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Ractopamine and lysine levels on performance and carcass characteristics of finishing pigs

Erin Caperuto de Almeida[1], Elias Tadeu Fialho[2], Paulo Borges Rodrigues[2], Márcio Gilberto Zangeronimo[2], José Augusto de Freitas Lima[2], Dalton de Oliveira Fontes[3]

[1] UFG.
[2] UFLA.
[3] UFMG.

ABSTRACT - It was evaluated the effect of diets supplemented or not supplemented with ractopamine and digestible lysine on the performance and carcass characteristics of finishing pigs. A total of 50 barrows and 50 gilts (90.2 kg ± 3.5 kg) were used. In the growth performance trial, a randomized block design was utilized in a 5 × 2 factorial arrangement, consisting of five levels of digestible lysine (0.68; 0.78; 0.88; 0.98 and 1.08%) and two levels of ractopamine (0 and 5 ppm), totaling ten diets and five replications. In a study of carcass characteristics, the same design and levels of lysine and ractopamine were used, but another factor (sex of animals- female and male) was included, totaling 20 treatments, each one with five replicates. Except for lysine daily intake, it was not observed effect of levels of digestible lysine. The supplementation with ractopamine improved daily weight gain and feed conversion but it did not affect the average feed intake. A greater loin depth and higher yield of carcass meat was obtained in gilts, regardless to supplementation with ractopamine, and also in the males fed ractopamine. The ractopamine improved the rib-eye area but it did not affect the yield and carcass length neither thickness of subcutaneous fat. The levels of digestible lysine did not affect carcass characteristics in either sex. It was found that sex had effect on backfat thickness, which was lower in the carcasses of gilts. The use of 5 ppm ractopamine improves animal performance and carcass characteristics of barrows. The level of 0.68% digestible lysine is sufficient for pigs of both sexes fed diets supplemented with or without ractopamine to show maximal performance and a good carcass composition.

Key Words: additives, amino acid, carcass modifier, nutrition

Ractopamina e níveis de lisina no desempenho e nas características de carcaça de suínos em terminação

RESUMO - Avaliou-se o efeito de rações suplementadas ou não com ractopamina e lisina digestível sobre o desempenho e as características de carcaça de suínos em terminação. Foram utilizados 50 suínos machos castrados e 50 fêmeas (90,2 kg ± 3,5 kg). No ensaio para avaliação do desempenho, adotou-se o delineamento de blocos casualizados em arranjo fatorial 5 × 2, composto de cinco níveis de lisina digestível (0,68, 0,78, 0,88, 0,98, 1,08%) e dois níveis de ractopamina (0 e 5 ppm), totalizando dez dietas e cinco repetições. No estudo das características de carcaça, adotou-se mesmo delineamento, e mesmos níveis de lisina e ractopamina, porém com mais um fator (o sexo dos animais – macho e fêmea), totalizando 20 dietas, cada uma com cinco repetições. Com exceção do consumo diário de lisina, não foi observado efeito dos níveis de lisina digestível. A suplementação com ractopamina melhorou o ganho de peso médio diario e a conversão alimentar, mas não afetou o consumo médio de ração. A maior profundidade de lombo e o maior rendimento de carne na carcaça foram obtidos nas fêmeas, independente da suplementação com ractopamina, e nos machos que receberam ractopamina. A ractopamina melhorou a área de olho-de-lombo, porém não influenciou o rendimento e o comprimento da carcaça nem a espessura de toucinho. Os níveis de lisina digestível não influenciaram as características de carcaça em nenhum dos sexos. O sexo teve efeito na espessura de toucinho, que foi menor nas carcaças de fêmeas. A utilização de 5 ppm de ractopamina melhora o desempenho dos animais e as características de carcaça de suínos machos castrados. O nível de 0,68% de lisina digestível é suficiente para que suínos de ambos os sexos recebendo rações suplementadas ou não com ractopamina expressem máximo desempenho e adequada composição de carcaça.

Palavras-chave: aditivos, aminoácido, modificador de carcaça, nutrição

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Corresponding author: erinalmeida@ig.com.br

Introduction

The use of ractopamine supplementation in diets of finishing pigs is restrained by the amount of protein and amino acids in the diet. According to Xiao et al. (1999), diets supplemented with ractopamine must receive a minimum of 16% CP (crude protein) and 30% more lysine than a typical diet to achieve significant results in performance and carcass quality. Therefore, ractopamine has been included in diets with 16% CP for pigs weighing from 41 to 109 kg (Apple et al., 2004). However, to obtain an ideal response to the use of this nutrient additive splitter, it is also necessary to provide adequate levels of amino acids in the diet to support the greatest weight gain in meat (Silveira, 2007).

Pérez et al. (2006) studied the effect of lysine (0.95, 1.05 and 1.15% total lysine) and ractopamine (0 and 10 ppm) on characteristics of the carcass. The authors found lower backfat thickness on the 10th rib when they used 1.15% total lysine and 10 ppm of ractopamine and observed a synergistic effect.

Marino et al. (2007a) also studied the interaction of two digestible lysine levels (0.67 and 0.87%) and ractopamine (0 and 5 ppm). The authors observed that the effect of ractopamine on loin depth is greater in diets containing 0.87% digestible lysine in barrows of approximately 85 kg that are selected for high lean gain.

Based on these results, levels of lysine can restrict the action of ractopamine, especially in pigs selected for high lean deposition, because the level of lysine is directly responsible for protein synthesis and subsequen deposition of muscle tissue. However, a surplus of lysine may also restrict the benefits provided by β-adrenergic agonists because these amino acids should compete for sites of absorption and catabolism of these amino acids surpluses at the expense of increased protein synthesis.

Thus, the purpose of this study was to investigate the effect of ractopamine, associated with different digestible lysine levels, on performance and carcass characteristics of finishing pigs weighing from 90 to 118 kg.

Material and Methods

The experiment was carried out from February to May 2008 in the Centro Experimental de Suínos do Departamento de Zootecnia, Universidade Federal de Lavras (UFLA), in Lavras, southern region of Minas Gerais. During the experimental period, the average temperature was 21.0°C with recorded minimal and maximal temperatures of 16°C and 26°C, respectively.

The study population consisted of 50 barrows and 50 gilts. They were hybrids (Topp × C-40) selected for high lean gain with initial weight 90.20 kg ± 3.5 kg and final weight 117.80 kg ± 4.1 kg.

In the performance assay, the experimental design was randomized blocks in a 5 × 2 factorial, composed of five levels of digestible lysine (0.68; 0.78; 0.88; 0.98 and 1.08%) and two levels of ractopamine (0 and 5 ppm), totaling ten diets with five replicates of two animals per experimental plot.

In the evaluation of carcass traits, the experimental design was also randomized blocks but an additional factor, the sex of the animal, was included, resulting in a 5 × 2 × 2 factorial composed of five levels of digestible lysine (0.68; 0,78; 0.88; 0.98 and 1.08%), two levels of ractopamine (0 and 5 ppm) and two sexes (male and female), totaling 20 treatments and five replicates of one animal per experimental plot. Initial weight was the criterion used to form the blocks.

The diets were formulated based on corn and soybean meal to meet the minimal requirements suggested by Rostagno et al. (2005) for barrows at 100 to 120 kg with high genetic potential and superior performance, with the exception of crude protein (16% CP), lysine, methionine and threonine. Concentrations of methionine (62%) and threonine (67%) were adjusted to fit the ideal AA profile in relation to lysine (100%). However, in diets with 0.68% digestible lysine, it was not possible to maintain the relationship to fit the ideal profile in relation to lysine because the use of corn and soybean meal provided unnecessary amounts of methionine and threonine (Table 1).

The diets and water were given ad libitum for a period of 28 days. The pens were cleaned every day, and feed was provided twice daily. Food wastes were weighed to determine consumption of each pen.

For the determination of weight gain, pigs were weighed at the beginning and at the end of the experiment. The average feed conversion was obtained using the ratio between feed intake and weight gain during all experimental period.

The variables analyzed for performance were final weight, average daily weight gain, average daily feed intake, feed conversion and intake of lysine.

At the end of the experimental period, animals underwent fasting from solids for a period of 16 hours. After fasting, all animals were weighed and slaughtered.

Following slaughter, evisceration was completed, and the carcasses were sawed in half lengthwise, weighed and then cooled at an average temperature of 4°C for 24 hours.

Table 1 - Composition of the experimental diets given to late finishing pigs, as-fed basis

Ingredient (%)	Lysine Level									
	No ractopamine					With ractopamine				
	0.68	0.78	0.88	0.98	1.08	0.68	0.78	0.88	0.98	1.08
Ground corn	74.38	74.38	74.38	74.38	74.38	74.38	74.38	74.38	74.38	74.38
Soybean meal, 46%	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Soybean oil	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Dicalcium phosphate	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Limestone, ground	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334
Salt	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Trace mineral premix[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Vitamin premix[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Tylan G-250	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
L-lysina HCl (78%)	-	0.124	0.248	0.378	0.501	-	0.124	0.248	0.378	0.501
L-threonine	-	-	0.066	0.130	0.205	-	-	0.066	0.130	0.205
DL-methionine	-	-	0.059	0.121	0.184	-	-	0.059	0.121	0.184
Cloridrate of ractopamine[3] 20%	-	-	-	-	-	0.025	0.025	0.025	0.025	0.025
Caolim	1.426	1.302	1.053	0.797	0.536	1.401	1.277	1.028	0.772	0.511
Calculated composition (%)										
Crude protein	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90	15.90
Metabolizable energy (kcal/kg)	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212	3,212
Digestible lysine (%)	0.68	0.78	0.88	0.98	1.08	0.68	0.78	0.88	0.98	1.08
Digestible met + cys (%)	0.484	0.484	0.546	0.608	0.670	0.484	0.484	0.546	0.608	0.670
Dig.stible threonine (%)	0.523	0.523	0.590	0.657	0.724	0.523	0.523	0.590	0.657	0.724
Available phosphorus (%)	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Calcium (%)	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453

[1] Provided per kilogram of diet: vitamin A - 2,638 IU; vitamin D_3 - 315 IU; vitamin E - 26.4 IU; menadione - 1.20 mg; vitamin B_{12} - 21 µg; riboflavin - 4.26 mg; pantothenic acid - 13.20 mg; and niacin - 19.80 mg. Antioxidant 1.500 mg.
[2] Provided per kilogram of diet: Fe - 26.25 mg; Zn - 78.0 mg; Mn - 41.85 mg; Cu - 15.75 mg; I - 0.37 mg; and Se - 0.30 mg.
[3] Cloridrate of Ractopamine was added at the expense of caolim to make diets with 5 mg/kg ractopamine.

After 24 hours of cooling, the left half of the carcass of each animal was sectioned at the last rib to measure the *longissimus* muscle area. All measurements were made in accordance with the standards of the Associação Brasileira dos Criadores de Suínos (ABCS, 1986).

In the study of carcass traits, income, length, *longissimus* muscle area, loin depth, backfat thickness and the estimated yield of carcass meat were evaluated as determined by analysis of prediction according to the formula described by Guidoni (2000):
RCCR=65.92-(0.685×ET)+(0.094×PL)-(0.026×HCW), in which RCCR = meat yield chilled carcass yield (%), ET = backfat thickness, PL = loin depth and HCW = hot carcass weight.

Data of the diets were subjected to analysis of variance using the computer program SISVAR developed by Ferreira (2000). When interaction among factors was not observed, polynomial regression for the levels of digestible lysine and F tests for levels of ractopamine and sex was applied.

Results and Discussion

There was no interaction between ractopamine and digestible lysine levels for the studied variables (P>0.05), which is in agreement with the results obtained by Marino et al. (2007a), who studied two levels of lysine (0.67 and 0.87%) and ractopamine (0 and 5 ppm) for barrows from 85 kg to 120 kg (Table 2).

The highest average daily weight gain and better feed conversion (P< 0.05) was observed in animals that were fed ractopamine. The increase in average daily weight gain was 6.6% for animals that consumed ractopamine, which is a result similar to that reported by Amaral et al. (2009), in which ractopamine improved 8.4% with this variable. Carr et al. (2005a) and Marino et al. (2007b) also demonstrated a positive effect on average daily weight gain with ractopamine in diets for finishing pigs.

However, in other studies, Pozza et al. (2003), Carr et al. (2005b) and Marino et al. (2007a) observed no effect of ractopamine on this variable. This divergence of results may be explained by the interaction among ractopamine, genotype and nutritional management (Dunshea et al., 1993).

The average daily feed intake was not affected (P>0.05) with the use of ractopamine. Similar results also occurred in studies by Marino et al. (2007a, b), Amaral et al. (2009) and Kiefer & Sanches (2009). According to these authors, supplementation in finishing pig diets with ractopamine improves weight gain and efficiency of lean meat without changing the daily diet. However, these results differ from

Table 2 - Main effect means for growth performance variables, measured at 28 days of fed either ractopamine - with supplemented or no-supplemented diets, and the effects of digestible lysine level in finishing pigs

Ractopamine	Digestible lysine level (%)					Means[2]
	0.68	0.78	0.88	0.98	1.08	
			Average daily gain (kg/day)			
With	1.14	1.09	0.98	1.08	1.01	1.06a
Without	0.96	0.94	1.07	0.97	0.98	0.99b
Mean	1.05	1.02	1.03	1.02	0.99	1.02
CV Without	11.93					
			Average daily feed intake (kg/day)			
With	3.47	3.29	2.94	3.24	3.09	3.21
Without	3.39	3.24	3.21	3.25	3.24	3.26
Mean	3.43	3.27	3.08	3.25	3.17	3.24
CV (%)	9.55					
			Feed conversion			
With	3.05	3.03	3.04	3.02	3.09	3.04b
Without	3.45	3.43	3.24	3.41	3.44	3.39a
Mean	3.25	3.23	3.14	3.21	3.27	3.22
CV (%)	10.04					
			Daily feed intake (g/day)			
With	23.60	25.68	25.92	31.74	33.37	28.06
Without	22.48	24.85	30.51	32.03	36.55	29.28
Mean	23.04	25.26	28.21	31.89	34.97	28.67
CV (%)	10.01					

[1] Linear effect (P<0.05).
[2] Within treatment coluns, means with different lower case letters differ (P<0.05) by F test.

those observed by Yen et al. (1990) and Carr et al. (2005b), who found reduction of the average daily feed intake of about 10%.

However, the daily feed intake improved by 10% with ractopamine added to the diet of pigs. Similar results were found by Carr et al. (2005a), Marino et al. (2007a, b) and Amaral et al. (2009). Based on these results, we can infer that pigs fed diets supplemented with ractopamine have more efficient use of feed per unit weight gain than pigs that are fed diets without supplementation.

According to Kessler (2001), the type of feed is highly correlated with variables representing the gain of lean tissue and, therefore, it persists as a performance measure and it is used as benchmark to evaluate the efficiency of production systems for pigs.

Overall, the improved feed indicates a change in metabolism induced by ractopamine with a possible change in the composition of the weight gain increasing the deposition of muscle tissue and, because of the partition of nutrients, reducing fat deposition (Schinkel et al., 2003). This change improves the efficiency of the weight gain from the feed because the synthesis of lean tissue requires less energy than fat (Zagury et al., 2002).

The levels of digestible lysine in the diet of finishing pigs did not have an influence (P>0.05) on performance. The results of average daily weight gain were similar to those obtained by Oliveira et al. (2003a,b) who observed pigs of 110 to 125 kg and 95 to 110 kg. However, the results differ from those reported by Abreu et al. (2007), who observed a quadratic effect of diets on average daily weight gain, where the maximal response was obtained with 0.87% lysine and 3,250 kcal/kg, which corresponded to a daily intake of 24.67 g/day.

Several authors, such as Arouca et al. (2005) and Abreu et al. (2007), also found no significant variation in the feed intake of pigs due to levels of lysine, indicating that the deficiency or excess of amino acid in the diet does not influence feed intake of pigs.

However, Chen et al. (1999) and Oliveira et al. (2003b) reported a reduction in feed intake due to increased levels of lysine in the diet for pigs in the finishing phase up to 120 kg. According to Henry (1985) and D'Mello (1993), the amino acid imbalance results in a characteristic reduction in feed intake as one of the symptoms. In this study, the imbalance of amino acids was prevented by supplementation with synthetic amino acids (DL-methionine and L-threonine) to the extent that the levels of lysine were increased to maintain the relationship between amino acids and lysine in the diet.

Similarly, for the variable feed, Moreira et al. (2002) also found no effect of lysine level on feed intake. Contrasting with the results observed in this study, several authors (Cline et al. 2000; Fabian et al., 2001) found a positive effect of lysine levels on the efficiency of feed utilization for weight gain in pigs in the finishing phase with final weights above 100 kg.

There was an effect of different levels of lysine (P< 0.05) on the intake of lysine, which increased linearly. The increase between the lowest and highest levels of lysine used in this experiment was 34.11%. Since the average daily consumption of the diet was not influenced by the levels of lysine, the increase in the consumption of lysine was occasioned by the level of dietary lysine. Because there was no difference in the performance, the level of 0.68% digestible lysine (23.04 g/day) was sufficient to meet the requirements of finishing pigs from 90 to 118 kg whether or not the diet was supplemented with ractopamine.

There was no effect of ractopamine (P>0.05) on the yield, carcass length or the thickness of subcutaneous fat (Table 3). In agreement with this work, several authors observed that ractopamine did not affect yield (Marino et al., 2007a, b; Amaral et a., 2009), carcass length (Carr et al., 2005a, b) or backfat thickness (Weber et al., 2006; Marino et al., 2007a). However, reductions in backfat thickness with the supplementation of ractopamine in the diet were observed by Marino et al. (2007b) and Amaral et al. (2009).

An increase was observed (P<0.05) from 4.25% in the *longissimus* muscle area when the additive β-adrenergic receptor was used. Weber et al. (2006) and Amaral et al. (2009) also observed this increase, but on the orders of 11.18% and 21.4%, respectively.

There was an interaction between the levels of ractopamine and the sex of the animals for the variable depth of loin and meat yield in carcass of finishing pigs (P<0.05). The greater loin depth and better carcass meat yield was obtained in the carcasses of females that were fed diets supplemented with or without ractopamine and steers receiving ractopamine (Table 4). These results demonstrate greater efficiency in the use of ractopamine in castrated males compared to females. These pigs tend to deposit fat earlier, and the function of â-adrenergic agonists in reducing lipogenesis and increasing protein synthesis becomes more evident.

Marino et al. (2007b) observed a 6.5% increase in loin depth and a 1.71% increase in carcass meat yield, while Zagury (2002) reported minor increases in pigs that were fed diets containing 5 ppm of ractopamine. These results show the efficiency of ractopamine as a divider of nutrients at increasing the rate of protein deposition by promoting an increase in the loin eye area, loin depth and yield of carcass meat, especially in barrows.

When evaluating the effects of ractopamine on carcass characteristics of pigs, other authors found no effect on the longissimus muscle area (Mimbs et al., 2005), loin depth (Marino et al. 2007a) or yield of carcass meat (Armstrong et al., 2004, Marino et al., 2007a) from barrows, which may be related to genetics and possibly to the different weights used among papers.

The inclusion of different levels of dietary lysine did not affect carcass characteristics of males and females at termination (P>0.05), irrespective of whether they had been or not supplemented with ractopamine. De la Llata et al. (2002)

Table 3 - Carcass yield, carcass length and backfat thickness of barrows and gilts fed either ractopamine-with supplemented or no-supplemented diets with differents levels of digestible Lysine level

Ractopamine	Digestible lysine level (%)										Means Barrow	Means Gilt	Overal Means
	0.68		0.78		0.88		0.98		1.08				
	Barrow	gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt			
Carcass yield (%)													
With supplemented diet	83.76	83.70	84.24	83.10	83.49	84.13	83.25	85.30	83.58	84.23	83.66	84.10	83.88
No supplemented diet	83.18	83.71	83.09	83.87	82.77	83.00	82.40	83.88	84.04	83.93	83.10	83.68	83.39
Mean	83.47	83.71	83.67	83.49	83.13	83.57	82.83	84.59	83.81	84.08	83.38	83.89	
Overall mean	83.59		83.58		83.35		83.71		83.95				83.64
CV (%)	1.53												
Carcass lenght (cm)													
With supplemented diet	97.60	98.00	98.00	97.00	97.80	97.40	96.13	96.70	98.80	96.60	97.67	97.14	97.41
No supplemented diet	97.90	98.10	96.30	97.20	97.80	97.80	97.20	98.70	97.90	97.70	97.42	97.90	97.66
Mean	97.75	98.05	97.15	97.10	97.80	97.60	96.66	97.70	98.35	97.15	97.54	97.52	
Overall mean	97,90		97.13		97.70		97.18		97.75				97.53
CV (%)	3.07												
Backfat thickness (mm)													
With supplemented diet	18.01	16.58	19.06	16.35	17.40	16.67	17.05	14.73	17.63	16.43	17.83	16.15	16.99
No supplemented diet	18.85	14.50	20.77	14.03	18.23	16.94	20.40	16.01	17.80	18.07	19.21	15.91	17.56
Means	18.43	15.54	19.91	15.19	17.82	16.80	18.73	15.37	17.71	17.25	18.52a	16.03b	
Overall mean	16.99		17.55		17.31		17.05		17.48				17.28
CV (%)	17.28												

[1] Within treatment coluns, means with different lower case letters differ (P<0.05) by F test.

Table 4 - Loin eye area, loin depth and carcass meat yield of barrows and gilts fed either ractopamine-with supplemented or no-supplemented diets with differents levels of digestible Lysine level

Ractopamine	Digestible lysine level (%)										Means Barrow	Means Gilt	Overal mean[1]
	0.68		0.78		0.88		0.98		1.08				
	Barrow	gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt			
Loin eye area (cm^2)													
With supplemented diet	45.20	46.19	45.46	43.59	47.67	44.48	46.28	48.88	45.06	45.79	45.94	45.79	45.87A
N supplemented diet	40.76	47.78	45.04	44.22	43.18	44.78	40.44	47.93	41.99	43.86	42.28	45.72	44.00B
Mean	42.98	46.99	45.25	43.91	45.43	44.63	43.36	48.41	43.53	44.83	44.11	45.75	
Overall mean	44.99		44.58		45.03		45.89		44.18				44.94
CV (%)	10,19												
Loin depth (mm)													
With supplemented diet	78.62	75.20	70.62	69.42	77.98	69.42	74.60	78.14	70.86	72.26	74.54A	72.89	73.72
No supplemented diet	65.00	74.30	72.88	72.12	67.70	69.76	69.28	78.06	71.38	71.70	69.25bB	73.19a	71.22
Means	71.81	74.75	71.75	70.77	72.84	69.59	71.94	78.10	71.12	71.98	71.89	73.04	
Overall mean	73.28		71.26		71.22		75.02		71.55				72.47
CV (%)	9.12												
Carcass meat yield (%)													
With supplemented diet	58.35	59.02	56.85	58.73	58.73	58.50	58.82	60.53	57.90	59.00	58.13A	59.16	58.65
No supplemented diet	56.63	60.43	56.01	60.60	57.25	58.32	55.94	59.71	56.48	57.70	56.46bB	59.35a	57.91
Mean	57.49	59.72	56.43	59.67	57.99	58.41	57.38	60.12	57.19	58.35	57,29	59,25	
Overall mean	58.61		58.05		58.20		58.75		57.77				58.28
CV (%)	4.02												

[1]Within treatment coluns, means with different upper case letters differ (P<0.05) by F test.

and Arouca et al. (2005) found no effect of lysine levels in diets on carcass traits of finishing pigs.

However, in the study by Abreu et al. (2007), the carcass yield was linearly influenced by levels of dietary lysine (0.70, 0.80, 0.90 and 1.00%), and the lowest level of this amino acid produced better carcass yield. Cline et al. (2000) also observed a linear decrease in carcass yield.

For backfat thickness, several authors observed no effect of lysine level (Moreira et al., 2002, Oliveira et al. 2003ab; Arouca et al., 2005). However, Cline et al. (2000) and Marino et al. (2007a) observed a linear decrease of this variable as levels of this amino acid increased.

Similar to the results for *longissimus* muscle area obtained in this study, Oliveira et al. (2003b) and Abreu et al. (2007) also found no effect of lysine levels in the diet. The difference in the ability of deposition of the carcass meat of animals used in the work previously cited may have contributed to the variation in the resulting of *longissimus* muscle area. By studying the body composition of pigs from 25 to 152 kg in five genetic populations, Wagner et al. (1999) found that the *longissimus* muscle area ranged from 27.68 to 35.91 cm^2 in barrows slaughtered at 114 kg.

No difference (P>0.05) was observed between levels of lysine when the percentage of carcass meat was analyzed. This result was similar to that achieved by Arouca et al. (2005), Fontes et al. (2005) and Abreu et al. (2007), who observed that levels of lysine do not affect this variable. However, Cline et al. (2000), Marino et al. (2007a), Zangeronimo et al. (2009a) and Zangeronimo et al. (2009b) observed that diets supplemented with increasing levels of this amino acid (0.80, 0.95, 1.10, 1.25, 1.40% total lysine and 0.67 and 0.87% lysine, respectively) linearly increased the percentage of meat.

The average yield of meat obtained in this study was 58.28%, similar to values (58.2%) reported by Varley (2001) and reported (57.2%) by Abreu et al. (2007).

An effect of sex on carcass characteristics was observed (P<0.05) in backfat thickness and carcass meat yield. The backfat thickness was lower and the carcass meat yield was greater in females than in barrows. Similar results were obtained by Latorre et al. (2004), Amaral et al. (2009), Cantarelli et al (2009a) and Cantarelli et al. (2009b). By studying the effect of sex on carcass characteristics of pigs with high weights, Latorre et al. (2004) considered that the influence of hormonal activity, the higher basal metabolism and the reduced consumption capacity of females may explain these results. Moreover, the barrows are more precocious than females regarded to deposition of fat in the carcass.

Conclusions

The use of 5 ppm of ractopamine in the diet improves the performance of barrows and gilts from 90 to 117 kg and improves carcass traits, such as loin depth and yield of carcass meat, of the barrows. Digestible lysine at a level of

0.68% (i.e., 23.04 g/day) is enough to reach maximal performance and suitable carcass yield for pigs of both sexes, regardless whether the pig is receiving or not ractopamine.

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