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Reduction in the protein level and addition of oil in diets for finishing pugs under different temperatures[1]

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ABSTRACT - The objective of this study was to evaluate the effect of reducing the crude protein (CP) with the use of amino acids in diets with the same amount of calories anddifferent levels of soybean oil (SO) for finishing pigs kept in two different ambient temperatures. A total of 120 barrows (initial weight of 68.0±1.9 kg) were utilized for the experiment. The design was of randomized blocks in a 2 × 3 × 2 factorial arrangement (two levels of CP, 16.2 and 13.7%; three levels of SO, 1.5; 3.0 and 4.5%; and two ambient temperatures, 19 and 31 °C), totaling twelve treatments with five replicates for thirty days. The heat reduced feed intake (FI) of the animals, regardless of the levels of CP and SO used, and reduced weight gain (WG) in diets with reduced CP and SO or higher SO. The increased level of CP and SO improved feed conversion (FC) when the animals were kept in thermoneutral environment and given a diet with higher protein content. The reduction in CP increased FI only in the thermoneutral environment. In the heat, WG increased in diets with higher levels of SO, without influencing FC. The manipulation of diet and temperature did not affect most carcass traits. The SO reduced backfat thickness (BT) only in diets with high CP and animals kept in thermoneutral environment. The reduction of CP increased the BT only in diets with high content of SO, both in hot and thermoneutral environments. Heat reduces FI and the inclusion of SO does not improve performance or carcass characteristics in these conditions. The reduction in CP improves WG only in diets with high oil content; however, it increases BT. In thermoneutral environment, increasing the SO is beneficial for performance and carcass characteristics, except when diets with reduced CP are used. The reduction in CP improves performance only in diets with low oil content.

Key Words: carcass, nutrition, performance, temperature

Introduction

In tropical countries, one of the challenges of production is the high temperature and humidity inside the facilities, which limit well-being and high productivity. Within the wide range of ambient temperature, there is a range in which the body temperature remains constant with minimal effort of thermoregulatory mechanisms, in which there is no sensation of cold or heat for the animals, called "Thermal Comfort Zone" or "Thermoneutral Zone."

When the environmental temperature rises above the upper limit of the Comfort Zone, the thermoregulatory system is activated to maintain thermal equilibrium between the animal and the environment, which represents an extra effort and, consequently, changes in productivity.

Pigs kept in thermo neutral environments tend to express their maximum genetic potential. However, when exposed to heat stress, feed intake, and consequently weight gain and feed efficiency are reduced. The composition and carcass characteristics may also be altered in an attempt to modify the heat load from digestive and metabolic processes.

Pigs living in hot environments present greater body length. According to Noblet et al. (2001), this represents the adjustment mechanisms that facilitate the heat dissipation through increased body surface area.

Levels of dietary protein, as well as temperature, have been associated with changes in deposition of fat and protein in pig carcass. The use of synthetic amino acids and the addition of oil in the diet formulation also constitute a nutritional alternative used to improve the productivity of pigs housed in high temperature environments, since they result in a smaller increase in calories. This indicates that modulation of the nutritional components of the diet can be

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a factor that interferes with the performance of pigs when subjected to high temperatures.

The objective of this study was to evaluate the effect of diets with reduced levels of crude protein supplemented with synthetic amino acids, and the addition of oil, on the performance and carcass characteristics of finishing barrows maintained in different ambient temperatures (19 and 31 ºC).

Material and Methods

The experiment was conducted at the Experimental Unit of Pig Metabolism, Department of Animal Science, Universidade Federal de Lavras, between the months of April and November 2010, in Lavras, Minas Gerais, Brazil.

A total of 120 barrows from a commercial strain selected for high lean gain, in the finishing phase, with initial weight of 68.0±1.96 kg and final weight of 95.4±3.60 kg were utilized in this experiment. In order for animals to adapt the to the environment, the experiment was preceded by a preparatory period of five days. Animals were housed in groups of two, in separate pens with bars, with concrete floor and equipped with semi-automatic feeders and adjustable nipple drinkers, located in two air-conditioned rooms, equipped with light bulbs, heaters, fans, humidifiers and dehumidifiers, connected to an automatic control panel located on the outside of the room.

In the environments of high temperature and thermal comfort, the control system was set to maintain the internal temperature of the room at 31 and 19 ºC, respectively. Temperature and relative humidity inside the rooms were monitored three times a day (8:00 a.m., 01:00 p.m. and 06:00 p.m.) throughout the experimental period by means of maximum and minimum thermometer, thermometer of dry bulb and wet bulb and black globe thermometer, kept in the center of the room at half the maximum height of the animal body. The values recorded were then used to calculate the index of black globe temperature and humidity (BGTHI), according to Buffington et al. (1981), characterizing the thermal environment in which the animals were maintained.

An experimental design in blocks was used (initial weight) in a 2 × 3 × 2 factorial arrangement (two levels of protein - 13.7 and 16.2%; three levels of oil - 1.5, 3.0 and 4.5%; and two ambient temperatures - 19 and 31 ºC), totaling 12 treatments. For the variables of performance, the plot was constituted by the pen with two animals, and for the variables of the carcass, by one animal. The experiment lasted 30 days.

Diets and water were provided to the animals *ad libitum*. The daily given feed and leftovers were weighed to determine the consumption by pigs per pen. Animals were weighed at the beginning and end of the experiment to determine weight gain and feed conversion.

At the end of the experimental period, animals were fasted (12 hours); one animal per pen was killed by bleeding after electrical stunning. For slaughter, the animal selected was the one showing closer weight to the average in the stall. Later, scalding, depilation, cleaning and gutting were performed.

At the end of the slaughter line, the carcasses were weighed to determine the hot carcass yield. Carcasses were split longitudinally in halves, weighed and then cooled at 1 °C for 24 hours. After this time, the half left carcasses were weighed and then cut at the last rib for exposing the *longissimus dorsi* muscle and fat to determine loin depth (LD) and backfat thickness (BT), with the aid of a caliper. The yield of chilled carcass (CC), carcass length (CL), ham yield (HY) and loin eye area (LEA) were also evaluated, in accordance with the rules of Associação Brasileira de Criadores de Suínos (ABCS, 1973). The yield of chilled carcass meat (YCCM) was estimated by analysis of prediction, using the formula proposed by Guidoni (2000):

$$YCCM = 65.92 - (0.685 \times BT) + (0.094 \times LD) - (0.026 \times HCW)$$

In which HCW = hot carcass weight.

Measurements of loin depth and backfat thickness were taken on the day of the cold carcass weighing. Afterwards, the loin eye area (LEA) and fat area (FA) were calculated. The meat:fat ratio was determined using LEA:FA, according to Bridi & Silva (2007).

The experimental diets had the same amount of calories and were formulated based on corn and soybean meal supplemented with vitamins, minerals and amino acids (Table 1). The minimum recommendations were met according to the strain.

The data were subjected to analysis of variance after testing for normality (Shapiro Wilk), and the means were obtained with the type of environment, protein levels were compared by F test and oil levels, by regression analysis. In the case of quadratic regression, the Student Newman Keuls test at 5% was used. For the backfat thickness variables, lean:fat ratio and loss by cooling, the square root of the data was used as a processing option. All statistical analyses were performed using the statistical software SISVAR (Sistema de Análise de Variância, version 4.0).

Results and Discussion

In the thermoneutral environment, ambient temperature and BGTHI were 19.5±0.4 and 69.5±0.8 ºC, respectively, similar to the thermal comfort conditions for finishing pigs established by Kiefer et al. (2010).

In the heat stress environment, the average air temperature was 31.8±2.0 °C, and black globe temperature was 32.2±2.2 °C. The BGT was calculated at 82.7±2.8, similar to that observed by Orlando et al. (2007) for pigs kept under high environmental temperatures.

There was interaction (P<0.05) between the levels of protein, oil and ambient temperature in all performance variables analyzed (Table 2). The reduction of crude protein in the diet increased (P<0.05) the consumption for all animals kept in thermoneutral environment, while in animals kept in hot environment, the same result was observed only in those fed higher level of oil (4.5%) in the diet. This result may be related to a greater caloric increase in diets with greater protein or to the deficiency of non-essential amino acids in diets with reduced crude protein, although the reduction of this nutrient in four percentage units with the inclusion of amino acids did not affect intake in most studies found in the literature (Zangeronimo et al., 2006).

The hot environment, in general, reduced consumption (P<0.05) in approximately 10% over the thermoneutral environment, which can be explained by the need to reduce the heat associated with the body ingestion, digestion, absorption and metabolism of nutrients (Forbes, 1995). Similar results were found by Manno et al. (2006) and Kiefer et al. (2010). According to Kipper et al. (2009), from 25 °C, for each increase of 1 °C at ambient temperature, there is a reduction of 53 g daily feed intake. In this study, the temperature increase from 19.5 to 31.8 °C reduced intake in approximately 280 g, equivalent to 23 g for each °C.

Table 1 - Proximate composition and calculated values of the experimental diets

Ingredients	Experimental diets					
Corn	61.00	61.00	61.00	64.20	64.20	64.20
Soybean meal	25.00	25.00	25.00	19.00	19.00	19.00
Cassava starch	8.53	5.00	1.45	10.87	7.34	3.80
Soybean oil	1.5	3.0	4.5	1.5	3.0	4.5
Dicalcium phosphate	1.34	1.34	1.34	1.34	1.34	1.34
Limestone	0.63	0.63	0.63	0.63	0.63	0.63
Iodized salt	0.41	0.41	0.41	0.41	0.41	0.41
Mineral premix[1]	0.10	0.10	0.10	0.10	0.10	0.10
Vitaminic premix[2]	0.10	0.10	0.10	0.10	0.10	0.10
DL-methionine 99%	0.02	0.02	0.02	0.05	0.05	0.05
L-lysine 78%	0.00	0.00	0.00	0.18	0.18	0.18
L-threonine 98%	0.02	0.02	0.02	0.12	0.12	0.12
L-tryptophan 98%	0.00	0.00	0.00	0.02	0.02	0.02
Tylan[3]	0.02	0.02	0.02	0.02	0.02	0.02
Kaolin	1.31	3.34	5.39	1.26	3.29	5.33
Potassium carbonate	0.00	0.00	0.00	0.18	0.18	0.18
BHT-antioxidant	0.02	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100	100
Calculated nutritional level						
Metabolizable energy(kcal/kg)	3250	3252	3253	3256	3257	3259
Crude protein (%)	16.2	16.2	16.2	13.7	13.7	13.7
Calcium (%)	0.65	0.65	0.65	0.64	0.64	0.64
Available phosphorus (%)	0.34	0.34	0.34	0.33	0.33	0.33
Sodium (%)	0.18	0.18	0.18	0.18	0.18	0.18
Digestible lysine (%)	0.75	0.75	0.75	0.75	0.75	0.75
Digestible methionine (%)	0.26	0.26	0.26	0.26	0.26	0.26
Digestible threonine (%)	0.57	0.57	0.57	0.58	0.58	0.58
Digestible tryptophan (%)	0.18	0.18	0.18	0.17	0.17	0.17
Electrolytic balance (mEq/g)[4]	158	158	158	158	158	158

[1] Mineral supplement containing, per kg of product: selenium - 500 mg; iron - 70.000 mg; copper - 20 000 mg; manganese - 40 000 mg; zinc - 80 000 mg; iodine - 800 mg; cobalt - 500 mg.
[2] Vitamin supplementation per kg product containing: vitamin A - 8 million IU; vitamin D3 - 1.2 million IU; vitamin E - 20,000 mg; vitamin K3 - 2500 mg; vitamin B1, 1000 mg; riboflavin (B2) - 4,000 mg; pyridoxine (B6) - 2000 mg; vitamin B 12 - 20 000 mcg; niacin - 25 000 mg; pantothenic acid - 10 000 mg; folic acid - 600 mg; biotin - 50 mg; vitamin C - 50 000 mg; antioxidant - 125 mg.
[3] Tylan antibiotic G-250 containing, per kg of product: tylosin - 100 g; sulfamethazine - 100 g; excipient q.s. - 1000 g.
[4] Calculated according to Mongin (1980).

Table 2 - Performance of finishing pigs kept under thermoneutral and hot environments, fed diets containing different levels of crude protein and oil

Environment	Protein (%)	Oil (%)			Mean
		1.5	3.0	4.5	
Mean daily feed intake (kg/day)*					
Thermoneutral*	13.7	2.890	2.782	2.874	2.849a
	16.2	2.760	2.690	2.771	2.740b
	Mean	2.825	2.736	2.822	
Hot	13.7	2.495	2.582	2.594a	2.557
	16.2	2.453	2.600	2.362b	2.472
	Mean	2.474	2.591	2.478	
	CV (%)	6.86			
Mean daily weight gain (kg/day)					
Thermoneutral	13.7	0.982a*	0.973	0.981	0.979
	16.2[1]	0.847b	0.898	0.970	0.905
	Mean	0.915	0.935	0.975*	
Hot	13.7	0.864	0.932	0.945a	0.914
	16.2	0.833	0.911	0.838b	0.861
	Mean	0.849	0.922	0.892	
	CV%	7.49			
Feed conversion					
Thermoneutral	13.7	2.97a	2.87	2.94	2.93
	16.2[1]	3.26b*	3.01	2.87	3.05
	Mean	3.11	2.94	2.91	
Hot	13.7	2.89	2.77	2.75	2.81
	16.2	2.94	2.86	2.82	2.87
	Mean	2.92	2.82	2.79	
	CV (%)	6.97			

Means differ by the F test (P<0.05).
* Differs in relation to heat by the F test (P<0.01).
[1] Significant linear regression (P<0.05).

In relation to the average daily weight gain, the ambient temperature reduced its value (P<0.05) only in animals that received the lowest levels of crude protein and oil in the diets and also in those which received the greatest level of oil, regardless of the level of crude protein in the diet. This result may be related to the lower caloric increment generated for diets with low nutrient content (low protein or oil) and the input of oil in the digestibility of the proteins, in which, according to Almeida et al. (2007), there is a positive correlation between these nutrients. In this case, it is the higher heat release brought about by this increase in digestibility for having influenced weight gain in animals maintained in a hot environment.

The oil level increased (P<0.05) weight gain of animals kept in thermoneutral environment linearly only when the diets used did not have reduced crude protein. However, this effect is not observed in animals under a hot environment.

This result is according to Wolp (2010), who observed that pigs kept in thermoneutral environment (24 °C) fed diets with 4.5% oil showed greater weight gain when compared with the use of diets with 1.5% oil. According to Almeida et al. (2007), the inclusion of oil in the diet increases the availability of amino acids from the crude protein diets. In the case of low crude protein diets, as in this experiment, this effect is not reflected in the weight gain increase. Moreover, in the warm environment, the reduction in intake might also have influenced these results.

In the thermoneutral environment, it was observed that the decrease in crude protein in the diet increased (P<0.05) the weight gain of animals only when diets with low oil content (1.5%) were used. Similar result was observed by Ferreira et al. (2005), working with growing barrows fed diets with 1% oil. Moreover, Orlando et al. (2006), working with diets containing oil levels ranging from 2.7 to 7.6% and Vidal et al. (2010) with 0.26% oil in the diet, did not observe any influence of dietary crude protein levels on the weight gain of animals, similar to the results obtained in this study.

On the other hand, under heat, reducing crude protein enhanced (P<0.05) weight gain when the animals were fed diets with the highest level of oil. In this case, the higher consumption in the diets with 13.7% crude protein and 4.5% oil for animals in the heat may have influenced these results.

Feed conversion was not affected (P>0.05), in general, by temperature; however, the levels of crude protein and oil acted differently in each environment. In the thermoneutral environment, a linear effect (y = 3.0799 to 0.0556 x) of the oil levels was observed in animals fed diets containing 16.2% crude protein, but this was not observed in diets with reduced crude protein or animals kept in a warm environment. This result in a thermoneutral environment can also be related to the oil extra caloric effect influencing the digestibility of dietary protein and the better utilization of amino acids. In the case of diets with reduced crude protein, this effect cannot be shown due to a greater amount of free amino acids and a lower protein diet, while in the warm environment, the lower feed intake may have limited this effect.

Spencer et al. (2005) found improvement in feed conversion of animals kept in the heat when receiving diets with 8% of soybean oil. According to the authors, this is due to the lowest caloric increment generated by the oil in the diets. This result could not be observed in this study due to the lower level of this ingredient used in the experimental diets.

It was also observed that animals kept in thermoneutral environment and which received higher levels of crude protein and 1.5% oil had a poorer feed conversion than those kept in a hot environment. This is due to higher feed intake and lower weight gain in animals maintained under comfortable environment. Manno et al. (2006) also verified that pigs that received 0.8% of soybean oil in the diet, kept in a hot environment, showed better feed efficiency than those kept in thermal comfort.

The reduction in crude protein from 16.2 to 13.7% with the addition of crystalline amino acids improved (P<0.05) feed conversion in diets containing low levels of oil in the thermoneutral environment, but there was no influence (P>0.05) when this ingredient was increased. This result may be related to reduction of caloric increment promoted by increase in the oil content or reduction of crude protein. The same effect cannot be observed in the warm environment. In this case, the lower intake promoted by the heat, regardless of the diet, can reduce the quantity of heat generated during the digestion process by itself.

Vidal et al. (2010) found a quadratic effect of levels of crude protein on the feed conversion of finishing pigs fed 0.26% soybean oil. Moreover, Ferreira et al. (2005) found no difference in feed conversion by reducing the dietary protein from 17 to 13% in 1.0% of soybean oil to growing crossbred pigs. This result can, however, be related to the age and genetics of the animals used.

With respect to carcass traits, there was interaction (P<0.05) between protein, oil and ambient temperature only in backfat thickness (Table 3). There was no effect (P>0.05) of these variables in the carcass yield, loin eye area, carcass meat yield and meat:fat ratio. Ambient temperature influenced only (P<0.05) loss by cooling.

Orlando et al. (2007) and Trindade Neto et al. (2008) found no effect of reduced crude protein on carcass characteristics of finishing pigs kept under heat stress and/or thermoneutral environment, respectively. Moreover, Kerr et al. (1995) and Tuitoek et al. (1997) reported that reducing the level of crude protein in the diet increased the amount of energy available for tissue deposition and favored the production of fatter carcasses at slaughter. In the present study, effect of crude protein only occurred (P<0.05) in diets with 4.5% oil, regardless of the temperature. These results were similar to Spencer et al. (2005), who observed higher fat thickness in animals fed diets containing lower crude protein and higher inclusion level of soybean oil. These results may be related to the higher value of net energy provided by low crude protein diets containing amino acid addition, coupled with the effect of extra caloric oil.

Table 3 - Carcass traits of finishing pigs kept under thermoneutral and hot environments, fed diets containing different levels of crude protein and oil

Environment	Protein (%)	Oil (%) 1.5	3.0	4.5	Mean
		Carcass yield (%)*			
Thermoneutral	13.7	80.3	80.8	79.6	80.2
	16.2	79.7	79.0	79.6	79.4
	Mean	80.0	79.9	79.6	
Hot	13.7	80.5	80.2	80.4	80.4
	16.2	80.3	79.6	80.0	80.0
	Mean	80.4	79.9	80.2	
	CV (%)	1.37			
		Backfat thickness at point P2 (mm)			
Thermoneutral	13.7	15.5	13.9	18.2a	15.9
	16.2[1]	17.5	15.3	13.4b	15.4
	Mean	16.5	14.6	15.8	
Hot	13.7	14.4	13.9	16.0a	14.8
	16.2	14.2	14.5	13.6b	14.1
	Mean	14.3	14.2	14.8	
	CV (%)	10.22			
		Loin eye area (cm^2)*			
Thermoneutral	13.7	56.7	64.1	55.9	58.9
	16.2	57.0	56.2	59.2	57.5
	Mean	56.9	60.2	57.6	
Hot	13.7	58.3	59.1	57.1	58.2
	16.2	58.9	57.2	57.2	57.8
	Mean	58.6	58.1	57.2	
	CV (%)	10.42			
		Carcass meat yield (%)*			
Thermoneutral	13.7	59.7	61.1	57.7	59.5
	16.2	58.3	59.8	61.0	59.7
	Mean	59.0	60.5	59.3	
Hot	13.7	60.6	61.0	59.6	60.4
	16.2	60.7	60.4	61.4	60.8
	Mean	60.7	60.7	60.5	
	CV (%)	3.95			
		Meat:fat ratio*			
Thermoneutral	13.7	3.01	3.22	2.85	3.03
	16.2	2.84	3.13	3.08	3.02
	Mean	2.93	3.18	2.97	
Hot	13.7	3.09	3.12	3.02	3.08
	16.2	3.18	2.85	3.21	3.08
	Mean	3.14	2.99	3.12	
	CV (%)	12.54			
		Loss by cooling (%)			
Thermoneutral[2]	13.7	2.86	3.04	2.73	2.88
	16.2	2.94	3.03	2.68	2.88
	Mean	2.90	3.03	2.71	
Hot	13.7	2.29	2.19	2.42	2.30
	16.2	2.14	2.18	1.94	2.09
	Mean	2.22	2.19	2.18	
	CV (%)	16.63			

Means differ by the F test (P<0.05).
[1] Significant linear regression (P<0.05).
[2] Differs in relation to heat by the F test (P<0.05).
* No significant difference by the F test (P>0.05).

According to Le Bellego et al. (2002), decrease in protein with amino acid supplementation increases body fat due to lower energy expenditure for the metabolism of these amino acids (lower calorific increase) and, consequently, increased release of available net energy which is deposited in the form of fat. Another likely explanation is related to the protein synthesis, once, in certain situations in which there is a reduction in the protein level of the diet, other amino acids such as isoleucine and valine can become limiting (Figueroa et al., 2002) and thus limit protein synthesis and direct nutrients to the synthesis of lipids.

The inclusion of oil in diets containing 16.2% crude protein decreased backfat thickness linearly (P<0.05). This result may be related to improvement in the digestibility of crude protein, releasing more amino acids for protein deposition at the expense of fat (Albin et al., 2001). In the case of hot environment, the lower intake made possible by these conditions might have attenuated this effect.

In the present study, the hot environment generating carcasses with less loss by cooling, regardless of the levels of protein and oil studied, was observed. These results were similar to Lebret et al. (2006), who found lower losses by cooling the carcass of pigs kept under environmental stress. This result suggests that pigs exposed to heat stress for a long time may show changes of carcass traits. Even so, the percentage of loss by cooling is within the normal range, which is 1.8 to 3.5% (Ashrae, 2001).

Conclusions

In thermoneutral environment, the inclusion of soybean oil at 4.5% in diets with the same amount of energy for finishing pigs is viable, except when diets with reduced crude protein supplemented with amino acids are used. On the other hand, reduction in crude protein shows positive results only in diets with low oil content. The hot environment is detrimental to performance and the inclusion of oil at 4.5% does not mitigate this problem.

The reduction of crude protein shows positive results only in diets containing high oil content, although it increases the backfat thickness. The use of modified diets in both thermoneutral and heat does not affect other quantitative carcass traits of barrows from 70 to 100 kg.

References

ALBIN, D.M.; SMIRICKY, M.R.; WUBBEN, J.E. et al. The effect of dietary level of soybean oil and palm oil on apparent ileal amino acid digestibility and postprandial flow patterns of chromic oxide and amino acids in swines. **Canadian Journal of Animal Science**, v.81, p.495-503, 2001.

ALMEIDA, E.C.; FIALHO, E.T.; CANTARELLI, V.S. et al. Digestibilidade ileal e perdas endogenas de aminoacidos de dietas com óleo de soja para suínos em crescimento. **Revista Brasileira de Zootecnia**, v.36, p.1045-1051, 2007.

ASHRAE. Thermal comfort. In: **Fundamentals**. Chapter 8. Atlanta, 2001. 400p.

ASSOCIAÇÃO BRASILEIRA DE CRIADORES DE SUÍNOS - ABCS. **Método brasileiro de classificação de carcaça**. 2.ed. Rio Grande do Sul: Estrela, ABCS, 1973. 17p.

BRIDI, A.M.; SILVA, C.A. **Métodos de avaliação da carcaça e da carne suína**. Londrina: Midiograf, 2007. 97p.

BUFFINGTON, D.E.; COLLASSO-AROCHO, A.; CANTON, G.H. et al. Black globe-humidity index (BGHI) as comfort equation for dairy cows. **Transactions of the ASAE**, v.24, p.711-714, 1981.

FERREIRA, R.A.; OLIVEIRA, R.F.M.; DONZELE, J.L. et al. Redução do nível de proteína bruta e suplementação de aminoácidos em rações para suínos machos castrados mantidos em ambiente termoneutro dos 30 aos 60 kg. **Revista Brasileira Zootecnia**, v.34, p.548-556, 2005.

FERREIRA, D.F. SISVAR: um programa para análises e ensino de estatística. **Revista Symposium**, v.6, p.36-41, 2008.

FIGUEROA, J.L.; LEWIS, A.J.; MILLER, P.S. et al. Nitrogen metabolism and growth performance of gilts fed standard corn-soybean meal diets or low-crude protein, amino acid-supplemented diets. **Journal of Animal Science**, v.80, p.2911-2919, 2002.

FORBES, J.M. **Voluntary food intake and diet selection in farm animals**. Cambridge, USA: CAB International, 1995. 531p.

GUIDONI, A.L. Melhoria de processos para tipificação e valorização de carcaças suínas no Brasil. In: CONFERÊNCIA INTERNACIONAL VIRTUAL SOBRE QUALIDADE DE CARNE SUÍNA, 2000, Concórdia. **Anais...** Concórdia: Embrapa Suínos e Aves, 2000. 14p.

KERR, B.J.; McKEITH, F.K.; EASTER, R.A. Effect on performance and carcass characteristics of nursery to finisher swines fed reduced crude protein, amino acid-supplemented diets. **Journal of Animal Science**, v.73, p.433-440, 1995.

KIEFER, C.; MOURA, M.S.; SILVA, E.A. et al. Respostas de suínos em terminação mantidos em diferentes ambientes térmicos. **Revista Brasileira de Saúde Produção Animal**, v.11, p.496-504, 2010.

KIPPER, M.S.; LOVATTO, P.A.; ANDRETTA, I. et al. Relação do estresse ambiental por calor com desempenho em suínos: uma meta-análise. In: SEMINÁRIO DE SISTEMAS DE PRODUÇÃO AGROPECUÁRIA, 3., 2009, Dois Vizinhos. **Anais...** Dois Vizinhos: UTPR, 2009. (CD-ROM).

LE BELLEGO, L.; van MILGEN, J.; NOBLET, J. Effect of high temperature and low-protein on the performance of growing-finishing swines. **Journal of Animal Science**, v.80, p.691-701, 2002.

LEBRET, B.; MEUNIER-SALAÜN, M.C.; FOURY, A. et al. Influence of rearing conditions on performance, behavioral, and physiological responses of swines to preslaughter handling, carcass traits, and meat quality. **Journal of Animal Science**, v.84, p.2436-2447, 2006.

MANNO, M.C.; OLIVEIRA, R.F.M.; DONZELE, J.L. et al. Efeitos da temperatura ambiente sobre o desempenho de suínos dos 30 aos 60 kg. **Revista Brasileira de Zootecnia**, v.35, p.471-477, 2006.

MONGIN, P. Role of sodium, potassium and chloride in eggshell quality. In: NUTRITION CONFERENCE OF FLORIDA, 1., 1980, Florida. **Proceedings...** Florida: NCF, 1980. p.114-117.

NOBLET, J.; LE BELLEGO, L.; VAN MILGEN, J. et al. Effect of reduction of dietary protein level and fat addition on heat production and energy balance in growing swines. **Animal Research**, v.50, p.227-238, 2001.

ORLANDO, U.A.D.; OLIVEIRA, R.F.M.; DONZELE, J.L. et al. Níveis de proteína bruta e suplementação de aminoácidos em rações para leitoas mantidas em ambiente termoneutro dos 60 aos 100 kg. **Revista Brasileira de Zootecnia**, v.35, p.478-484, 2006.

ORLANDO, U.A.D.; OLIVEIRA, R.F.M.; DONZELE, J.L. et al. Níveis de proteína bruta e suplementação de aminoácidos em dietas para leitoas dos 60 aos 100 kg mantidas em ambiente de alta temperatura. **Revista Brasileira de Zootecnia**, v.36, p.1069-1075, 2007.

SPENCER, J.D.; GAINES, A.M.; BERG, E.P. et al. Diet modifications to improve finishing pig growth performance and pork quality attributes during periods of heat stress. **Journal of Animal Science**, v.83, p.243-254, 2005.

TRINDADE NETO, M.A.; MOREIRA, J.A.; BERTO D.A. et al. Níveis de proteína bruta em dietas comerciais para suínos em crescimento e terminação. **Revista Brasileira de Zootecnia**, v.37, p.103-108, 2008.

TUITOEK, K.; YOUNG, L.G.; DE LANGE, C.F. et al. The effect of reducing excess dietary amino acids on growing-finishing pig performance: an elevation of the ideal protein concept. **Journal of Animal Science**, v.75, p.1575-1583, 1997.

VIDAL, T.Z.B.; FONTES, D.O.; SILVA, F.C.O. et al. Efeito da redução da proteína bruta e da suplementação de aminoácidos para suínos machos castrados, dos 70 aos 100kg. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.62, p.914-920, 2010.

WOLP, R.C. **Suínos em crescimento mantidos em ambiente de alta temperaturas alimentados com dietas contendo diferentes níveis de óleo e proteína bruta**. 2010. 55f. Dissertação (Mestrado em Nutrição Animal) - Universidade Federal de Lavras, Lavras.

ZANGERONIMO, M.G.; FIALHO, E.T.; LIMA, J.A.F. et al. Redução do nível de proteína bruta da ração suplementada com aminoácidos sintéticos para leitões na fase inicial. **Revista Brasileira de Zootecnia**, v.35, p.849-856, 2006.