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

Energia líquida para suínos dos 60 aos 120kg recebendo dietas com redução de proteína

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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±1.05kg, Exp. 1, 93.0±1.56kg, Exp. 2) were allotted in a randomized block design to 3 dietary treatments. Exp. 1 had 6 pens treatment^{-1} and Exp. 2 had 8 pens treatment^{-1} and all pens had 2 pigs. The treatments were: 199g kg^{-1} CP and 2566kcal kg^{-1} NE, 155g kg^{-1} CP and 2631kcal kg^{-1} NE, 155gk g^{-1} CP and 2566kcal kg^{-1} NE in Exp. 1, and 180g kg^{-1} CP and 2588kcal kg^{-1} NE, 145g kg^{-1} CP and 2638kcal kg^{-1} NE, 145g kg^{-1} CP and 2588kcal kg^{-1} NE, in Exp. 2. In Ep.1, except for average daily gain (ADG) there was no effect of dietary CP or NE on any other parameter evaluated. The diet with 155g kg^{-1} CP and 2566kcal kg^{-1} NE resulted in greatest ADG. In Exp. 2, the greatest results of ADFI and ADG were obtained with 145g kg^{-1} CP and 2588kcal kg^{-1} of NE. Pigs fed the diet with 180g kg^{-1} CP and 2588kcal kg^{-1} NE had less carcass meat. There was no effect of dietary CP or NE on backfat. The CP diet containing 2566kcal kg^{-1} NE resulted in greatest ADG of 60- to 95-kg barrows. For 95- to 120-kg barrows the diet with 145gk g^{-1} CP and 2588kcal kg^{-1} of NE resulted in greatest ADG and carcass meat.

Key words: *carcass, finishing phase, nutrition, requirement.*

RESUMO

Dois experimentos foram conduzidos para determinar os efeitos da energia líquida (EL) da ração no desempenho e nas características de carcaça de suínos, recebendo dietas com proteína bruta reduzida (PB). Os suínos (60,0±1,05kg, Exp. 1, 93,0±1,56kg, Exp. 2) foram distribuídos em delineamento de blocos casualizados, com três tratamentos. O Exp. 1 teve seis baias/tratamento e o Exp. 2 teve 8 baias/tratamento e todas as baias tiveram 2 animais. Os tratamentos foram: 199g kg^{-1} PB e 2566kcal kg^{-1} NE, 155g kg^{-1} PB e 2.631kcal kg^{-1} NE, 155g kg^{-1} PB e 2.566kcal kg^{-1} NE no Exp. 1, e 180g kg^{-1} PB e 2588kcal kg^{-1} NE, 145g kg^{-1} PB e 2638kcal kg^{-1} NE, 145g kg^{-1} de PB e 2588kcal kg^{-1} NE, no Exp. 2. No Exp.1, a ração com 155g kg^{-1} PB e 2566kcal kg^{-1} EL resultou em maior GPD. Não houve efeito dos níveis PB ou EL sobre os demais parâmetros. No Exp. 2, os melhores resultados de CRD e GDP foram obtidos com 145g kg^{-1} PB e 2588kcal kg^{-1} EL. Os suínos alimentados com a dieta com 180g kg^{-1} PB e 2.588kcal kg^{-1} NE apresentaram menor quantidade de carne na carcaça. Não houve efeito do conteúdo de PB ou EL da ração na espessura de toucinho. A ração contendo 155g kg^{-1} PB e 2.566kcal kg^{-1} NE resultou em maior GPD de suínos dos 60 aos 95kg. Dos 95 aos 120kg, a dieta com 145g kg PB e 2588kcal kg^{-1} EL resultou em maior GPD e carne na carcaça.

Palavras-chave: *carcaça, exigência, nutrição, terminação.*

INTRODUCTION

Proteins have higher caloric increment than carbohydrates and fat which is a result of the energy released as heat during digestion, absorption and metabolism of nutrients and other physiological mechanisms (NOBLET & SHI, 1994). Reducing dietary crude protein (CP) will result in a decrease in deamination of the excess of amino acids and consecutive synthesis and excretion of urea in urine

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which also contributes to lower heat production of pigs. Consequently, reducing diet CP will improve the efficiency of ME utilization, with consecutive increasing in the NE availability, and attenuate heat stress of finishing pigs under high environmental temperatures, a common condition in most of Brazil.

As feed represent the most important cost of pig production and energy is considered the first most expensive component in pig diets (LÉTOURNEAU-MONTMINY et al., 2011), optimizing feed energy utilization by adjusting the dietary NE content in low-crude protein diets is important to lower formulation costs without compromising pigs' performance. Such diets can also markedly reduce nitrogen excretion enhancing sustainable pig production.

Thus, the objective of this study was to evaluate the effect of the net energy content in diets with low crude protein level supplemented with industrial amino acids on performance and carcass traits of barrows from 60 to 95 and 95 to 120kg.

MATERIAL AND METHODS

In Exp. 1, commercial hybrid barrows (n=36) with an initial BW of 60±1.05kg were assigned to 3 dietary treatments in a randomized block design with 6 replicates pens per treatment and 2 pigs per pen. In Exp. 2, 48 barrows (initial BW: 93.0±1.56kg) were assigned to 3 dietary treatments in a randomized block design with 8 replicate pens and 2 pigs per pen. In both experiments the initial weight was used as criteria in the blocks formation. Pigs were housed in pens with semi-automatic feeder, drinkers, and concrete floors.

Experimental diets (Tables 1 and 2) were mainly composed of corn, soybean meal, and supplemented of minerals, and vitamins according to ROSTAGNO et al. (2005), except for metabolizable energy, crude protein and digestible lysine. The digestible lysine levels were based on the studies of ABREU et al. (2007) on Exp. 1, and SANTOS et al. (2007) on Exp. 2. The NE content of the diets were calculated based on the values by ROSTAGNO et al. (2005). In each experimental diet industrial amino acids were added maintaining the ratios with digestible lysine, according to the ideal protein concept for finishing pigs (ROSTAGNO et al., 2005). The treatments were as follow: 199g kg^{-1} CP and 2566kcal kg^{-1} NE, 155g kg^{-1} CP and 2631kcal kg^{-1} NE, 155g kg^{-1} CP and 2566kcal kg^{-1} NE in Exp. 1, and 180g kg^{-1} CP and 2588kcal kg^{-1} NE, 145g kg^{-1} CP and 2638kcal kg^{-1} NE, 145g kg^{-1} CP and 2588kcal kg^{-1} NE, in Exp. 2.

Pigs had free access to feed and water throughout the 30-d experimental period. Daily feed waste was manually collected and weighed. Animals were weighed at the beginning and at the end of the experimental period to calculate 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 18h and transported to a slaughterhouse (Meat Industry Vale do Piranga, Ponte Nova, MG, Brazil). Pigs were electrically stunned followed by exsanguination. The carcasses were eviscerated, weighed, and evaluated for backfat thickness and quantity of meat, using the Henessy Grade Probe (HGP-4), following the procedures adopted in the slaughterhouse.

The performance data (ADFI, DLI, NEI, ADG, and F:G) and carcass traits (carcass meat and backfat thickness) data were analyzed using the procedures for analysis of variance with comparison of means done by the test of Tukey using the System for Statistical and Genetics Analysis (SAEG), developed at Universidade Federal de Viçosa (UFV, 2000), version 9.0. For all statistical procedures it was adopted 0.05 as the critical probability level for the type I error.

RESULTS AND DISCUSSION

The range of thermoneutral zone suggested by PERDOMO (1994) for growing and finishing pigs is between 18 and 23°C and 12 and 18°C, respectively. The average maximum and minimum temperatures observed (28.3±1.5 and 19.5±1.2°C, respectively) during the experimental periods indicates that pigs in both experiments were under heat stress.

In experiment 1 (Exp. 1), dietary crude protein (CP) or net energy (NE) content in the diets had no effect ($P>0.05$) on average daily feed intake (ADFI) of pigs (Table 3). On the other hand, in experiment 2 (Exp. 2), the ADFI observed in pigs fed the diet containing 145g kg^{-1} C P and 2588kcal kg^{-1} NE was greater ($P<0.05$) compared to pigs fed the diet with 180g kg^{-1} CP and 2588kcal kg^{-1} NE. Pigs that were fed the diet with 145g kg^{-1} CP and 2638kcal kg^{-1} NE diet showed an intermediate value of feed intake (Table 3).

The result of ADFI in Exp. 1 is in agreement with those of KERR et al. (2003), who verified no changes on feed intake of finishing pigs fed low-CP diets with different NE content supplemented with industrial amino acids. Similarly, VIDAL et al. (2010)

Table 1 - Ingredient composition and nutritional values of dietary treatments fed to pigs from 60 to 95kg (Exp. 1).

Ingredient	----------------------Crude protein (g kg^{-1}) and net energy (kcal kg^{-1})---------------------------		
	199/2566	155/2631	155/2566
Corn	613.15	742.16	757.14
Soybean meal	325.50	193.00	192.00
Soybean oil	39.15	34.80	20.90
Dicalcium phosphate	9.42	10.17	10.12
Limestone	5.82	6.10	6.10
L-lysine	0.00	4.02	4.02
DL-methionine	0.10	1.24	1.24
L-threonine	0.00	1.52	1.49
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
BHT	0.10	0.10	0.10
----------------------Calculated composition ----------------------			
Metabolizable energy, kcal kg^{-1}	3400	3400	3332
Net energy, kcal kg^{-1}	2566	2631	2566
Crude protein, g kg^{-1}	198.9	154.9	155.6
Digestible lysine, g kg^{-1}	9.40	9.40	9.40
Digestible met + cys, g kg^{-1}	5.83	5.83	5.83
Digestible threonine, gk g^{-1}	6.64	6.30	6.30
Digestible tryptophan, g kg^{-1}	2.16	1.51	1.51
Digestible valine, gk g^{-1}	8.40	8.40	8.40
Calcium, gk g^{-1}	5.51	5.51	5.51
Available phosphorus, g kg^{-1}	2.82	2.82	2.82
Sodium, g kg^{-1}	1.70	1.70	1.70

[1]Provided per kg of product: vitamin A – 6,000,000IU; vitamin D3 – 1,500,000IU; vitamin E – 15,000,000IU; vitamin B1 – 1.35g; vitamin B2 - 4g; vitamin B6 - 2g; pantothenic acid – 9.3g; vitamin K3 – 1.5g; nicotinic acid – 20.0g; vitamin B12 – 20.0g; folic acid – 0.6g; biotin – 0.08g; selenium – 0.3g; vehicle q.s.p. – 1,000g.
[2]Provided per kg of product: iron - 100g, copper - 10g, cobalt - 1g, manganese - 40g, zinco - 100g, iodine – 1.5g, vehicle q.s.p. – 1,000g.
[3]Tylosin.

reduced 45g kg^{-1} CP in the diet for 70- to 100-kg pigs without any variation on ADFI. In a more recent study, MOURA et al. (2011) evaluated NE in diets for finishing gilts (60- to 92-kg) and also verified no effect on ADFI.

The lack of effect of NE on ADFI in our study may be associated to the narrow range of NE (65kcal kg^{-1}) among the diets. This statement is in accordance with that of KERR et al. (2003) in which the difference in the dietary NE content from the high to the low level (124, 118, 76, and 90kcal kg^{-1}) was considered too low to affect ADFI.

Reducing CP content in the diet may lead to deficiency of essential amino acids and according to some authors (KERR et al., 2003) the imbalance of amino acids in the diet may influence negatively the voluntary feed intake of pigs. In the present study, there was no amino acid imbalance as diets were supplemented with industrial amino acids until the next amino acid become limiting.

The reduction on feed intake as a result of high environmental temperatures, a common situation in most of Brazil, becomes a thermoregulatory mechanism particularly important in the current lines of pigs which because of the high genetic potential for lean tissue accretion, produce large amounts of metabolic heat and are therefore more susceptible to heat stress. According to QUINIOU et al. (2000), the detrimental effect of high environmental temperature increases with body weight indicating that the pigs become more sensitive to heat stress as they become heavier. Lowering the CP level of a corn-soybean meal diet can reduce body protein turnover and heat production of pigs (KERR et al., 2003), which considering the condition of heat stress verified in the present study may have favored the greater ADFI

Table 2 - Ingredient composition and nutritional values of dietary treatments fed to pigs from 95 to 120kg (Exp. 2).

Ingredientes	---Crude protein (g kg^{-1}) and net energy (kcal kg^{-1})---		
	180/2588	145/2638	145/2588
Corn	671.77	773.31	786.02
Soybean meal	273.66	170.00	168.10
Soybean oil	35.32	31.80	21.00
Dicalcium phosphate	7.68	8.27	8.21
Limestone	4.66	4.86	4.90
L-lysine	0.00	3.15	3.18
DL-methionine	0.00	0.65	0.64
L-threonine	0.00	0.94	0.93
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
BHT	0.10	0.10	0.10
---Calculated composition---			
Metabolizable energy, kcal kg^{-1}	3400	3400	3332
Net energy, kcal kg^{-1}	2588	2638	2588
Crude protein, g kg^{-1}	180	145	145
Digestible lysine, g kg^{-1}	8.20	8.20	8.20
Digestible met + cys, g kg^{-1}	5.32	5.08	5.09
Digestible threonine, g kg^{-1}	5.99	5.50	5.49
Digestible tryptophan, g kg^{-1}	1.91	1.40	1.40
Digestible valine, g kg^{-1}	7.60	5.97	5.98
Calcium, g kg^{-1}	4.53	4.53	4.53
Available phosphorus, g kg^{-1}	2.45	2.45	2.45
Sodium, g kg^{-1}	1.70	1.70	1.70

[1]Provided per kg of product: vitamin A – 6,000,000IU; vitamin D3 – 1,500,000IU; vitamin E – 15,000,000IU; vitamin B1 – 1.35g; vitamin B2 - 4g; vitamin B6 - 2g; pantothenic acid – 9.35g; vitamin K3 – 1.5g; nicotinic acid – 20.0g; vitamin B12 – 20.0g; folic acid – 0.6g; biotin – 0.08g; selenium – 0.3g; vehicle q.s.p. – 1,000g.
[2]Provided per kg of product: iron - 100g, copper - 10g, cobalt - 1g; manganese - 40g; zinco - 100g, iodine – 1.5g, vehicle q.s.p. – 1,000g.
[3]Tylosin.

of 95- to 120-kg pigs fed the low-CP diet in Exp. 2 compared to 60- to 95-kg pigs in Exp.1.

Digestible lysine intake (DLI) and NE intake (NEI) of pigs in Exp. 1 were not influenced (P>0.05) by the dietary contents of CP and NE (Table 3), which may be explained by the lack of variation observed on ADFI. Although no differences on ADFI was verified, pigs fed diets with 155gk g^{-1} CP and 2566kcal kg^{-1} NE had in numerical values an increase of 11.5% on NEI and DLI intake compared to those fed the diet containing 199gk g^{-1} CP and 2566kcal kg^{-1} NE. In Exp. 2, DLI was higher (P>0.05) in pigs fed the diet with 145gk g^{-1} CP and 2588kcal kg^{-1} NE. Similarly, the NEI did not differ among pigs fed low-CP diets but was higher compared to pigs in 180g kg^{-1} CP and 2588kcal kg^{-1} NE diet (Table 3). Since digestible lysine concentration did not vary among the diets it can be concluded the variation on DLI and also on NEI was a result of the greater ADFI of pigs fed the low-CP diets.

Based on the results of NEI obtained in our studies, the thermic effect of the diet appears to be an important factor influencing the feed intake of finishing pigs under heat stress.

In Exp. 1 and 2, the average daily gain (ADG) was influenced (P<0.05) by the dietary CP and NE content (Table 3). In Exp. 1, the ADG observed in pigs fed the diet containing 155g kg^{-1} CP and 2566kcal kg^{-1} NE was similar to that of pigs fed the 155g kg^{-1} CP and 2631kcal kg^{-1} NE diet, however, it was higher compared to the ADG of pigs fed diets with 190gk g^{-1} CP and 2566kcal kg^{-1} NE. Likewise, in Exp. 2, the ADG observed in pigs fed the low-CP diets was similar, however, the 155gk g^{-1} CP and 2631kcal/kg NE diet resulted in greatest ADG compared to the diet with 190gk g^{-1} CP and 2566kcal kg^{-1} NE.

Table 3 - Effects of dietary crude protein and net energy content on performance and carcass traits of pigs from 60 to 95kg (Exp. 1) and from 95 to 120kg (Exp. 2).

Item	CP (g kg^{-1}) and NE (kcal kg^{-1}), Exp. 1			CV (%)
	199/2566	155/2631	155/2566	
Feed intake, g day^{-1}	2,793	2,923	3,115	6.75
Digestible lysine intake, g day^{-1}	26.26	27.47	29.28	6.75
Net energy intake, kcal day^{-1}	7168	7690	7994	6.78
Weight gain, g day^{-1}	1, 067b	1,121ab	1,194a	5.16
Feed conversion	2.62	2.61	2.61	6.02
Carcass traits				
Carcass meat, kg	36.97	37.23	37.96	4.45
Backfat thickness, mm	12.91	13.97	13.78	17.93
Item	CP (g kg^{-1}) and NE (kcal kg^{-1}), Exp. 2			CV (%)
	180/2588	145/2638	145/2588	
Feed intake, g day^{-1}	2,910b	3,156ab	3,200a	6.10
Digestible lysine intake, g day^{-1}	23.86b	25.88ab	26.24a	6.10
Net energy intake, kcal day^{-1}	7531b	8326a	8283a	6.10
Weight gain, g day^{-1}	875b	999ab	1037[a]	10.06
Feed conversion	3.33	3.16	3.09	8.58
Carcass traits				
Carcass meat, kg	46.28b	48.85a	47.79ab	5.47
Backfat thickness, mm	15.72	18.48	15.91	42.49

Means with different letters in the same row differ by Tukey test at 5%.

Contrary to the findings of MOURA et al. (2011), who reported no effect of NE content on ADG of 60- to 90-kg gilts, the results of our studies indicate that dietary NE content may affect the performance of pigs fed low-CP diets supplemented with industrial amino acids by favoring a higher DL and NE intakes, possibly due to the lower thermogenic effect of these type of diets. It also must be considered that the greater ADG of pigs fed the diets containing 155g kg^{-1} CP and 2566kcal kg^{-1} NE (Exp. 1) and 145gk g^{-1} CP and 2588kcal kg^{-1} NE (Exp. 2) may have occurred due to the lower energy expenditure for deamination of amino acids in excess and consecutive synthesis and excretion of urea.

Dietary CP or NE content had no effect (P>0.05) on feed conversion (FC) of pigs in Exp. 1 and 2 (Table 3). These results do not agree with that of YI et al. (2010) who verified improvements on FC of pigs by increasing dietary NE (2250 to 2450kcal kg^{-1} NE).

Feed represent the most important cost of pig production and energy is considered the first most expensive component in pig diets (LÉTOURNEAU-MONTMINY et al., 2011). In this sense, maximizing feed energy utilization of pigs by making adjustments on the supply of energy in the diet is important to lower formulation costs without compromising pigs' performance. In Exp. 1 and 2, reducing 44 and 35g kg^{-1} CP, respectively, through the reduction of soybean meal with the addition of industrial amino acids to the diet and maintaining the same dietary NE content of the diets with 199g kg^{-1} CP (Exp. 1) and 180g kg^{-1} CP (Exp.2) positively influenced the performance of pigs under heat stress.

In Exp. 1, there was no effect (P>0.05) of dietary CP or NE on the amount of meat in the carcass of pigs (Table 3). In Exp. 2, carcass meat of pigs fed the low-CP diets was similar, however, pigs fed the 145g kg^{-1} CP and 2638kcal kg^{-1} NE diet had the greatest (P<0.05) value of meat in the carcass compared to those fed the diet with 190g kg^{-1} CP and 2566kcal kg^{-1} NE (Table 3).

Similarly to our results in Exp. 1, KERR et al. (2003) verified no effect of dietary NE content on carcass traits of pigs. REZENDE et al. (2006) evaluating levels of energy for finishing barrows with energy concentrations been obtained by including soybean oil in the diets which probably contributed to increase dietary NE content (NOBLET & SHI, 1994), also found no effect on carcass traits. More recently, MOURA et al. (2011), investigating the effects of increased NE levels (2300 to 2668kcal kg^{-1}) in diets for finishing gilts observed no differences on lean meat percentage and carcass yield. PAIANO et al. (2008) in a study with finishing pigs also observed no effect of NE content on carcass weight and carcass length, loin eye area, hot carcass yield and amount of meat in the carcass. However, these same authors verified that muscle depth increased quadratically up to 2517kcal kg^{-1} NE maximum response.

Pigs fed low-crude protein diets may have fatter carcasses because these types of diets have been associated with reduction in energy losses with consecutive increase in the energy availability (LE BELLEGO et al., 2001). However, in Exp. 1 and 2, no differences (P>0.05) on backfat (BF) of pigs was verified. According to DOURMAD & NOBLET (1998), pigs selected for lean gain are less likely to have the carcass quality compromised when fed diets containing higher energy levels. These authors did not worked with low-CP diets which improve the efficiency of metabolizable energy utilization as NE further increasing this way the amount of NE available which may negatively affect carcass traits even of pigs selected for lean gain, a fact that was not observed in our study. The lack of effect of NE on BF in our study may be due to the fact that the differences among the dietary NE contents used in Exp. 1 (65kcal kg^{-1}) and Exp. 2 (50kcal kg^{-1}) were not large enough to influence carcass fatness.

In addition to the positive effects of low-crude protein diets on energy utilization by pigs, studies have been shown that lowering dietary CP supplemented with industrial amino acids besides maintaining pigs' performance also decrease N content in the manure and NH_3 emissions as a consequence. In a study with growing-finishing pigs, CANH et al. (1998) obtained a 31% reduction of N content in the manure (7.65 versus 11.13g N100 g^{-1} dry matter) and a 49% reduction of NH_3 emissions (4.79 versus 9.44g per pig per day) by lowering CP content from 165 to 125g kg^{-1}. PORTEJOIE et al. (2004) obtained 56% reduction of N content in manure and 76% reduction of NH_3 emissions in a study with finishing pigs fed low-crude protein diets. Thus, low-crude protein diets have special environmental advantages for pig production. Moreover, studies with growing and finishing pigs also has been shown that low-crude protein diets supplemented with industrial amino acids had economic advantages compared to pigs fed normal CP diets when performance was maintained (YUE & QIAO, 2008).

CONCLUSION

A reduction of 44 and 35g kg^{-1} of crude protein with adequate amino acid supplementation, maintaining the same NE content of the diets with 199g kg^{-1} CP (Exp. 1) and 180g kg^{-1} CP (Exp.2) resulted in greatest performance of 60- to 95- and 95- to 120-kg barrows, respectively.

ETHICS COMMITTEE AND BIOSAFETY

Protocol n. 2/2013

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