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PAPER

Nitrogen and energy partitioning in two genetic groups of pigs fed low-protein diets at 130 kg body weight

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Abstract

The aim was to evaluate the effect of low-protein (LP) or low-amino acid diets on digestibility, energy and nitrogen (N) utilisation in 2 genetic groups (GG) of pigs (129±11 kg BW). Duroc Large White (A) pigs were chosen to represent a traditional GG for ham production, and Danbred Duroc (D) pigs to represent a GG with fast growing rate and high carcass lean yield. Dietary treatments: a conventional diet (CONV) containing 13.2% CP, and two LP diets, one with LP (10.4%) and low essential AA (LP1), the second with LP (9.7%) and high essential AA (LP2). Compared to CONV, LP2 had the same essential AA content per unit feed, while LP1 the same essential AA content per unit CP. Feed was restricted (DMI=6.8% $BW^{0.75}$). Four consecutive digestibility/balances periods were conducted with 24 barrows, 12 A and 12 D. Metabolic cages and respiration chambers were used. No significant difference between diets was registered for digestibility. Nitrogen excreted: 41.3, 33.4 and 29.0 g/d ($P=0.009$), for CONV, LP1 and LP2 diets, respectively. Nitrogen retention was similar between the diets. Heat production (HP) was the lowest for LP diets. There was a tendency ($P=0.079$) for a lower energy digestibility in D group. The D pigs also had a higher HP and hence a lower retained energy in comparison with the A pigs. In conclusion: it is possible to reduce N excretion using very LP diets and LP low AA diets; Danbred GG have a higher heat production and a lower energy retention than A pigs.

Introduction

To be labelled as protected designation of origin (PDO) product, the Italian dry cured ham must be produced complying the Consortia guidelines establishing that at slaughter pigs must be at least 9 months old, 160 kg body weight (BW)±10%, with optimal carcass and ham fat coverings (European Commission, 1996). A restricted energy regime must be applied to achieve this goal (Mordenti *et al.*, 2003), and a further protein restriction might be required for pigs with a high potential for a fast lean growth rate (Bosi and Russo, 2004). Recently, pigs of traditional genetic groups (GG) were partially replaced by commercial pigs with a better feed efficiency, but with carcass and hams too lean for PDO ham production (Lo Fiego *et al.*, 2005). A reduction in the protein supply might be useful for these kinds of pigs. The use of low-protein diets was proposed to reduce the nitrogen (N) excretion from pig farms (Schiavon *et al.*, 2009; Galassi *et al.*, 2010; Gallo *et al.*, 2014); however, different GG pigs would perform differently when exposed to the same diet (Bosi and Russo, 2004; Peloso *et al.*, 2010). The effects of low-protein diets or low-amino acid diets on nutrient digestion, metabolism (Hoffmann *et al.*, 1990; Jentsch *et al.*, 1993; Noblet *et al.*, 1994; Schiemann *et al.*, 1989) and excretion (Scipioni and Martelli, 2001; Prandini *et al.* 2013; Zanfi *et al.*, 2014) on pigs above 120 kg BW have been studied. From 120 to 160 kg BW the use of low-protein diets might exert relatively small effects on body protein and energy partitioning, as the pigs are approaching their physiologic maturity. However, as the feed consumed in this BW range is about 50% that required for the whole production cycle, the effects of energy and protein restriction in heavy pigs of different GG need to be investigated. In this experiment was investigated the effects of diets with conventional or reduced crude protein (CP) and essential amino acids (AA) contents on the energy and N partitioning of 130 kg BW pigs belonging to a traditional or a commercial crossbred type GG were investigated.

Materials and methods

All animals were cared for in accordance with the guidelines on animal welfare in animal research of the Italian Legislative decree no. 116/1992 (Italian Regulation, 1992).

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Diets, pigs and planning of the experiments

Three experimental diets (Table 1) were fed to pigs: a control conventional diet (CONV), containing cereal meals (corn, barley and wheat, 69.1%), soybean meal (9.2%), wheat bran (8.0%), wheat middling (6.0%), minerals and supplements and two low-protein diets (LP1 and LP2) without soybean meal and supplemented with different amounts of crystalline amino acids. The CONV diet was a commercial feed with ingredients and nutritional characteristics comparable to those commonly used in the PDO dry-cured ham production circuit (Gallo *et al.*, 2014; Mordenti *et al.*, 2012). The CONV diet was formulated according to the National Research Council (2012) although a moderate lysine deficiency can be evidenced (Table 2). The CONV and LP1 diets had a comparable essential AA content per unit of CP and were formulated to contain, per kg of feed, 132 and 104 g of CP, and 4.4 and 3.5 g of standardized ileal digestible (SID) lysine, respectively. The LP2 diet was formulated to contain 97 g CP/kg and this diet had the same content of essential SID AA, compared to the CONV diet, per unit of feed. The pigs had free access to water and feed was restricted to allow a daily DMI of 6.8% of $BW^{0.75}$, as traditionally done with heavy pigs destined for the production of PDO dry-cured ham.

The trial utilized 24 barrows and consisted in 4 consecutive digestibility/balances periods. Two crossbred types were used: a traditional GG (A) obtained from Italian selection (pigs

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national breeders association: ANAS) by breeding Italian Duroc boars with Italian Large White sows and Danbred Duroc GG (D). The first genetic line was chosen because it received a genetic pressure based on carcass and ham quality traits (Fontanesi *et al.*, 2012; Cecchinato *et al.*, 2008), the second line was chosen because of the high selective pressure to increase daily gain, lean meat percentage and feed efficiency. The animals of the 2 GG were acquired from 2 commercial herds taking care that all the piglets were born within the same week.

Twenty four pigs of 101±8.4 kg BW, 12 per each of the 2 GG, were allotted in 6 pens (4 animals per pen) and fed the 3 experimental diets (2 pens per diet: 1 of A pigs and 1 of D pigs).

After 3 weeks 6 pigs (1 pig A and 1 pig D per each of the 3 diets) were housed individually in metabolic cages for the first of 4 digestibility/balances periods. Each digestibility period lasted 14 days: 7 days of cage adaptation, and 7 days of measurements to determine the digestibility of the diets and the N and energy balances. The experimental design was a factorial design, with 3 diets 2 GG 4 periods. Globally, the experiment involved 12 pigs per GG and 8 pigs per diet, and lasted 56 days. The average BW of the pigs in the trial period was 129±11 kg.

Digestibility, nitrogen and energy balances

During each of the 4 measurement periods the animals in the cages were placed individually in an open-circuit respiration chamber described by Crovetto (1984) to measure respiratory exchange over three consecutive 24 h cycles.

Heat production (HP) for each animal was calculated from Brouwer's equation (1965):

$$HP\ (kJ/d)=(16.175\ O_2)+(5.021\ CO_2)-(2.167\ CH_4)-(5.987\ N)$$

where: O_2, CO_2 and CH_4 are the volumes (l/d) of the gases at standard temperature (0°C) and pressure (760 mm Hg) conditions, consumed or produced during respiration and N is the urinary nitrogen (g/d). Corrections for personnel entrance were applied.

During the digestibility and metabolic trial pigs were fed at 08:00 and at 17:00 h. During each measurement period urine was collected individually in a vessel containing 150 mL of a 20% (vol/vol) H_2SO_4 solution to maintain the pH below 2.5 and avoid ammonia loss. Urine was weighed daily, sampled (10% of total weight), pooled per pig and frozen (-20°C) for subsequent chemical analysis. Individual fae-

Table 1. Ingredient composition (g/kg as fed) of the experimental diets.

Ingredient°	Diet		
	CONV	LP1	LP2
Corn grain	384.3	382.4	541.3
Barley grain	200.0	200.0	340.0
Wheat grain	106.7	200.9	0.0
Soybean meal	91.7	0.0	0.0
Wheat bran	80.0	80.0	40.0
Wheat middling	60.0	60.0	0.0
Cane molasses	40.0	40.0	40.0
Beef tallow	14.0	11.0	8.0
Calcium carbonate	13.5	13.7	11.5
Dicalcium phosphate	2.0	2.2	6.0
Sodium bicarbonate	2.5	2.5	2.5
Sodium chloride	3.0	3.0	3.0
Vitamin and mineral premix#	2.0	2.0	2.0
Choline HCl	0.4	0.4	0.4
L-Lysine HCl	0.0	1.4	2.8
L-Threonine	0.0	0.5	1.5
L-Tryptophan	0.0	0.1	0.5
DL-Methionine	0.0	0.0	0.5

CONV, conventional diet; LP1, low protein and low essential amino acids content diet; LP2, low protein and conventional essential amino acids content diet. °Actual daily loads of feed ingredients recorded by the weighing platforms of the feed firm. #Providing the following per kilogram of diet: vitamin A, 7200 U; vitamin D_3, 1600 U; vitamin E, 32 mg; vitamin K_3, 1.68 mg; vitamin B_1, 1.2 mg; vitamin B_2, 3.2 mg; vitamin B_6, 2.4 mg; vitamin B_{12}, 0.016 mg; d-panthotenic acid, 16.2 mg; zinc, 105 mg; copper, 16 mg; iodine, 1.5 mg; iron, 182 mg; manganese, 75 mg; selenium, 0.36 mg.

Table 2. Nutrient content (g/kg as fed, unless otherwise indicated) of the experimental diets.

	Diet		
	CONV	LP1	LP2
Analysed nutrient composition			
DM,	882	883	885
CP (N×6.25)	132	104	97
Starch	443	486	519
NDF	121	129	120
ADF	38	39	36
EE	40	38	35
Ash	44	40	40
ME, MJ/kg	13.85	13.79	13.82
Calculated nutrient composition°			
ME, MJ/kg	13.17	13.19	13.21
NE, MJ/kg	10.02	10.16	10.26
CP (N×6.25)	133	101	96
Fermentable fibre	101	84	83
Calculated total amino acid content°			
Lysine	5.5	4.3	5.1
Methionine	2.2	1.9	2.2
Threonine	4.6	3.8	4.5
Tryptophan	1.5	1.2	1.4
Calculated SID amino acid content°			
Lysine	4.4	3.5	4.4
Methionine	1.9	1.6	1.9
Threonine	3.6	3.0	3.8
Tryptophan	1.1	0.8	1.1

CONV, conventional diet; LP1, low protein and low essential amino acids content diet; LP2, low protein and conventional essential amino acids content diet; DM, dry matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; EE, ether extract; ME, metabolisable energy (determined by respiratory chambers); NE; net energy; SID, standardised ileal digestible amino acid. °According to the National Research Council (2012).

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ces were daily weighed and sampled (20% of total weight), pooled per pig and frozen (-20°C) for subsequent chemical analysis.

Feed and excreta analysis

All the diets were daily sampled to determine the DM content after drying at 55°C in a forced ventilation oven until constant weight. Furthermore, diet, faeces and urine daily samples were pooled for each period for further analysis. Before feeding, all remaining feed was removed from the trough, weighed and analysed for DM content. Analytical DM was determined by heating at 105°C for 3 h (AOAC, 1995, method 945.15), ash by incineration at 550ºC for 2 h (AOAC, 1995, method 942.05), ether extract by solvent extraction (AOAC, 1995, method 920.29), N (wet faecal samples and urine) by the Kjeldahl method (AOAC, 1995, method 984.13), starch content was determined using Megazyme kit K-TSTA (Megazyme International Ireland Ltd., Wicklow, Ireland) for total starch assay procedure according to the method 996.11 (AOAC, 1998), NDF and ADF by Ankom^{II} Fibre Analyzer (Ankom Technology Corporation, Fairport, NY) following the procedure of Mertens (2002) for NDF and Van Soest *et al.* (1991) for ADF. The GE of feeds, faeces and urine was measured using an adiabatic bomb calorimeter (IKA 4000; Ika, Staufen, Germany).

Statistical analysis

Data were analysed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC, USA) according to the following linear model:

$$y_{ijk}=\mu+diet_i+GG_j+period_k+e_{ijk}$$

where y_{ijk} is the observed trait; μ is the overall intercept of the model, $diet_i$ is the fixed effect of the i_{th} feeding treatment (i=1, …, 3), GG_j is the fixed effect of the genetic group (j=1, 2), $period_k$ is the fixed effect of the measurement period (k=1, …, 4), and e_{ijk} is the random residual. Residuals was assumed to be independently and normally distributed with a mean of zero and variance σ^2_e.

For all data, the model initially included diet×period, GG×period, and diet×GG interactions as main effects; later the effects of the interactions were excluded from the model since they were not significant. For all statistical analyses, significance was declared at P≤0.05 and trends at P≤0.10.

Results and discussion

Diets and excreta

Table 2 reports the analyses of the experimental diets in comparison with the expected data. The CP contents of the three diets were similar to those expected. On the contrary, the ME content of the three diets was higher than foreseen: on average 13.82 *vs* 13.19 MJ/kg. This has probably to be ascribed to the fact that the ME determined in the present experiment was obtained from heavy animals fed restricted, whilst the ME predicted by the National Research Council 2012 from the chemical analysis of the feedstuffs (Le Goff and Noblet, 2001; Noblet and Perez, 1993) is based on data obtained in literature and usually referred to light pigs fed ad libitum. As pointed out by Noblet and Shi (1994) the digestive ability of a heavy pig is higher than that of a lighter pig. Moreover, in the present experiment the urinary energy is low due to the low protein concentration of the diets, and this increases the ME concentration of the diets.

The LP diets did not include the soybean meal in order to decrease the CP concentration (and hence hopefully N excretion) in a physiological stage where the requirement of protein is low in comparison with previous stages (Bosi and Russo, 2004; National Research Council, 2012). Considering the feed intake of the animals fed the CONV, LP1 and LP2 diets (on average 2623, 2605 and 2580 g DM daily) and the calculated SID amino acid content of the diets (Table 2), the SID-lysine ingested with the 3 diets was 13.1, 10.3 and 12.8 g/d for the CONV, LP1 and LP2 diets, respectively. For the other essential AA supplied as crystalline AA in the LP diets (methionine, threonine and tryptophan) the ratios with lysine were similar in the 3 diets. The concentrations of lysine, methionine, threonine and tryptophan in LP2 diet were similar to those of CONV diet.

The recommendations of the National Research Council (2012) for pigs of 100-135 kg BW fed ad libitum and with a potential protein accretion of 115 g/d and an ADG of 804 g, indicates a requirement of 15.6 g/d of SID-lysine. The CONV diet supplied daily 13.1 g/d of SID-lysine. However, it has to be considered that to obtain pigs destined for the PDO ham production the growth rate must be in the order of 700 g/d, which is obtained by a restricted feeding regime.

In a recent experiment (Gallo *et al.*, 2014) suggested that for PDO pigs 13.4 and 11.7 g/d dietary SID-lysine would be adequate in the ranges of 90 to 130 and 130 to 167 kg BW, respectively. Therefore, the amounts of SID-lysine supplied in the present experiment by the CONV and LP2 diets seems adequate, whilst LP1 diet supplied a very low amount.

Considering the non-supplemented essential AA and the non-essential AA, the LP diets had certainly very low concentrations due to the low CP contents. On average, the amounts of CP ingested were 307 and 283 g/d with LP1 and LP2 diets, respectively, whereas the CP ingested with the CONV diet was equal to 392 g/d. Particularly, for the SID-isoleucine, intakes of 11.6, 7.7 and 7.0 g/d can be predicted (National Research Council, 2012) respectively with CONV, LP1 and LP2 diets, compared to 8.4 g/d recommended by the National Research Council (2012) for pigs of 100-135 kg BW with a protein accretion of 115 g/d.

The amounts of faeces and urine produced by the animals on experiment do not show significant differences between diets, whilst a difference is registered between the 2 GG for the individual urine yield: 3002 and 4854 g/d for A and D, respectively (P=0.018). The higher water intake which determined the higher urine yield might be attributed to the high voracity of the D group, as suggested by Schiavon and Emmans (2000). For environmental reasons it is preferable to have smaller volumes of slurry and therefore A genotype seems better than D under this point of view.

Apparent faecal digestibility

No significant difference between the experimental diets was registered for digestibility, (Table 3).

Looking at the differences between the 2 GG, the D group had a lower digestibility of EE (P=0.010) and a trend for a lower digestibility of DM (P=0.074) and energy (P=0.079) in comparison with the A group. A possible explanation of this phenomenon might be a higher transit rate of the feed in the gastro-intestinal tract in the D pigs. However, to our knowledge there are no papers in literature comparing the feeding behavior of these 2 GG. Indeed, the Danbred genotype has been selected to grow fast under an *ad libitum* feed regime: the high feed transit rate can reduce digestibility, but this negative effect can be counterbalanced by a higher feed intake to attain similar or even better growth performance. In the present experiment pigs were fed restricted (the daily DM intake for the 2 GG was similar, on average 2605 g), but the D pigs could have had a faster gastro-intestinal transit rate anyway, for the genetic selection applied. Moreover, the presumably higher water intake (given the higher urine yield) might have increased the GI transit time.

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Nitrogen balance

The results of the N balance are reported in Table 4. Due to the lower CP concentration, the pigs fed the LP1 and LP2 diets had lower N intakes in comparison with the pigs fed the CONV diet (-22% and -28%, respectively; P<0.001). Faecal N was similar for the 3 diets in terms of both absolute values and as percentage of the N intake.

On the contrary, the amounts of urinary N with the LP diets were much lower (P=0.006) than the amount excreted with the diet CONV. Considering the N urinary excretion as a percentage of the intake N, the reduction in comparison with the CONV diet is not significant.

Globally, the N excreted by pigs fed the CONV, LP1 and LP2 diets, was respectively 41.3, 33.4 and 29.0 g/d, with significant differences between CONV and the LP diets (P=0.009).

Nitrogen retention was similar among all the diets when expressed both in absolute values and in percentage of the N intake.

Considering the N balance of the 2 GG, the only significant difference is the N intake, slightly in favor of the A group. This is due to the fact that one pig of the D group had some orts during the digestibility period. It has to be underlined that, with a restricted feed regime even a little difference in feed intake can be statistically significant, although not so important under a practical point of view.

Energy balance

The results of the energy balance are reported in Table 5. Consistently with the low N content of the LP diets seen above, the urinary energy loss was smaller (P=0.009) with the LP diets as compared to CONV diet. However, the ME content of the 3 diets is not different. On the contrary, for HP different losses were registered between the experimental diets. Particularly, the HP associated to the LP2 diet was lower (P=0.041) than that related to the LP1 diet, probably due to the less metabolic work required by diet LP2 to excrete N as urea.

No difference was registered between the diets in terms of retained energy, whilst the respiratory quotient (RQ) was higher (P=0.008) for the LP diets (1.24) in comparison with the CONV diet (1.18). A high RQ means a high fat deposition and this is consistent with a numerically lower N retention (g/d) of the LP diets in comparison with the CONV diet. This in turn is in agreement with Bunger *et al.* (2014), which found a slightly greater fat deposition in muscle of pigs fed with low-protein diet compared with control diet.

Looking at the energy balance of the 2 GG, the trend (P=0.079) for a lower energy digestibility in the D group led to a ME for the D group significantly lower (P=0.007) in absolute values and numerically lower

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Table 3. Apparent digestibility (%) of the experimental diets at 2 genetic lines of 129 (±9) kg body weight pigs.

	Diet					Genetic line			
	CONV	LP1	LP2	SEM	P	ANAS	DANBRED	SEM	P
DM	87.2	86.9	88.3	0.75	0.314	88.0	86.8	0.44	0.074
OM	88.8	88.5	90.0	0.67	0.218	89.6	88.7	0.39	0.114
CP	84.9	81.8	82.9	1.24	0.139	83.4	83.0	0.72	0.760
EE	72.9	73.4	71.8	2.16	0.817	75.3	70.1	1.24	0.010
NDF	56.1	54.9	57.7	2.58	0.427	57.3	55.2	1.49	0.340
ADF	41.8	36.2	36.7	3.80	0.868	39.9	36.5	2.19	0.507
Energy	87.1	86.8	88.2	0.72	0.309	88.0	86.8	0.43	0.079

CONV, conventional diet; LP1, low protein and low essential amino acids content diet; LP2, low protein and conventional essential amino acids content diet; DM, dry matter; OM, organic matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre. Values refer to 24 animals with 8 replications per diet and 12 replications per genetic lines. No Diet×Genetic line interaction was recorded.

Table 4. Effects of dietary protein and essential amino acid content on nitrogen balance in 2 genetic lines of 129 (±9) kg body weight pigs.

	Diet					Genetic line			
	CONV	LP1	LP2	SEM	P	ANAS	DANBRED	SEM	P
NI, g/d	62.8[a]	49.0[b]	45.0[c]	0.31	<0.001	52.7	51.8	0.20	0.003
Faecal N									
g/d	9.30	8.89	7.69	0.607	0.269	8.57	8.68	0.350	0.823
% NI	15.1	18.2	17.1	1.24	0.139	16.6	17.0	0.72	0.759
Urinary N									
g/d	32.6[a]	24.3[b]	21.0[b]	1.93	0.006	25.4	26.6	1.53	0.517
% NI	52.0	49.2	46.0	3.58	0.623	47.8	50.4	2.41	0.400
Excreted N									
g/d	41.3[a]	33.4[b]	29.0[b]	2.19	0.009	34.0	35.2	2.00	0.568
% NI	66.2	67.7	63.7	4.20	0.738	64.4	67.3	3.25	0.453
Retained N									
g/d	21.6	15.6	15.8	2.33	0.135	18.8	16.5	2.17	0.367
% NI	33.8	32.3	36.3	4.20	0.738	35.6	32.7	3.25	0.453

CONV, conventional diet; LP1, low protein and low essential amino acids content diet; LP2, low protein and conventional essential amino acids content diet; NI, nitrogen intake. [a-c]Within a row, means without a common superscript differ (P<0.05). Values refer to 24 animals with 8 replications per diet and 12 replications per genetic lines. No Diet×Genetic line interaction was recorded.

Table 5. Effects of dietary protein and essential amino acid content on energy balance in 2 genetic lines of 129 (±9) kg body weight pigs.

	Diet					Genetic line			
	CONV	LP1	LP2	SEM	P	ANAS	DANBRED	SEM	P
EI, MJ/d	48.6[a]	48.1[a]	47.1[b]	0.26	0.009	48.3	47.5	0.15	0.001
Faecal E									
MJ/d	6.23	6.33	5.55	0.340	0.203	5.81	6.26	0.196	0.126
% EI	12.9	13.2	11.8	0.74	0.308	12.0	13.2	0.43	0.079
Urinary E									
MJ/d	1.10[a]	0.88[b]	0.75[b]	0.078	0.009	0.91	0.90	0.038	0.840
% EI	1.98	1.67	1.94	0.218	0.341	1.84	1.89	0.218	0.759
CH4 E									
MJ/d	0.27	0.27	0.29	0.051	0.981	0.25	0.31	0.029	0.167
% EI	0.65	0.57	0.51	0.074	0.433	0.51	0.64	0.060	0.122
Metabolised E									
MJ/d	41.1	40.7	40.3	0.52	0.661	41.4	40.0	0.30	0.007
% EI	84.6	84.6	85.7	0.82	0.555	85.6	84.3	0.47	0.065
HP									
MJ/d	20.7[ab]	21.4[a]	19.9[b]	0.40	0.041	19.9	21.4	0.33	0.005
% EI	42.3	44.6	42.5	0.99	0.069	41.2	45.1	0.57	<0.001
Retained E									
MJ/d	20.6	19.2	20.3	0.80	0.240	21.5	18.6	0.46	0.001
% EI	42.3	40.0	43.2	1.57	0.159	44.4	39.2	0.90	0.001
RQ	1.18[b]	1.24[a]	1.24[a]	0.014	0.008	1.24	1.20	0.008	0.003

CONV, conventional diet; LP1, low protein and low essential amino acids content diet; LP2, low protein and conventional essential amino acids content diet; EI, energy intake; E, energy; HP, heat production; RQ, respiratory quotient. [a,b]Within a row, means without a common superscript differ ($P<0.05$). Values refer to 24 animals with 8 replications per diet and 12 replications per genetic lines. No Diet×Genetic line interaction was recorded.

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($P=0.065$) in percentage of the ingested energy. The D pigs had also a higher HP and this determined a lower RE ($P=0.001$) in comparison with the A pigs, both in absolute and relative values. The higher HP is likely due to the high-energy expenditure of more nervous and active animals. Unfortunately the metabolic cages and the respiration chambers were not equipped with sensors to register the animal activity and behavior. However, we noticed clearly that the D pigs were in general more active than the A pigs, both in the cages and in the pens.

The RQ is lower ($P=0.003$) for the D pigs, and this is consistent with the traits of this GG, particularly selected for lean meat and consequently with a low back fat depth.

Conclusions

The overall experimental data obtained indicate that the LP diets are effective in decreasing N excretion significantly with no detrimental influence on nitrogen retention. Between the two low-protein diets, the LP2 had a lower energy loss in comparison with the LP1. Looking at the genetic groups, no difference was registered for the N balance, whilst A pigs had better energy utilization as compared to D pigs. The A pigs fed LP diets seem the most promising solution in view of a good dietary energy and nitrogen utilisation in the last fattening period of the heavy pigs.

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