Revista Brasileira de Zootecnia
© 2011 Sociedade Brasileira de Zootecnia
ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.40, n.3, p.581-586, 2011

Levels of digestible methionine+cystine in diets for high genetic potential barrows from 95 to 125 kg[1]

Fabrício de Almeida Santos[1], Juarez Lopes Donzele[2], Francisco Carlos de Oliveira Silva[3], Rita Flávia Miranda de Oliveira[2], Márvio Lobão Teixeira de Abreu[4], Alysson Saraiva[1], Douglas Haese[5], João Luís Kill[5]

[1] *Doutorando em Zootecnia – DZO/UFV.*
[2] *DZO/UFV.*
[3] *EPAMIG.*
[4] *DZO/UFPI.*
[5] *DZO/UVV.*

ABSTRACT - This study was carried out to evaluate the effects of increasing levels of digestible methionine+cystine on performance and carcass composition of high genetic potential barrows for lean deposition. Sixty-four barrows with initial weight of 95.46 ± 1.09 kg were allotted to a completely randomized block design, with four levels of digestible methionine+cystine (0.427, 0.466, 0.504, and 0.545%, corresponding to the digestible methionine+cystine:digestible lysine ratios of 57.0, 62.0, 67.0 and 73.0%, respectively), with eight replicates, and two animals per experimental unit. Experimental diets and water were provided *ad libitum* until the end of the experimental period when pigs reached 125.21 ± 2.49 kg. Levels of digestible methionine+cystine did not affect daily intake, daily weight gain and feed conversion of the animals, but they affected daily intake of digestible methionine+cystine which increased linearly. Levels of digestible methionine+cystine did not affect carcass weight, meat amount, backfat thickness at P_2, and daily meat deposition. The digestible methionine+cystine level of 0.427%, corresponding to the digestible methionine+cystine:lysine ratio of 57.0% and to a daily digestible methionine+cystine intake of 14.20 g/d, provides the best performance and carcass traits for high genetic potential barrows in the phase of 95 to 125 kg.

Key Words: carcass, genotype, late finishing, performance, sulfur amino acids

Níveis de metionina+cistina digestíveis em rações para suínos machos castrados de alto potencial genético de 95 a 125 kg

RESUMO - Este estudo foi realizado para avaliar o efeito de níveis crescentes de metionina+cistina digestível sobre o desempenho e a composição da carcaça de suínos machos castrados de alto potencial genético para deposição de carne. Sessenta e quatro suínos com peso inicial 95,46 ± 1,09 kg foram distribuídos em delineamento de blocos ao acaso, com quatro níveis de metionina+cistina digestível (0,427; 0,466; 0,504 e 0,545%, correspondentes às relações de metionina+cistina:lisina digestíveis de 57,0; 62,0; 67,0 e 73,0%, respectivamente), com oito repetições e dois animais por unidade experimental. As rações experimentais e a água foram fornecidas à vontade até o final do período experimental, quando os animais atingiram 125,21 ± 2,49 kg. Os níveis de metionina+cistina digestível não tiveram efeito sobre o consumo diário de ração, o ganho de peso diário e a conversão alimentar dos animais, mas afetaram o consumo diário de metionina+cistina digestível, que aumentou de forma linear. Os níveis de metionina+cistina digestível não influenciaram o peso da carcaça, a quantidade de carne, a espessura de toucinho no ponto P_2 e a deposição diária de carne. O nível de 0,427% de metionina+cistina digestível, correspondente a uma relação de 57,0% com a lisina digestível e a um consumo de metionina+cistina digestíveis de 14,20 g/dia, proporcionou os melhores resultados de desempenho e características de carcaça de suínos machos castrados de alto potencial genético na fase dos 95 aos 125 kg.

Palavras-chave: aminoácidos sulfurosos, carcaça, desempenho, genótipo, terminação tardia

Introduction

The growing demand of consumers for a healthy pig meat has been increasing the interest of pig producers and pork industries in slaughtering pigs with higher amount of meat and less fat in the carcass. Meeting this demand has been made possible through genetic selection resulting in lines of pigs with higher

Received August 18, 2008 and accepted August 27, 2010.
Corresponding author: fcosilva@epamig.br

potential for protein accretion and less fat deposition (Moura et al., 2006).

The production of these new commercial lines makes it viable to the meat industries to slaughter heavier pigs, with higher carcass yield and weight of the major commercial cuts without significant alteration in the percentage of these cuts (Irgang & Protas, 1986). Slaughtering pigs at heavier weights also results in an increase of meat production with no need to change the number of sows, leading to a 20 to 30% increase in the meat supply, therefore improving the income of the producer (Faccin, 1997).

This market tendency for animals with higher weights at slaughter and the introduction of commercial lines specialized in lean meat accretion require nutritionists to update the amino acids requirement of pigs from 95 to 125 kg (Kiefer et al., 2005).

The growing rate and efficiency of pigs can be impaired by an intake of amino acids above or below the amount required by the animals. However, an adequate level of amino acid in the diet can improve feed efficiency and increase both growth rate and profit (Kiefer et al., 2005).

According to the NRC (1998), pigs with high genetic potential have daily protein accretion rate equal or higher than 350 g/day which results in higher requirements of amino acids for maintenance and growth. Among these amino acids, methionine+cystine stands out in the maintenance functions for being engaged in the renewal of intestinal tissues and as precursor of substances with various biological functions. Methionine is important in the biosynthesis of creatine, carnitine, poliamines, epinefrine, choline, and melatonin (Baker, 1991). Cystine participates in the structure of many proteins such as in the hormone insulin, in the immunoglobulin, and for linking polypeptide chains by disulfide bonds (Baker, 1991).

There are much information about lysine requirement of pigs from different genetic groups, categories and sex. However, there is a lack of studies on requirements of sulfur amino acids for late finishing pigs.

Accordingly, this work was conducted to evaluate the effects of different dietary methionine+cystine levels on performance and carcass traits of castrated male pigs with high genetic potential for meat deposition from 95 to 125 kg.

Material and Methods

The experiment was carried out at the Fazenda Experimental Vale do Piranga, of the state-owned Empresa de Pesquisa Agropecuária de Minas Gerais – EPAMIG (Oratórios, Minas Gerais, Brazil), during September and November of 2005.

Sixty-four commercial hybrid male pigs (PIC) with high genetic potential for meat deposition were used allotted in a completely randomized block design with four treatments, eight replicates, and two pigs per experimental unit which was represented by the pen. Body weight was used as criterion in the formation of the blocks (heavy pig vs. light pig).

Experimental diets (Table 1) were mainly composed of corn, soybean, and sorghum meals supplemented with minerals and vitamins, according to Rostagno et al. (2000). The treatments evaluated consisted of 0.427, 0.466, 0.504, and 0.545% digestible methionine+cystine, corresponding to digestible methionine+cystine and lysine ratios of 57.0, 62.0, 67.0, and 73.0%, respectively, obtained from a basal diet supplemented with DL-methionine.

The ratios between lysine and the other amino acids in the basal diet were checked in order to insure that in all treatments no other amino acid except methionine was limiting in the diet. When the amino acid ratios where being evaluated, it was considered those suggested by Fuller (1996) in the ideal protein for 50 to 110 kg pigs (threonine 70, valine 68, methionine+cystine 65, isoleucine 60, leucine 100, fenilalanine+thyrosine 95, histidine 32, tryptophan 19, arginine 30, and lysine 100). DL-methionine was incorporated into the diets in replacement of glutamic acid proportionally to their nitrogen concentrations.

Pigs were housed in pens with semi-automatic feeders, drinkers, and concrete floor. The thermal environment inside the facility was monitored daily by using minimum and maximum thermometer

Pigs were fed *ad libitum* and water was provided throughout the experimental period. Daily feed waste and animals were weighed weekly to calculate feed intake, daily weight gain, feed conversion, and methionine+cystine intake.

At the end of the experiment, when pigs reached 125.21 ± 2.49 kg, they were weighed after eighteen hours of fasting and then sent to be slaughtered in a commercial meat industry (FRIVAP). Pigs were electrically stunned followed by exsanguinations.

The carcasses were boiled, shaved with flame thrower, eviscerated, weighed, and evaluated for backfat thickness and amount of meat by using apparatus to carcass classification with Henessay Grading Probe (HGP-4), in accordance with procedures used in the meat industry.

Daily meat deposition (DMD) was estimated by using the data of initial weight of the animal (IW), carcass yield

Table 1 - Proximate composition and nutritional values of experimental diets

Ingredients (%)	Digestible methionine+cystine levels (%)			
	0.427	0.466	0.504	0.545
Corn	43.269	43.269	43.269	43.269
Soybean meal	14.700	14.700	14.700	14.700
Sorghum	37.000	37.000	37.000	37.000
Soybean oil	1.700	1.700	1.700	1.700
Dicalcium phosphate	1.225	1.225	1.225	1.225
Limestone	0.720	0.720	0.720	0.720
Glutamic acid	0.263	0.224	0.186	0.147
L-lysine HCl (78,5%)	0.300	0.300	0.300	0.300
L-threonine (98,5%)	0.102	0.102	0.102	0.102
DL-methionine (99%)	0.037	0.076	0.114	0.153
L-thriptophan (99%)	0.022	0.022	0.022	0.022
Vitamin premix[1]	0.150	0.150	0.150	0.150
Mineral premix[2]	0.150	0.150	0.150	0.150
Salt	0.332	0.332	0.332	0.332
Butil-hydroxitoluene[3]	0.010	0.010	0.010	0.010
Zinc bacitracin	0.020	0.020	0.020	0.020
Nutritional calculated composition[4]/estimated[5]				
Crude protein (%)	14.05	14.05	14.05	14.05
Digestible energy (kcal/kg)	3.400	3.400	3.400	3.400
Total lysine (%)	0.833/0.825	0.833/0.825	0.833/0.825	0.833/0.825
Digestible lysine (%)	0.753/0.746	0.753/0.746	0.753/0.746	0.753/0.746
Digestible met + cys (%)	0.452/0.427	0.491/0.466	0.528/0.504	0.566/0.545
Digestible threonine (%)	0.549/0.500	0.549/0.500	0.549/0.500	0.549/0.500
Digestible tryptophan (%)[4]	0.158/0.154	0.158/0.154	0.158/0.154	0.158/0.154
Calcium (%)	0.655	0.655	0.655	0.655
Available phosphorus (%)	0.322	0.322	0.322	0.322
Sodium (%)	0.162	0.162	0.162	0.162
Digestible mehionine+cystine:lysine ratios	57.0	62.0	67.0	73.0

[1] Provided per kg of product:: A vit. - 6,000,000 IU; D3 vit. - 1,500,000 IU; E vit. - 15,000,000 IU; B1 vit. - 1.35 g, vit. B2 - 4 g, B6 vit. - 2 g, pantothenic acid - 9.35 g, K3 vit. - 1.5 g, nicotinic acid - 20.0 g, B12 vit. - 20.0 g, folic acid - 0.6 g, biotin - 0.08 g, Se - 0.3 g, vehicle q. s. p. - 1,000 g.
[2] Provided per kg of product : Fe - 100 g, Cu - 10 g, Co - 1 g, Mn - 40 g, Zn - 100 g, I - 1.5 g, veihcle q.s.p.- 1.000 g.
[3] Butil Hidroxi Tolueno.
[4] Composition calculated according to Rostagno et al. (2000).
[5] Estimated composition from the amino acid analysis realized at the Laboratory of Ajinomoto Biolatin and from the digestibility coefficients proposed by Rostagno et al. (2000).

(CY), estimated carcass weight (SCW), carcass lean meat percentage (CLM), estimated meat amount (EMA), final meat amount (FMA), initial estimated meat amount (IEMA), and days in the experimental study (D), calculated by using the equations:

$SCW = (IW \times CY)/100$

$IEMA = (ECW \times CLM)/100$

$EMA = FMA – IEMA$

$DDC (g/d) = (EMA / D) \times 1000$

The values of carcass yield were obtained using the data of Rossoni et al. (2008) in which the carcass yield was obtained using the Método Brasileiro de Classificação de Carcaça (MBCC), considering the relationship between hot carcass weight and final body weight of the animal whereas the meat percentage in the carcass was determined according to the methodology used by the meat industry (FRIVAP).

The variables evaluated were daily feed intake, daily weight gain, methionine+cystine intake, feed conversion, backfat thickness at P_2, amount of meat, carcass weight, and daily meat deposition.

Performance and carcass traits data were analyzed using the procedures for analysis of variance and regression contained in the Sistema para Análises Estatísticas e Genéticas (SAEG), developed at the Universidade Federal de Viçosa (UFV, 2000), version 8.0, using the procedures for variance and regression analysis, according to the following statistical model:

$$Y_{ijk} = \mu + B_i + T_j + e_{ijk},$$

where: Y_{ijk} = characteristic observed; μ = overall mean of the characteristics; B_i = effect of block i; i = 1, 2... e 8; T_j = effect of methionine+cystine level j; j = 1, 2... e 4; e_{ijk} = random error associated with each observation.

Estimates of methionine+cystine requirements were determined through linear or quadratic regressions, or by the discontinuous Linear Response Plateau (LRP) model contained in SAEG (UFV, 2000), as the best fit for each variable and taking into account the biological behavior of each animal.

Results and Discussion

During the experimental period, the minimal and maximal temperatures inside the facility corresponded to 27.88 ± 3.75°C and 19.13 ± 1.5°C, respectively. Considering that according to Perdomo (1994), the range of thermoneutral temperature for finishing pigs is between 12 and 18°C, so it can be inferred that pigs were subjected to periods of heat stress.

The digestible methionine+cystine levels in the diets did not influence (P>0.05) daily feed intake (Table 2). In studies carried out with finishing pigs, Loughmiller et al. (1996), Santos et al. (2007), and Pena et al. (2008) did not observe significant variation in the voluntary feed intake of the animals by increasing the dietary digestible levels of methionine+cystine, neither.

On the other hand, Loughmiller et al. (1998) evaluated sulfur amino acids levels in diets for finishing female pigs and found significant alteration in the daily feed intake of animals. Based on the results of the studies cited above, it can be assumed that sex of the animal is one factor that can influence the feed intake pattern due to the variation in the dietary levels of methionine+cystine.

Thus, the daily feed intake pattern obtained in this study by increasing the levels of dietary methionine+cystine confirmed the report of Edmonds and Baker (1987) that pigs can tolerate considerable excess of methionine in the diet without presenting significant variation in feed intake.

As the average daily feed intake of pigs in this study corresponded to 3210 g, it can be inferred that periods of high temperatures that pigs were subjected to were not sufficient to compromise their voluntary feed intake, based on the feed intake value of 3100 g/day suggested by Rostagno et al. (2005) for this animal category.

Dietary methionine+cystine levels influenced (P<0.01) methionine+cystine intake which increased linearly according to the equation: $\hat{Y} = 2.7023 + 26.9185\,X$ ($r^2 = 0.98$). Similarly, Santos et al. (2007) also observed linear increase in the digestible methionine+cystine intake of finishing pigs fed different levels of these amino acids in the diets. The result obtained in this study can be justified by the fact that the voluntary feed intake of pigs did not vary significantly among the levels of amino acids evaluated.

There was no effect (P>0.05) of methionine+cystine levels in the daily weight gain of pigs. Similar results were observed by Grandhi and Nyacothi (2002) and Pena et al. (2008), who also found no variation in the daily weight gain of pigs in the finishing phase when levels sulfur amino acids were increased in the diets.

However, Loughmiller et al. (1998) and Santos et al. (2007) observed significant variation in the growing rate of finishing pigs by increasing the levels of methionine+cystine in the diets.

Feed conversion was not influenced (P>0.05) by the increase in the dietary methionine+cystine levels. Consistently with this result, Knowles et al. (1998) and Pena et al. (2008) also found no influence of dietary sulfur amino acids in the feed efficiency for weight gain of finishing barrows from 77 to 144 kg and 84 to 109 kg, respectively.

By contrast, assessing methionine+cystine levels in diets for finishing pigs, Santos et al. (2007) found that the feed conversion improved up to the estimated level of 0.506%. The inconsistency among results regarding to weight gain and feed conversion may be related to differences in the genetic potential of pigs for growth.

According to Thong and Liebert (2004), the difference in the genetic potential for weight gain is one of the major factors that influence the requirements of amino acids by the pigs.

There were no effects (P>0.05) of the dietary methionine+cystine levels in the carcass weight, meat amount, backfat thickness at P_2, and daily meat deposition (Table 3). These results were similar to those described by Loughmiller et al. (1998), Grandhi and Nyacothi (2002), and Pena et al. (2008), who also did not find significant variation in the carcass traits by increasing the levels of dietary digestible methionine+cystine in studies with finishing pigs.

Likewise, when evaluating different total methionine+cystine:lysine ratios (50.0, 55.0, 60.0, 65.0, and 70.0%) in diets with 0.55 or 0.65% lysine for male pigs with 60 to 95 kg, Knowles et al. (1998) also observed no effect of these amino acids levels in the carcass traits irrespective of lysine level

Table 2 - Performance and intake of digestible methionine+cystine of 95 to 125 kg castrated male pigs, according to the digestible methionine+cystine in the diets

Item	Digestible methionine+cystine levels (%)				CV (%)
	0.427	0.466	0.504	0.545	
Feed intake (g/d)	3338 ± 0.46	3250 ± 0.22	3233 ± 0.23	3190 ± 0.13	8.15
Digestible methionine+cystine intake (g)[1]	14.25 ± 1.96	15.14 ± 1.01	16.29 ± 1.18	17.39 ± 0.73	7.65
Weight gain (g/d)	1145 ± 0.12	1098 ± 0.05	1094 ± 0.10	1085 ± 0.06	7.87
Feed conversion (g/g)	2.92 ± 0.25	2.96 ± 0.21	2.96 ± 0.07	2.94 ± 0.14	6.67

[1] Linear effect (P<0.01).

Table 3 - Carcass traits of 95 to 125 kg castrated male pigs, according to the digestible methionine+cystine in the diets

Item	Digestible methionine+cystine levels (%)				CV (%)
	0.427	0.466	0.504	0.545	
Carcass weight (kg)	87.97 ± 2.37	88.35 ± 5.19	87.25 ± 5.32	90.04 ± 2.60	4.52
Meat amount (kg)	49.80 ± 1.60	50.26 ± 4.17	50.30 ± 3.40	49.96 ± 2.55	6.53
Backfat thickness P_2 (mm)	16.24 ± 2.53	16.55 ± 3.80	14.13 ± 3.58	17.72 ± 2.94	18.17
Meat deposition (g/d)	540.5 ± 71.21	548.0 ± 68.09	557.1 ± 100.5	478.2 ± 75.41	14.76

used, confirming that for castrated male pigs, the methionine+cystine:lysine ratio for better carcass traits do not differ between the finishing (60 to 95 kg) and late finishing (95 to 125 kg) phases.

Nevertheless, Knowles et al. (1998), in a study with finishing female pigs (74 to 110 kg), found significant variation in the percentage of fat free meat in the carcass by increasing the concentration of methionine+cystine in the diet when assessing levels of these amino acids which corresponded to the ratios of 35 and 65% with lysine.

Sex of the animals and the levels of amino acids assessed are among the factors that may have contributed for the differences observed among studies, because according to Peisker (1982), cited by Thong and Liebert (2004), when weight variation between sexes is the same, females have 13.5% higher protein accretion than castrated males due to the lack of sexual hormones in these animals, resulting in lower capacity of this category to incorporate the amino acids in muscular tissues (Xue et al., 1997).

The results of carcass traits found in this study are consistent with those of performance and show that the digestible methionine+cystine level of 0.427% in the diet, corresponding to a ratio of 57.0 with the digestible lysine met the requirement of late finishing castrated male pigs.

Conclusion

The greatest performance and carcass traits of 95 to 125 kg castrated male pigs with high genetic potential for meat deposition is obtained at 0.427% of digestible methionine+cystine, corresponding to a ratio of 57.0% with the digestible lysine.

Acknowledgements

To the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG), by granting the PhD scholarship. To the Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), for the facilities to conduct the experiment. To the Frigorífico Industrial Vale do Piranga (FRIVAP), for the permission to follow up the slaughter. To the graduate and undergraduate students, for their assistance in conducting the experiment.

References

ASSOCIAÇÃO BRASILEIRA DE CRIADORES DE SUÍNOS. **Método brasileiro de classificação de carcaça**. Estrela, RS: ABCS, 1973. 17p.

BAKER, D.H. Partitioning of nutrients for growth and other metabolic functions. **Poultry Science**, v.70, p.1797-1805, 1991.

CHUNG, T.K.; IZQUIERDO, O.A.; HASHIMOTO, K. et al. Methionine requirement of the finishing pig. **Journal of Animal Science**, v.67, p.2.677-2.683, 1989.

EDMONDS, M.S.; GONYOU, H.W.; BAKER, D.H. Effect of excess levels of excess methionine, tryptofhan, arginine, lysine or threonine on growth and dietary choice in the pig. **Journal of Animal Science**, v.65, p.179-185, 1987.

FACCIN, M. Tendências da suinocultura brasileira. In: VIII CONGRESSO BRASILEIRO DE VETERINÁRIOS ESPECIALISTAS EM SUÍNOS, 1997, Foz do Iguaçu. **Anais...** Foz do Iguaçu: ABRAVES, 1997. p.57-69.

FULLER, M. Macronutrient requirements of growing swine. In: SIMPÓSIO INTERNACIONAL SOBRE EXIGÊNCIAS NUTRICIONAIS DE AVES E SUÍNOS, 1., 1996, Viçosa, MG. **Anais...** Viçosa, MG: UFV, Imprensa Universitária, 1996. p.205-221.

GRANDHI, R.R.; NYACHOTI, C.M. Effect of true ileal digestible dietary methionine to lysine ratios on growth performance and carcass merit of boards, gilts and barrows selected for low backfat. **Canadian Journal of Animal Science**, v.82, p.399-407, 2002.

IRGANG, R.; PROTAS, J.F.S. Peso ótimo de abate de suínos. II. Resultados de carcaça. **Pesquisa Agropecuária Brasileira**, v.21, p.1337-1345, 1986.

KIEFER, C.; FERREIRA, A.S.; DONZELE, J.L. et al. Exigência de metionina + cistina digestíveis para suínos mantidos em ambiente termoneutro dos 30 aos 60 kg. **Revista Brasileira de Zootecnia**, v.34, n.3, p.847-854, 2005.

KNOWLES, T.A; SOUTHERN, L.L.; BINDER, T.D. Ratio of total sulfur amino acids to lysine for finishing pigs. **Journal of Animal Science**, v.76, p.1081-1090, 1998.

KRICK, B.J.; BOYD, R.D. Influence of genotype and sex on the response of growing pigs to recombinant porcine sonatotropin. **Journal of Animal Science**, v.70, p.3024, 1992.

LOUGHMILLER, J.A.; GOODBAND, R.D.; TOKACH, M.D. et al. Evaluation of the sulfur amino acid requirement of finishing pigs. **Swine Day Report**, p.130-132, 1996a.

LOUGHMILLER, J.A.; NELSSEN, J.L.; GOODBAND, R.D. et al. Influence of dietary total sulfur amino acid and methionine on growth performance and carcass characteristics in finishing gilts. **Journal of Animal Science**, v.76, p.2129-2137, 1998.

MAVROMICHALIS, I.D.; CERA, K.R. Update on ideal amino acid profile for finishing pigs. **Feedstuffs**, v.73, n.26, p.11-13, 2001.

MOURA, J.O.; BRUSTOLINI, P.C.; SILVA, F.C.O. et al. Exigências de aminoácidos sulfurados digestíveis para suínos machos castrados e fêmeas de 15 a 30 kg. **Revista Brasileira de Zootecnia**, v.35, n.3, p.1085-1090, 2006 (supl.)

NATIONAL RESEARCH COUNCIL - NRC. **Nutrient requirements of swine**. 10.ed. Washington, D.C.: National Academic Science, 1998. 189p.

PENA, S.M.; LOPES, D.C.; ROSTAGNO, H.S. et al. Relações metionina mais cistina digestível:lisina digestível em dietas suplementadas com ractopamina para suínos em terminação. **Revista Brasileira de Zootecnia**, v.37, n.11, p.1978-1983, 2008.

PERDOMO, C.C. Conforto ambiental e produtividade de suínos. In: SIMPÓSIO LATINO AMERICANO DE NUTRIÇÃO DE SUÍNOS, 1994, São Paulo. **Anais...** São Paulo: Colégio Brasileiro de Nutrição Animal, 1994. p.19-26.

ROSSONI, M.C.; DONZELE, J.L.; OLIVEIRA, R.F.M. et al. Níveis de treonina digestível para suínos machos castrados, de alto potencial genético para deposição de carne, na fase de terminação. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.60, n.4, p. 884-889, 2008.

ROSTAGNO, H.S.; ALBINO, L.F.T.; DONZELE, J.L. et al. **Composição de alimentos e exigências nutricionais de aves e suínos**: Tabelas Brasileiras. Viçosa, MG: UFV, 2000. 141p.

ROSTAGNO, H.S.; ALBINO, L.F.T.; DONZELE, J.L. et al. **Tabelas brasileiras para aves e suínos**: composição de alimentos e exigências nutricionais. 2.ed. Viçosa, MG: UFV, Imprensa Universitária, 2005. 186p.

SANTOS, F.A.; DONZELE, J.L.; OLIVEIRA, R.F.M. et al. Exigência de metionina + cistina digestíveis em suínos machos castrados de alto potencial genético na fase dos 60 aos 95 kg. **Revista Brasileira de Zootecnia**, v.36, p.2047-2053, 2007.

THONG, H.T. Amino acid requirement of growing pigs depending on amino acid efficiency and level of protein deposition 1st communication: lysine. **Archives of Animal Nutrition**, v.58, Issue 1, p.69-87, 2004.

THONG, H.T.; LIEBERT, F. Potencial for protein and threonine requeriment of modern genotype barrows fed graded levels of protein with threonine as the limiting amino acid. **Journal Animal Physiologic Nutrition**, v.88, p.196-203, 2004.

UNIVERSIDADE FEDERAL DE VIÇOSA - UFV. **SAEG - Sistemas de Análises Estatísticas e Genéticas**. Versão 9.0. Viçosa, MG: 2000. 301p.

XUE, J.L.; DIAL, G.D.; PETTIGREW, J.E. Performance, carcass, and meat quality advantages of boars over barrow: a literature review. **Swine Health and Production**, v.5, p.21-28, 1997.