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Net energy for 60 to 120 kg pigs fed low crude protein diets

Energia líquida em rações com redução de proteína bruta para suínos dos 60 aos 120 kg

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Abstract

Two experiments were conducted to determine the effects of dietary net energy content (NE) on performance and carcass traits of finishing barrows fed low crude protein (CP) diets. Pigs (60.0 ± 2.41 kg, Exp. 1; 90.0 ± 2.96 kg, Exp. 2) were allotted in randomized design to four dietary treatments. Exp. 1 had nine pens treatment^{-1} and Exp. 2 had eight pens treatment^{-1}, with two pigs in all pens. The treatments were as follows: 179 g kg^{-1} CP and 2589 kcal NE kg^{-1}, 134 g kg^{-1} CP and 2631 kcal NE kg^{-1}, 134 g kg^{-1} CP and 2589 kcal NE kg^{-1}, and 134 g kg^{-1} and 2589 kcal NE kg^{-1} (pair-feeding to 179 g kg^{-1} CP and 2589 kcal NE kg^{-1}) in Exp. 1 and 166 g kg^{-1} and 2604 kcal NE kg^{-1}, 123 g kg^{-1} CP and 2645 kcal NE kg^{-1}, 123 g kg^{-1} CP and 2604 kcal NE kg^{-1}, and 12.34% CP and 2604 kcal NE kg^{-1} (pair feeding to 166 g kg^{-1} CP and 2604 kcal NE kg^{-1}) in Exp. 2. In Exp. 1, there was no effect of CP or NE on any performance and carcass traits evaluated. In Exp. 2, the greatest result of average daily gain was obtained with 123 g kg^{-1} CP and 2645 kcal NE kg^{-1}. There was no effect of CP or NE on any other performance and carcass traits evaluated. For 60 to 90 kg barrows, reducing the CP of the diet from 179 g kg^{-1} to 134 g kg^{-1}, adjusting or not adjusting the NE content of the diets with 134 g kg^{-1} CP does not compromise performance or carcass traits. For 90 to 110 kg barrows, reducing the CP of the diet from 16.62 to 123 g kg^{-1}, while maintaining the same NE content (2604 kcal kg^{-1}) of the diet with 166 g kg^{-1} CP does not compromise performance or carcass traits.

Key words: Carcass. Finishing phase. Nutritional requirement. Swine.

Resumo

Dois experimentos foram conduzidos para avaliar níveis de energia líquida (EL) da ração sobre o desempenho e características de carcaça de suínos alimentados com dietas com redução de proteína bruta (PB). Os suínos (60,0 ± 2,41 kg, Exp. 1; 90,0 ± 2,96 kg, Exp. 2) foram distribuídos em delineamento inteiramente casualizado em quatro tratamentos. O Exp. 1 teve nove repetições/tratamento e o Exp. 2, teve oito repetições/tratamento. Todas repetições tiveram dois animais por unidade experimental. Os tratamentos foram: 179 g kg^{-1} PB e 2589 kcal EL kg^{-1}; 134 g kg^{-1} PB e 2621 kcal EL kg^{-1}; 134 g kg^{-1} PB e 2589 kcal EL kg^{-1} e 134 g kg^{-1} PB e 2589 kcal EL kg^{-1} (alimentação pareada a 179 g kg^{-1} PB e 2589 kcal EL kg^{-1}) no Exp. 1 e 166 g kg^{-1} PB e 2604 kcal EL kg^{-1}; 123 g kg^{-1} PB e 2645 kcal EL kg-1; 123 g kg^{-1} PB e 2604 kcal EL kg^{-1} e 123 g kg^{-1} PB e 2604 kcal NE kg^{-1} (alimentação pareada a 166 g kg^{-1} PB e 2604 kcal EL kg^{-1}) no Exp. 2. No Exp. 1, não houve efeito da PB ou EL nas variáveis de desempenho e de

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carcaça. No Exp. 2, o melhor resultado do ganho médio diário foi obtido com a dieta contendo 123 g kg^{-1} PB e 2645 kcal EL kg^{-1}, comparado com 166 g kg^{-1} PB e 2604 kcal EL kg^{-1}. Não houve efeito da PB ou da EL em nenhuma outra variável de desempenho e de carcaça. Para suínos dos 60 aos 90 kg, a redução da PB de 179 g kg^{-1} para 134 g kg^{-1}, mantendo-se ou não o nível de EL da ração, não compromete o desempenho, nem as características de carcaça. Para suínos dos 90 aos 110 kg, a redução da PB de 16,62 para 123 g kg^{-1} mantendo-se o mesmo nível de EL (2604 kcal/kg) da ração com 166 g kg^{-1} de PB, não compromete o desempenho nem as características de carcaça.
Palavras-chave: Exigência nutricional. Carcaça. Suínos. Terminação.

Introduction

The energy of a particular diet is commonly estimated based on its digestible energy (DE) and metabolizable energy (ME) content. However, according to the chemical composition of the feed, these values may vary. In this sense, the energy measurement system of the diet based on its net energy (NE) content may be more efficient, considering that it describes the ingested energy that is actually retained by the animal, in this case, pigs (MOEHN et al., 2013).

When DE or ME systems are adopted for diet formulation with reduced crude protein (CP), the energy value is underestimated, because pigs may be consuming more energy than expected. Thus, to increase the suitable energy consumption in diets with reduced CP, one must consider their NE contents, since the energy surplus can result in negative effects on pig carcass characteristics by increased fat deposition.

The differences in the efficiency of ME use among nutrients are associated with the heat increment (HI), which can be defined as the amount of heat released due to the energy costs of digestion and metabolic processes (KERR et al., 2003a) and may vary according to the nutrients of the feed, being higher for CP and fiber compared to starch and fat (NOBLET; MILGEN VAN, 2004).

Feed costs have the greatest impact on pig production costs, and energy is considered the component with the highest impact on these costs (LÉTOURNEAU-MONTMINY et al., 2011); thus, the formulation of diets that meet as closely as possible the nutritional requirements of pigs is a constant concern of nutritionists who aim to reduce formulation costs without compromising animal performance.

The reduction of CP, together with the adjustment of the NE content in pig diets, apart from being an alternative to reduce formulation costs without compromising performance and pig carcass traits, can also significantly reduce nitrogen excretion, thereby contributing to reduce the environmental impact caused by pig manure.

Thus, the present study was conducted to evaluate the effects of reducing the CP content of the diet and adjusting or not adjusting the NE level on the performance and carcass characteristic traits of pigs with weights ranging from 60 to 90 and from 90 to 110 kg.

Material and Methods

Research on animals was conducted according to the guidelines of the Institutional Ethics Committee of Animal Production Use (CEUAP-UFV) (protocol no. 55/2014).

In Experiment 1 (Exp. 1), commercial hybrid barrows (n = 72) with an initial body weight (BW) of 60.0 ± 2.41 kg were assigned to four dietary treatments in a completely randomized design with nine replicate pens per treatment and two pigs per pen. In Experiment 2 (Exp. 2), 64 commercial hybrid barrows (initial BW: 90.0 ± 2.96 kg) were assigned to four dietary treatments in a randomized design with eight replicate pens per treatment and two pigs per pen. In both experiments, pigs were housed in pens with semi-automatic feeders, nipple drinkers, and concrete floors. The environmental conditions inside the facility were monitored daily at 16:00 through maximum and minimum thermometers kept in an empty pen at half height of the pigs' body in each experiment.

Experimental diets (Tables 1 and 2) were mainly composed of corn, soybean meal, and supplements of minerals and vitamins to meet the requirements for all nutrients (ROSTAGNO et al., 2011), except for crude protein (CP) and metabolizable energy (ME). The ME levels used were based on the study of Saraiva et al. (2014); NE contents of the diets were calculated based on the values proposed by Rostagno et al. (2011). To the diets with reduced crude protein, industrial amino acids were added, maintaining the ratios with digestible lysine, according to the ideal protein concept for finishing pigs (ROSTAGNO et al., 2011). In Exp. 1, the treatments were as follows: 179 g kg^{-1} CP and 2,589 kcal NE kg^{-1}, 134 g kg^{-1} CP and 2,631 kcal NE kg^{-1}, 134 g kg^{-1} CP and 2,589 kcal NE kg^{-1}, and 134 g kg^{-1} CP and 2,589 kcal NE kg^{-1} (pair-feeding to 179 g kg^{-1} CP and 2,589 kcal NE kg^{-1}), and 166 g kg^{-1} CP and 2,604 kcal NE kg^{-1}, 123 g kg^{-1} CP and 2,645 kcal NE kg^{-1}, 123 g kg^{-1} CP and 2,604 kcal NE kg^{-1}, and 123 g kg^{-1} CP and 2,604 kcal NE kg^{-1} (pair-feeding to 166 g kg^{-1} CP and 2,604 kcal NE kg^{-1}) in Exp. 2.

In both experiments, pigs had free access to feed throughout the 30-d experimental periods, except for pigs pair-fed with diets containing 17.85% CP and 2,589 kcal NE kg^{-1} (Exp. 1) and 16.62% CP and 2,604 kcal NE kg^{-1} (Exp. 2). The amount of feed provided to the pair-fed pigs was calculated every three days in both experiments. Water was provided *ad libitum*.

Daily feed waste was manually collected and weighed. Pigs were weighed at the beginning and at the end of the experimental periods to calculate average daily feed intake (ADFI), digestible lysine intake (DLI), net energy intake (NEI), average daily gain (ADG), and feed conversion (F: G).

At the end of the experiments, pigs were fasted for 18 h and one pig per pen with a BW closest to 90 kg (Exp. 1) and 110 kg (Exp. 2) was electrically stunned and subsequently exsanguinated.

Loin eye area (LEA) and backfat thickness (BF) were obtained on the half right carcass, chilled for 24 hours after slaughter, from a transversal cut in the *Longissimus dorsi* between the 10^{t} and the 11^{th} rib. The cross-sectional area was taken up using transparent plastic sheets. The LEA values were obtained through the ImageJ program (r) 1.49r and BF measurements, using a digital caliper.

Data were analyzed separately for each experiment, using the MIXED procedures (SAS, Inst. Inc., Cary, NC), following a completely randomized design and using the initial BW as covariate. The pen was used as the experimental unit for statistical analysis of ADFI, DLI, NEI, ADG, and F: G. However, only one pig was slaughtered per pen for carcass trait measurements. In both experiments, mean comparison was made by Fischer LSD tests; probability values less than 0.05 were considered significant.

Table 1. Ingredient composition and nutritional values of dietary treatments fed to pigs from 60 to 90 kg.

Ingredient, g kg^{-1}	Crude protein (g kg^{-1}) / net energy (kcal kg^{-1})		
	179/2,589	134/2,631	134/2,589
Corn	662.37	794.09	804.63
Soybeam meal	279.5	143.9	142.5
Soybean oil	36.9	32.4	23.23
Dicalcium phosphate	8.04	9.22	9.22
Limestone	6.04	6.04	6.04
Salt	3.55	3.55	3.55
L-lysine	0.00	4.14	4.17
DL-methionine	0.00	1.00	1.00
L-threonine	0.00	1.38	1.38
L-tryptophan	0.00	0.30	0.30
L-valine	0.00	0.38	0.38
Mineral premix[1]	1.50	1.50	1.50
Vitamin premix[2]	1.50	1.50	1.50
Growth promoter[3]	0.50	0.50	0.50
Antioxidant[4]	0.10	0.10	0.10
Calculated nutritional composition[5]			
Metabolizable energy, kcal kg^{-1}	3400	3400	3354
Net energy, kcal kg^{-1}	2,589	2,631	2,589
Starch, g kg^{-1}	450.0	516.0	522.4
Crude protein, g kg^{-1}	178.5	134.0	134.0
Fat, g kg^{-1}	65.6	63.7	55.0
Crude fiber, g kg^{-1}	26.3	21.4	21.5
Digestible lysine, g kg^{-1}	8.29	8.29	8.29
Met + cys, g kg^{-1}	5.16	4.97	4.97
Digestible threonine, g kg^{-1}	6.05	5.55	5.55
Digestible trytophan, g kg^{-1}	1.92	1.49	1.49
Digestible valine, g kg^{-1}	7.59	5.72	5.72
Digestible isoleucine, g kg^{-1}	6.83	4.56	4.56
Calcium, g kg^{-1}	5.12	5.12	5.12
Available phosphorus, g kg^{-1}	2.50	2.50	2.50
Sodium, g kg^{-1}	1.60	1.60	1.60

[1]Content per kg product: Fe (64.0 g), Cu (9.6 g), Mn (32.0 g), Zn (88.0 g), I (800 mg), Se (290 mg) and vehicle q.s.p. (1000 g).
[2]Content per kg of product: vitamin A (5,500,000 UI), vitamin D3 (1,200,000 UI), vitamin E (32,000 UI), vitamin B1 (800 mg), vitamin B2 (2.5 g), vitamin B6 (1.6 g), vitamin B12 (16 mg), vitamin K3 (2.4 g), biotin (80.0 mg), pantothenic acid (12.0 g), folic acid (240.0 mg), nicotinic acid (24.0g), folic acid (240.0 mg) and vehicle q.s.p. (1000 g).
[3] Tylan 40® Premix – content per kg of product: tylosin activity (as phosphate) 88 g, vehicle q.s.p. 1,000 g.
[4]β-Hydroxytoluene.
[5]Values calculated according to Rostagno et al. (2011).

Table 2. Ingredient composition and nutritional values of dietary treatments fed to pigs from 90 to 110 kg.

Ingredient, g kg^{-1}	Crude protein (g kg^{-1}) / net energy (kcal kg^{-1})		
	166/2,604	123/2,645	123/2,604
Corn	702.83	828.22	838.67
Soybean meal	245.0	116.3	115.0
Soybean oil	33.8	29.6	20.46
Dicalcium phosphate	7.3	8.42	8.42
Limestone	5.71	5.7	5.7
Salt	3.31	3.31	3.31
L-lysine	0.00	3.93	3.94
DL-methionine	0.00	0.77	0.74
L-threonine	0.00	1.16	1.16
L-tryptophan	0.00	0.29	0.3
L-valine	0.00	0.25	0.25
Mineral premix[1]	0.75	0.75	0.75
Vitamin premix[2]	0.75	0.75	0.75
Growth promoter[3]	0.45	0.45	0.45
Antioxidant[4]	0.10	0.10	0.10
Calculated nutritional composition[5]			
Metabolizable energy, kcal kg^{-1}	3400	3400	3355
Net energy, kcal kg^{-1}	2,604	2,645	2,604
Starch, g kg^{-1}	471.0	533.4	540.0
Crude protein, g kg^{-1}	166.2	123.4	123.4
Fat, g kg^{-1}	63.5	62.0	53.0
Crude fiber, g kg^{-1}	25.1	20.5	21.0
Digestible lysine, g kg^{-1}	7.49	7.49	7.49
Digestible met + cys, g kg^{-1}	4.88	4.49	4.49
Digestible threonine, g kg^{-1}	5.62	5.01	5.01
Digestible tryptophan, g kg^{-1}	1.75	1.35	1.35
Digestible valine, g kg^{-1}	7.05	5.16	5.16
Digestible isoleucine, g kg^{-1}	6.27	4.12	4.12
Calcium, g kg^{-1}	4.74	4.74	4.74
Available phosphorus, g kg^{-1}	2.31	2.31	2.31
Sodium, g kg^{-1}	1.50	1.50	1.50

[1]Content per kg product: Fe (64.0 g), Cu (9.6 g), Mn (32.0 g), Zn (88.0 g), I (800 mg), Se (290 mg) and vehicle q.s.p. (1000 g).
[2]Content per kg of product: vitamin A (5,500,000 UI), vitamin D3 (1,200,000 UI), vitamin E (32,000 UI), vitamin B1 (800 mg), vitamin B2 (2.5 g), vitamin B6 (1.6 g), vitamin B12 (16 mg), vitamin K3 (2.4 g), biotin (80.0 mg), pantothenic acid (12.0 g), folic acid (240.0 mg), nicotinic acid (24.0g), folic acid (240.0 mg) and vehicle q.s.p. (1000 g).
[3] Tylan 40® Premix – content per kg of product: tylosin activity (as phosphate) 88 g, vehicle q.s.p. 1,000 g.
[4]β-Hydroxytoluene.
[5]Values calculated according to Rostagno et al. (2011).

Results and Discussion

Average maximum and minimum temperatures in the pens were 29.89 ± 4.03°C (Exp. 1) and 21.10 ± 1.61°C (Exp. 2). Based on the thermoneutral temperature range (15 to 22°C) suggested by Sampaio et al. (2004) for growing and finishing pigs, it can be inferred that the pigs were subjected to periods of heat stress.

In Exp. 1 and Exp. 2, there was no effect (P > 0.05) of CP and NE contents on the average daily intake (ADFI) of pigs (Tables 3 and 4). A similar result was reported by Saraiva et al. (2014), who also found no effect of dietary CP and NE content on ADFI of pigs from 60 to 95 kg. However, these same authors observed a decrease in ADFI of barrows (95 to 120 kg) fed diets with 180 g kg^{-1} CP compared to those fed a diet with reduced CP (145 g kg^{-1}), maintaining the same NE (2,588 kcal kg^{-1}) in both diets.

The lack of an effect on ADFI in the present studies, concerning the NE content of the diets, may be associated with a narrow range of NE (42 kcal kg^{-1}, Exp. 1; 41 kcal kg^{-1}, Exp. 2) among the diets used in each experiment. Kerr et al. (2003a), studying different NE concentrations in diets for pigs from 25.3 to 109.7 kg, also found no differences in ADFI. According to these authors, the differences between the highest and the lowest NE content of the diet in each growth phase (124 kcal NE kg^{-1} for 25 to 41 kg, 118 kcal NE kg^{-1} for 41 to 58.8 kg, 76 kcal NE kg^{-1} for 58.8 to 82.3 kg, and 90 kcal NE kg^{-1} for 82.3 to 109.7 kg pigs) were not sufficient to influence ADFI.

Considering that diets with reduced CP values may result in essential amino acid deficiency, adversely impacting voluntary feed intake of pigs (KERR et al., 2003b), it can be inferred that the diets used in both studies were adequately supplemented with industrial amino acids.

The diets with low CP values in both experiments (134 g kg^{-1}, Exp.1; 123 g kg^{-1}, Exp.2) could contribute to reduce heat production of pigs (WOLP et al., 2012). Thus, under heat stress conditions, those diets could favor the ADFI of pigs, also possibly associated with the improvement of performance, as verified by Saraiva et al. (2014). This, in turn, could lead to a misinterpretation of the results, thus justifying the pair-feeding in both studies. However, this response was not observed.

The NE intake (NEI) and digestible lysine intake (DLI) were not affected (P > 0.05) by CP and NE contents in the diets in both experiments (Tables 3 and 4). The absence of an effect on NEI and DLI in both studies can be explained by the lack of a change of the ADFI of pigs. However, in Exp. 2, the NEI of pigs fed diets with low CP values (123 g kg^{-1} and 2,645 kcal of NE kg^{-1}) increased by 12.77% compared to the NEI of pigs fed diets with 166 g kg^{-1} CP and 2,604 kcal of EL kg^{-1}.

Le Bellego et al. (2002) also reported no difference in NEI of pigs from 64 to 100 kg fed low-CP diets; however, pigs that consumed diets with higher CP contents (176 g kg^{-1}) had higher DLI values compared to pigs fed diets with low CP (134 or 138 g kg^{-1}). Moehn et al. (2013) found no effect of CP (200 or 112 g kg^{-1}) on the NEI values of finishing pigs. Moreover, Quiniou and Noblet (2012), in a study with pigs from 35 to 110 kg fed diets with NE values ranging from 2,300 to 2,800 kcal kg^{-1}, reported a linear increase of NEI with increasing NE concentration of the diet.

Table 3. Effects of dietary crude protein and net energy content on performance and carcass traits of pigs from 60 to 90 kg (Exp. 1).

Item[1]	Crude protein (g kg^{-1}) / net energy (kcal kg^{-1})				SEM	P- value
	178.5/2589	134/2631	134/2589	134/2589		
IBW, kg	61.27	61.18	61.27	61.21	0.86	0.999
FBW, kg	89.67	91.21	89.72	88.78	0.73	0.186
ADFI, g dia^{-1}	2645	2706	2623	2585	0.05	0.527
NEI, kcal dia^{-1}	6847	7120	6791	6693	142	0.243
DLI, g dia^{-1}	21.92	22.43	21.74	21.42	0.48	0.455
ADG, g dia^{-1}	1053	1110	1079	1048	0.02	0.181
F:G	2.51	2.44	2.43	2.47	0.05	0.617
Carcass traits						
LEA, cm^2	38.85	40.45	38.53	39.03	0.98	0.565
BF, mm	11.4	12.1	12.1	11.7	0.66	0.86

[1]IBW = initial body weight, FBW = final body weight, ADFI = average daily feed intake, ADG = average daily gain, F:G = feed conversion, LEA = loin eye area, BF = backfat thickness.
*Means followed by distinct uppercase letters in the lines are different by Fischer DMS test Fischer at 5% probability.
*SEM = standard error of the mean.

Table 4. Effects of dietary crude protein and net energy content on performance and carcass traits of pigs from 90 to 110 kg (Exp. 2).

Item[1]	Crude protein (g kg^{-1}) / net energy (kcal kg^{-1})				SEM	P – value
	166.2/2604	123.4/2645	123.4/2604	166.2/2604		
IBW, kg	90.56	90.6	90.5	90.49	1.12	0.999
FBW, kg	109.01	112.49	110.56	110.32	1.15	0.222
ADFI, g dia^{-1}	2936	3314	3107	3066	0.11	0.137
NEI, kcal dia^{-1}	7646	8765	8092	7986	289	0.071
DLI, g dia^{-1}	22	25	24	23	0.84	0.113
ADG, g dia^{-1}	923^{b}	1149^{a}	1032^{ab}	1028^{ab}	0.05	0.028
F:G	3.04	2.89	2.96	2.99	0.06	0.292
Carcass traits						
LEA, cm^2	45.61	44.28	45.34	44.27	0.87	0.586
BF, mm	11.9	14.3	12.1	12.5	0.93	0.279

[1]IBW = initial body weight, FBW = final body weight, ADFI = average daily feed intake, ADG = average daily gain, F:G = feed conversion, LEA = loin eye area, BF = backfat thickness.
*Means followed by distinct uppercase letters in the lines are different by Fischer DMS test Fischer at 5% probability.
*SEM = standard error of the mean.

In Exp. 1, the average daily gain (ADG) was not influenced ($P > 0.05$) by the dietary CP and NE content (Table 3). Similar to the results observed for the ADG in Exp.1, Figueroa et al. (2001) found that dietary CP can be reduced from 160 to 120 g kg^{-1} without affecting the ADG of growing gilts, since the amino acid deficiency of the diet is mitigated by the addition of amino acids from industrial sources, and the optimal ratios of these amino acids are maintained with lysine. Moura et al. (2011) also found no effect of NE content on the ADG of gilts from 60 to 90 kg. However, Saraiva et al. (2014) reported that pigs from 60 to 95 kg fed diets containing 155 g kg^{-1} CP and 2,566 kcal NE kg^{-1} showed higher ADG values compared to those fed a diet containing 199 g kg^{-1} CP and 2,566 kcal NE kg^{-1}; however, the pigs fed the diet with a low CP had a numerical DLI increase of 3.02 g. The values of

ADG obtained in Exp. 1 are consistent with the lack of variation in NEI and DLI among the treatments.

In Exp. 2, the pigs' ADG increased ($P < 0.05$) with increasing NE concentrations from 2,604 to 2,645 kcal NE kg^{-1} by means of reducing dietary CP from 166 g kg^{-1} to 123 g kg^{-1}. Pigs fed the diet containing 123 g kg^{-1} CP and 2,604 kcal NE kg^{-1} had ADG values intermediate to the pigs fed the other experimental diets (Table 4). Quiniou and Noblet (2012) observed an increase in the ADG of growing and finishing pigs with the increase in NE (ranging from 1,935 to 2,651 kcal kg^{-1}). However, Saraiva et al. (2014), in a study with pigs from 95 to 120 kg, found that those pigs fed diets containing 145 g kg^{-1} CP and 2,588 kcal NE kg^{-1} had higher ADG values compared to pigs fed 180 g kg^{-1} CP and 2,588 kcal NE kg^{-1}; however, they were similar to those of the pigs fed 145 g kg^{-1} CP and a 2,639 kcal NE kg^{-1} diet.

Low CP diets are associated with lower energy loss. Due to the decrease of excessive protein consumption, the need for deamination of excess amino acid is reduced with a decrease in urea synthesis and subsequent excretion through urine (LE BELLEGO et al., 2001).

The reduction of CP in the diet also reduces protein turnover and the production of heat by the animals (FULLER et al., 1987; NOBLET et al., 1987), leading to a more efficient energy use (LE BELLEGO et al, 2001). The greater ADG of pigs in Exp. 2, fed the diet with CP reduced from 166 to 123 g kg^{-1} with no adjustment in NE concentration, is in agreement with this proposition.

There were no effects ($P > 0.05$) of CP and NE contents on feed conversion (F: G) of pigs in both experiments (Tables 3 and 4). Based on the values of F: G observed in both experiments, it was evident that the ADG variation in Exp. 2 was probably due to the numerical increases in ADFI (11.41%), NEI (12.77%), and DLI (12%) of pigs fed diets with 123 g kg^{-1} CP and 2,645 kcal NE kg^{-1} compared to those fed 166 g kg^{-1} CP and 2,604 kcal NE kg^{-1} diets. These results are in agreement with those of Saraiva et al. (2014), studying NE levels in diets with reduced CP values for pigs from 60 to 95 kg. In contrast, a linear improvement in F: G of pigs was observed by Quiniou and Noblet (2012) and Gonçalves et al. (2015), studying, respectively, five (2,300; 2,425; 2,550; 2,675, and 2,800 kcal kg^{-1}) and six (1,935; 2,078; 2,221; 2,365; 2,508, and 2,651 kcal kg^{-1}) dietary NE levels.

Feed has the highest impact on pig production costs, and energy is considered the component with the greatest impact on these costs (LÉTOURNEAU-MONTMINY et al., 2011). In this sense, optimizing the use of energy, through adjustments in the supply of energy in the diet, is important to minimize formulation costs without compromising pig performance. In both experiments, the reduction of CP by means of reducing soybean meal, keeping the same NE concentration of the diet with reduced CP by the addition of soy oil, did not negatively impact the performance of the animals. These results can be considered positive, since formulations of diets with reduced CP, correcting the EL content, may decrease the costs of feeding pigs.

Loin eye area (LEA) was not influenced ($P > 0.05$) by dietary CP and NE contents of pigs in both experiments (Tables 3 and 4). These results are consistent with those of Rezende et al. (2006), evaluating metabolizable energy levels (ranging from 3,100 to 3,500 kcal kg^{-1}) in the diet for barrows, where the dietary energy concentrations were obtained by adding soybean oil to the diets, which probably contributed to the increase in NE contents in the diets. The authors of a similar study (NOBLET; SHI, 1994) also found no effect on carcass traits. Moura et al. (2011), studying the effects of high NE levels (2,300 to 2,668 kcal kg^{-1}) in diets for finishing gilts, also reported no differences in the percentages of lean meat and carcass yield. Similarly, Paiano et al. (2008), in a study on growing and finishing pigs, found no effects of NE (2,410; 2,450; 2,490; 2,530 or 2,570 kcal kg^{-1}) on carcass weight, LEA, carcass yield, or the amount of meat in the carcass.

On the other hand, Kerr et al. (2003a), evaluating CP and NE for pigs from 25.3 to 109.7 kg, observed no effect of NE on LEA; however, pigs fed the diet with a higher CP content had a higher LEA value.

There was no difference ($P > 0.05$) in the backfat (BF) of pigs related to CP and NE in the diets. Low CP diets with no adjustments of NE concentrations may result in a loss of carcass quality by increased fat deposition (KERR et al., 1995; LE BELLEGO et al., 2001; PAIANO et al., 2008). The lack of an effect of NE on BF in our studies may be due to the fact that the amplitude between the NE content of the experimental diets used in each experiment was not sufficient to influence the NEI and, consequently, carcass fat deposition.

A similar result was obtained by LE BELLEGO et al. (2002), who found no effect of reducing CP values in diets for growing (200, 158, and 163 g kg^{-1}) and finishing (176, 134, and 138 g kg^{-1}) pigs on BF. Likewise, Quiniou and Noblet (2012) verified no differences in the BF of 37 to 110 kg pigs fed diets with varying NE contents, even with a difference of 716 kcal kg^{-1} between the diets with highest and lowest NE contents. Saraiva et al. (2014) also reported no effect of dietary CP (199 or 155 g kg^{-1}) and NE (2,566 and 2,631 kcal kg^{-1}) on the BF of barrows from 60 to 95 kg.

These results confirm the report of Dourmad and Noblet (1998), who stated that pigs selected for meat deposition are less likely to have impaired carcass quality when fed diets with high energy levels.

The values of LEA and BF verified in Exp. 1 and Exp. 2 are consistent with the values of F: G, showing no evidence of variation in gain composition.

Conclusions

A reduction of CP from 179 g kg^{-1} to 134 g kg^{-1} of the diet, with adequate supplementation of industrial amino acids, adjusting or not adjusting the NE content, does not compromise the performance or carcass traits of pigs from 60 to 90 kg. For pigs weighing between 90 and 110 kg, the diet with 123 g kg^{-1} CP and higher NE content (2,645 kcal kg^{-1}) resulted in the greatest average daily gain.

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Bioethics and Biosecurity Committee Approval

All procedures involving animal handling were performed in accordance with the regulations approved by the Institutional Ethics Committee of Animal Production Use (CEUAP-UFV) of the Universidade Federal de Viçosa, Brazil. Protocol 55/2014.

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