dried and pre-defatted samples were then ground with a "ball" grinder and maintained refrigerated for further analysis (AOAC, 1975).

Carcasses were analyzed for protein (CCP), water (CWA), fat (CFAT), and ash (CASH) contents. The values obtained during pre-drying and pre-fat extraction were employed for calculating values in whole carcasses. Daily protein (DPA) and fat (DFA) accretion were also estimated.

The DPA was calculated by the following formula: $DPA = (AP_{EC} - AP_{IC}) / EP$, where AP_{EC} and AP_{IC} are, respectively, the amount (in grams) of protein in the carcass at the end and at the beginning of the trial; EP is the experimental period (in days). The AP_{EC} was obtained by multiplying the carcass weight of one pig by its respective CCP, while the AP_{IC} was obtained by multiplying the body weight of the same pig by the average carcass yield (65.5%) and the CCP (average of three pigs slaughtered at the beginning of the trial = 17.99kg).

The DFA was calculated by the following formula: $DFA = (AF_{EC} - AF_{IC}) / EP$, where AF_{EC} and AF_{IC} are, respectively, the amount (in grams) of fat in the carcass at the end and at the beginning of the trial; EP is the experimental period (in days). The AF_{EC} and $AF_{IC,}$ as well as the AP_{EC} and AP_{IC}, were obtained by using CFAT.

Statistical analysis. The analyzed variables were = performance (daily feed intake, daily weight gain, and feed:gain ratio), body composition (water, protein, and fat content), PUN and absolute and relative organ weights. Data were submitted to the polynomial regression analysis, according to the following mathematic model:

$$Y_{ijk} = \mu + b_1(N_j - N) + b_2(N_j - N)^2 + e_{ijk},$$

where: Y_{ijk} was the value of variables, relative to each individual *k*, receiving energy level *j*; μ was the general constant; b_1 was the linear regression coefficient of energy level on Y variable; b_2 was the quadratic regression coefficient of energy level on Y variable; N_j was the energy levels in diets, being *j* = 3,264, 3,329, 3,395, and 3,460 kcal of ME/kg; N was the average level of energy in diets (3,362); and e_{ijk} was the random error associated with each observation.

RESULTS AND DISCUSSION

Table 5 shows the initial body weight, daily feed intake (DFI), daily weight gain (DWG), feed:gain ratio (F:G), daily energy intake (DEI), and plasma urea nitrogen level (PUN). No effect (P>0.05) of increasing metabolizable energy levels was reported on DFI, DWG, and F:G for the different periods (0-14 and 14-23 days). Since no effect (P>0.05) of ME levels on pigs performance on the 0 to 14-day-period and 14 to 23-day-period was reported, discussion would be based on the total 0 to 23-day-period of the experiment.

ME levels did not influence (P>0.05) the DFI, although the daily energy intake (DEI) changed from 3,960 to 4,379 kcal; which indicated that the barrows did not adjust their feed intake with diet energy density. The mean DFI was of 1236 g/day, that is, lower than the 1302 g/day expected by the NRC (1998). According to Coffey et al. (1982), pigs feeding *ad libitum* apparently consume enough to attend their energy requirements, whereas their consumption is influenced by diet energy content.

Results were similar to those by Oliveira et al. (1997b) who failed to find any influence of increasing energy levels on DFI of gilts during the initial phase (15 to 30 kg). However, Donzele et al. (1997), Oliveira et al. (1997a), and Lopez-Bote

et al. (1997) reported decrease in the feed intake, whereas diet energy level of gilts and barrows in the initial phase (15 to 30 kg) and in the growing and finishing pigs increased, respectively.

The lysine requirement was expressed in terms of lysine:DE ratio, because the pigs consumed diet to achieve their energetic requirements. Chiba et al. (1990) suggested that amino acid requirements were related to energy content. In our experiment, this ratio was of 2.82g of digestible lysine/Mcal of DE; which was close to the ratio (2.88g) indicated by NRC (1998), for 10-20 kg BW piglets.

An increase in DWG (P=0.056) was accounted for as a function of the ME levels. Improvement of weight gain could be explained by an increase (P=0.048) in the DEI. These results were different from those by Stahly and Cromwell (1979), Coelho et al. (1987), and Tavares et al. (1999) who failed to record any difference in the weight gain of barrows (8–60kg) caused by the energy level. However, Dividich and Noblet (1986), using weaning piglets, evaluated a diet with two levels of DE (3,100 and 3,600 kcal) and proved that a lower dietary energy level led to lower weight gain.

The ME level increase (P>0.05) did not influence the feed:gain ratio. This result was different from that by Stahly and Cromwell (1979) who observed an improvement in F:G of growing and finishing pigs in proportion to fat supplementation. Likewise, Beterchini et al. (1986), Lima et al. (1990), and Stein et al. (1996) found that starting, growing, and finishing pigs improved F:G owing to an increase in the DE diet level.

According to Usry et al. (1998), pigs fed on diets with higher levels of energy, with constant feed intake, would increase weight gain. If energy intake was constant, feed intake would be reduced and, consequently, feed:gain ratio improved. There was no effect (P>0.05) of ME levels increase on PUN (Table 5). These results suggested that an increase of ME levels did not improve the use of amino acids by pigs.

Table 6 shows results of body composition and protein and fat deposition rate as a function of ME levels increase. Water and protein contents decreased linearly (P<0.05) with the ME level increase. These results were similar to those by Campbell and Tavener (1988) and Donzele et al. (1992). These authors also observed an increase on carcass fat due to water detriment. The ME increase in diet levels influenced the increase of DWG; in fact, it was directly related to the DEI increase, which influenced the weight gain composition.

The ME levels of diets led to a linear increase (P>0.05) of the carcass fat deposition rate (Table 6). Several authors (Donzele et al., 1997; Oliveira et al., 1997b; and Ferreira et al., 1998) reported an increase in carcass fat deposition rate as a result of an increase in the diet energy content of 15-30 kg barrows' body weight. Close and Stanier (1984) and Bikker et al. (1995) showed that carcass fat deposition rate was more dependent on energy intake than on protein intake. In our experiment, an increase in fat content and fat deposition rate, along with the highest ME levels, was observed; which indicated that above 3,264 kcal ME, there was a surplus of energy higher than requirements for protein deposition; also, the excess resulted in fat storage. The same result was found by Greef et al. (1994) who observed that above maximum capacity of protein deposition, the high daily energy intake caused increase in the carcass's lipid:protein ratio.

Being the pigs from the dam line hybrids, their maximum capacity of protein deposition was achieved at 3,264 kcal of ME/kg or less. Higher ME levels would carry the energy over to carcass's fat deposition; which suggested that in the case of these barrows, the ME requirement was of 3,264 kcal/kg, eventually identical to the level indicated by NRC (1998) and by Rostagno et al. (2000).

Since the protein deposition rate was not influenced (P>0.05) by the ME level increase, it was observed that the 3,264 kcal of ME level associated with the 0.96% of digestible lysine formed an adequate balance of ingested nutrients to meet all genetic capacity of muscular protein deposition. Similarly, Fraga (2002) did not find any variation on protein deposition rate in improved 15-30kg barrows carcass as to evaluate any level increase of total lysine (0.8 to 1.4%), in which lysine:essential amino acids at level 3,400 kcal DE of diet was maintained.

After analyzing PUN (Table 5) and protein deposition (Table 6) results, it was observed that although there was no difference (P>0.05) on PUN rates, individual values showed numeric behavior opposed to protein deposition rate and they also differed (P>0.05) from each other. In other words, for the highest protein deposition (98.5g/d), the smallest PUN (9.95) value was attributed; and for the lowest protein deposition (86.7g/d), the highest PUN (11.68) was available. A lack in the detection

of differences in PUN results might be due to high coefficient variation (27.47%).

Table 7 shows the absolute weight (in grams) and the relative weight as a percentage of live weight and organs (liver, kidneys, heart, lungs, pancreas, spleen, stomach, and tongue) of barrows fed on diets with different DE levels. There was no effect (P>0.05) of diet's ME level on the absolute or the relative weight of organs. These results were similar to those by Oliveira et al. (1997b) who did not observe any effect of the DE level of the diet on the relative and the absolute weights of organs (liver, kidneys, heart, and lungs). On the other hand, Ferreira et al. (1998), evaluating the effect of DE levels increase in 15-30kg female piglets, found that the DE level of the diet reduced the absolute and the relative weights of the kidneys.

Table 5 - Daily feed intake (DFI), daily weight gain (DWG), feed:gain ratio (F:G), daily energy intake (DEI), daily protein intake (DPI) and plasma urea nitrogen level (PUN) of pigs (15 to 30 kg), fed on diets containing graded levels of metabolizable energy (ME) over various parts of the experimental periods

Item	ME levels, kcal /kg				Average	CV,%	Probability
	3,264	3,329	3,395	3,460			
Initial body weight, kg	15.6± 1.458	15.6 ± 1.430	15.5 ± 1.382	15.5 ± 1.371	15.6 ± 1.295	0.40	P>0.05
0-14 days							
DFI, g/d	1053 ± 0.068	1054 ± 0.190	1093 ± 0.110	1102 ± 0.066	1075 ± 0.112	9.64	P>0.05
DWG, g/d	580 ± 28	596 ± 114	628 ± 41	651 ± 54	614 ± 69	11.44	P>0.05
F:G	1.82 ± 0.031	1.77 ± 0.133	1.74 ± 0.109	1.70 ± 0.129	1.76 ± 0.109	5.57	P>0.05
14-23 days							
DFI, g/d	1476 ± 0.136	1401 ± 0.244	1544 ± 0.092	1520 ± 0.072	1485 ± 0.149	9.19	P>0.05
DWG, g/d	799 ± 57	738 ± 107	809 ± 46	833 ± 55	794 ± 74	7.57	P>0.05
F:G	1.85 ± 0.106	1.89 ± 0.124	1.91 ± 0.084	1.84 ± 0.171	1.87 ± 0.119	7.04	P>0.05
0-23 days							
DFI, g/d	1219 ± 0.091	1190 ± 0.205	1270 ± 0.093	1266 ± 0.059	1236 ± 0.120	8.65	P>0.05
DWG, g/d	665 ± 33	652 ± 102	699 ± 21	722 ± 36	685 ± 60	7.59	L*:P=0.056[1]
F:G	1.83 ± 0.064	1.82 ± 0.085	1.81 ± 0.080	1.76 ± 0.120	1.81 ± 0.088	4.66	P>0.05
DEI, kcal ME/d	3,978 ± 296	3,960 ± 684	4,310 ± 317	4,379 ± 205	4,157 ± 430	8.59	L*:P=0.048[2]
DPI, g/d	219.4 ± 16.31	214.1 ± 36.97	228.5 ± 16.79	227.8 ± 10.66	222.5 ± 21.56	8.64	P>0.05
PUN, mg/dL	10.9 ± 1.423	11.7 ± 3.702	9.9 ± 2.264	11.6 ± 4.587	11.0 ± 3.313	27,47	P>0.05

L* Linear

[1] DWG = - 445.87 + 0.33 ME;

[2] DEI = -3,871.62 + 2.38 ME

Table 6 - Body composition, protein and fat deposition rate of barrows fed diets containing graded levels of metabolizable energy (ME)

Item	ME levels, kcal /kg				Average	CV , %	Effect
	3,264	3,329	3,395	3,460			
Slaughter weight, kg	29.8	29.4	30.4	30.8	30.1	-	-
Body composition, %							
Water	63.5 ± 0.848	63.1 ± 0.270	62.0 ± 0.749	61.3 ± 1.837	62.5 ± 1.288	1.65	L*:P=0.019[1]
Protein	17.8 ± 0.217	17.5 ± 0.502	17.1 ± 0.387	17.0 ± 0.625	17.4 ± 0.513	2.49	L*:P=0.034[2]
Fat	15.0 ± 0.933	16.0 ± 0.615	17.8 ± 1.232	18.5 ± 2.979	16.8 ± 2.052	9.67	L*:P=0.017[3]
Ash	3.4 ± 0.265	3.1 ± 0.103	3.3 ± 0.099	3.4 ± 0.176	3.3 ± 0.179	5.47	P>0.05
Deposition rate, g/d							
Protein	93.4 ± 1.233	86.7 ± 5.978	98.5 ± 10.233	94.4 ± 7.883	93.3 ± 7.532	8.65	P>0.05
Fat	96.4 ± 8.819	103.3 ± 14.253	131.4 ± 19.787	140.4 ± 42.958	117.9 ± 28.802	20.53	L*:P=0.030[4]

L* Linear

[1] Water =101.55 -0.012 ME;

[2] Protein =31.65 -0.004 ME;

[3] Fat = - 46.08 + 0.018 ME;

[4] FDR = - 706.43 + 0.24 ME

Table 7 - Absolute (g) and relative weight (% of BW) of organs, of pigs (30 kg) fed on diets containing graded levels of metabolizable energy (ME)

Organs	ME levels, kcal /kg				Average	CV, %	Effect
	3.264	3.329	3.395	3.460			
	Absolute weight, g						
Liver	794 ± 64.0	886 ± 189.6	830 ± 7.2	852 ± 63.5	841 ± 96.2	12.28	P>0.05
Kidneys	176 ± 10.4	160 ± 12.9	179 ± 12.1	171 ± 10.4	172 ± 12.4	7.87	P>0.05
Heart	138 ± 10.5	141 ± 14.0	139 ± 8.5	145 ± 9.0	141 ± 9.6	7.27	P>0.05
Lungs	391 ± 187.8	316 ± 38.1	285 ± 57.0	255 ± 28.8	312 ± 101.1	30.58	P>0.05
Pancreas	62 ± 2.1	58 ± 2.0	58 ± 7.1	67 ± 11.8	61 ± 7.2	10.89	P>0.05
Spleen	52 ± 2.9	47 ± 7.5	49 ± 13.1	45 ± 5.5	48 ± 7.4	16.20	P>0.05
Stomach	219 ± 19.7	217 ± 12.9	232 ± 3.5	223 ± 19,3	223 ± 14.4	6.89	P>0.05
Tongue	95 ± 9.3	94 ± 8.7	100 ± 7.6	106 ± 4.0	99 ± 8.3	7.38	P>0.05
	Relative weight, %						
Liver	2.66 ± 0.20	3.01 ± 0.56	2.73 ± 0.08	2.77 ± 0.16	2.79 ± 0.30	11.26	P>0.05
Kidneys	0.59 ± 0.04	0.55 ± 0.04	0.59 ± 0.02	0.55 ± 0.02	0.57 ± 0.03	5.97	P>0.05
Heart	0.46 ± 0.03	0.48 ± 0.04	0.46 ± 0.03	0.47 ± 0.05	0.47 ± 0.04	8.38	P>0.05
Lungs	1.31 ± 0.63	1.08 ± 0.09	0.94 ± 0.19	0.83 ± 0.13	1.04 ± 0.34	30.56	P>0.05
Pancreas	0.21 ± 0.01	0.20 ± 0.01	0.19 ± 0.02	0.22 ± 0.04	0.20 ± 0.02	9.89	P>0.05
Spleen	0.17 ± 0.01	0.16 ± 0.04	0.16 ± 0.04	0.15 ± 0.03	0.16 ± 0.03	17.67	P>0.05
Stomach	0.74 ± 0.07	0.74 ± 0.44	0.77 ± 0.04	0.72 ± 0.06	0.74 ± 0.05	6.93	P>0.05
Tongue	0.32 ± 0.03	0.32 ± 0.04	0.33 ± 0.03	0.35 ± 0.03	0.33 ± 0.03	9.41	P>0.05

Nevertheless, the same authors justified that kidney reduction could occur because of the linear reduction of protein intake and, consequently, of the quantity of urea eliminated directly in the urine.

CONCLUSION

Results suggest that for improved barrows (15 to 30 kg) of the dam line, fed on 0.96% digestible lysine diets, formulated according to the ideal protein concept, the ME requirement is 3,264 kcal/kg or less.

RESUMO

A exigência de energia metabolizável (EM) para suínos machos castrados foi determinada no presente experimento. Foram utilizados 43 suínos geneticamente melhorados, distribuídos em delineamento experimental de blocos inteiramente casualizados, com quatro tratamentos, cinco blocos e dois animais por unidade experimental. Tratamento 1 constituiu-se de uma dieta contendo 3.264 kcal de EM/kg contendo 0,96% de lisina digestível, 0,55% de metionina + cistina digestíveis, 0,60% de treonina digestível e 0,188% de triptofano digestível, atendendo ao conceito de proteína ideal. Tratamentos 2, 3 e 4 foram semelhantes à do Tratamento 1, onde os níveis de energia foram 2, 4 e 6% maiores que o Tratamento 1. A relação lisina/EM foi mantida constante (2,82 g) em todos tratamentos. O consumo diário de ração e conversão alimentar não foram influenciados pelos níveis crescentes de EM. Ocorreu aumento linear do ganho diário de peso, consumo diário de energia, porcentagem de gordura e taxa de deposição de gordura. Houve redução linear da porcentagem de proteína na carcaça. Os resultados sugerem que, para suínos (15 - 30 kg) machos castrados, geneticamente melhorados, alimentados com dietas de 0,96% de lisina, formuladas de acordo com o conceito de proteína ideal, a exigência de energia metabolizável é de 3.264 kcal/kg ou menos.

ACKNOWLEDGEMENTS

The authors wish to thank AJINOMOTO BIOLATINA for supplying the amino acids; Mrs. Marlene Leiko Doi Sakuno for analyzing the urea; and CNPq-Brazil for granting scholarships to the authors.

REFERENCES

Association of Offical Analitical Chemists -AOAC (1975), *Official methods of analysis*. AOAC, Washington, D.C.

Baker, D. H. (1996), Advances in amino acid nutrition and metabolism of swine and poultry. In: Kornegay, E. T. (Ed.). *Nutrient management of food animals to enhance and protect the environment*. Boca Raton: CRC Press. pp. 41-53.

Bertechini, A. G.; Rostagno, H. S.; Pereira, A. A. et al. (1986), Níveis de energia para suínos nas fases de crescimento e terminação. *Revista Brasileira de Zootecnia*, **15**, 452-461.

Bikker, P.; Karabinas, V.; Verstegen, M. W. A. et al. (1995), Protein and lipid accretion in body components of growing gilts (20 to 45 kilograms) as affected by energy intake. *Journal of Animal Science*, **73**, 2355-2363.

Cai, Y; Zimmerman, D. R. and Ewan, R. C. (1994), Diurnal variation in concentrations of plasma urea nitrogen and amino acids in pigs given free access to feed or fed twice daily. *Journal of Nutrition*, **124**, 1088-1093.

Caldara, F. R.; Berto, D. A.; Bisinoto, K. S. et al. (2001), Exigências de lisina de leitões (6-11 kg) alimentados com rações formuladas com base no conceito de proteína ideal. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 38. 2001, Piracicaba. *Anais...* Piracicaba: Sociedade Brasileira de Zootecnia, 2001. pp. 884-885.

Campbell, R. G. and Taverner, M. R. (1988), Relationship between energy intake and protein and energy metabolism growth and body composition of pigs kept at 14 or 32^{o}C from 9 to 20 kg. *Livestock Production Science*, **18**, 289-303.

Chen, H. Y.; Lewis, A. J.; Wolverton, C. K. et al. (1995), Changes in plasma urea content diet can be used to used to determine protein requirements of two populations of pigs with different protein accretion rates. *Journal of Animal Science*, **73** : (9), 2631-2639.

Chiba, L. I.; Lewis, A. J.; Peo Jr, E. R. (1990), Efficacy of the urea dilution technique in estimating empty body composition of pigs weighing 50 kilograms. *Journal of Animal Science*, **68**, 372-383.

Close, W. H. and Stahly, T. S. (1984), Effects of plane of nutrition and environmental temperature on the growth and development of the early-weaned piglet**.** *Animal Production*, **38**, 221-231.

Coelho, L. S. S.; Costas, P. M. A.; Pereira, J. A. A. et al. (1987), Exigência de lisina para suínos de 15 a 30 kg em rações com alta ou baixa densidade calórica. *Revista Brasileira de Zootecnia*, **16**, 91-101.

Coffey, M. T.; Seerley, R. W.; Furderburke, D. W. et al. (1982), Effect of heat increment and level of dietary energy and environmental temperature on the performance of growing-finishing swine. *Journal of Animal Science*, **54**, 95-105.

Dividich, J. L. and Noblet, J. (1986), Effect of dietary energy level on the performance of individually housed early weaned piglets in relation to environmental temperature. *Livestock Production Science*, **14**, 255-263.

Donzele, J. L.; Costa, P. M. A.; Rostagno, H. S., et al. (1992), Efeitos de níveis de energia digestível na composição da carcaça de suínos dos 5 aos 15 kg. *Revista Brasileira de Zootecnia*, **6**, 1101-1106.

Donzele, J. L.; Oliveira, R. F. M.; Freitas, R. T. F. et al. (1997), Avaliação de níveis de energia digestível para leitoas dos 15 aos 30 kg mantidas em ambiente de alta temperatura. *Revista Brasileira de Zootecnia*, **4**, 744-752.

Ferreira, R. A.; Oliveira, R. F. M.; Donzele, J. L. et al. (1998), Níveis de energia digestível para leitoas de 15 a 30 kg mantidas em ambiente frio. *Revista Brasileira de Zootecnia*, **27**, 1131-1139.

Fraga, A. L. (2002), *Exigências de lisina para suínos em fase inicial (15-30 kg) de dois grupos genéticos, em rações formuladas de acordo com o conceito de proteína ideal.* M. Sc. Thesis, Universidade Estadual de Maringá, Maringá, Brasil.

Greef, K. H.; Verstegen, M. W. A.; Kemp, B. et al. (1994), The effect of body weight and energy intake on the composition of deposited tissue in pigs. *Animal Production*, **58**, 263-270.

Lima, J. A. F.; Pereira, J. A. A.; Costas, P. M. A. et al. (1990), Efeito da idade de desmama sobre os níveis de energia digestível para leitões na fase inicial de crescimento (15 a 30 kg PV). *Revista Brasileira de Zootecnia*, **19**, 408-415.

Lopes-Bote, C. J.; Sanz, M.; Isabel, B. et al. (1997), Effect of dietary lard on performance, fatty acid composition and susceptibility to lipid peroxidation in growing-finishing female and entire male pigs. *Canadian Journal of Animal Science*, **77**, 301-306.

National Research Council (1998), *Nutrient requirements of swine*. 10th ed. Washington, D.C.: National Academy Press.

Newman, D. J. and Price, C. P. (1999), Renal function and nitrogen metabolites. In-BURTIS, C. A. E ASHWOOD, E. R. *Tietz textbook of clinical chemistry*. 3rd ed. Philadelphia: W. B. Saunders Company. pp. 1204-1270.

Oliveira, R. F. M.; Donzele, J. L.; Freitas, R. T. F et al. **(**1997a), Níveis de energia digestível para leitões dos 15 aos 30 kg de peso mantidos em ambiente de conforto térmico. *Revista Brasileira de Zootecnia*, **26**, 539-547.

Oliveira, R. F. M.; Donzele, J. L.; Freitas, R. T. F et al. (1997b), Avaliação de níveis de energia digestível para leitoas em recria mantidas em ambiente de conforto térmico. *Revista Brasileira de Zootecnia*, **26**, 779-786.

Penz Junior, A. M.; Meinerz, C. E. T.; Magro, N. (1999), Efeito da nutrição na quantidade e na qualidade dos dejetos suínos. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 36., 1999, Porto Alegre. *Anais*... Porto Alegre: Sociedade Brasileira de Zootecnia. pp. 281-294.

Rostagno, H. S.; Albino, L. F. T.; Donzele, J. L. et al. (2000), *Composição de alimentos e exigências nutricionais de aves e suínos (tabelas brasileiras)*, Imprensa Universitária/UFV, Viçosa, MG.

Stahly, T. S. and Cromwell, G. L. (1979), Effect of environmental temperature and dietary fat supplementation on the performance and carcass characteristics of growing and finishing swine. *Journal of Animal Science*, **49**, 1478-1488.

Stein, H. H.; Hahn, J. D. and Easter, R. A. (1996), Effects of decreasing dietary energy content diet in finishing pigs on carcass composition. *Journal of Animal Science*, **74** : (Suppl. 1), 65.

Tavares, S. L. S.; Donzele, J. L.; Oliveira, R. F. M. et al. (1999), Níveis de energia digestível para leitões dos 30 aos 60 kg mantidos em ambiente de conforto térmico. *Revista Brasileira de Zootecnia*, **28**, 569-576.

Usry, J.; Campbell, R. and Burnham, D. (1998), *Model developed to optimize energy formulation*. F*eedstuffs.* pp. 12-18.

Received: April 12, 2004;
Revised: November 18, 2004;
Accepted: August 03, 2005.