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(Article begins on next page)

PAPER

Effect of dietary protein level (as substitution of maize with soybean meal) on growth rate and feed efficiency of the Cinta Senese pig in the growing-fattening period

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Abstract

This study aimed to provide first indications on the protein requirement of Cinta Senese pigs. The effect of various dietary protein contents on *in vivo* performance was tested. Sixty Cinta Senese pigs were equally distributed in four dietary groups, balanced for sex (barrow and gilt) and live weight. At the start of the trial, pigs were approximately 130 d old and weighed an average 46.6 kg. Groups were fed four diets with different protein content (approximately 8, 10, 13 and 16%, named 8% P, 10% P, 13% P, 16% P, respectively), obtained by using different maize/soybean meal ratios. Diets were administered to pigs during the entire growing-fattening period in a controlled dose of 90 g/kg $W^{0.75}$, until a maximum of 2.5 kg/d *pro capite*. Feed distributed per pen was recorded daily and individual weight and ultrasonic backfat thickness were periodically recorded. The trial lasted approximately 250 d and finished when animals reached the target slaughter weight of 145 kg.

The 8% P diet determined a lower growth rate than the other diets; after 250 d, pigs receiving this diet were 20 kg lighter than those receiving the other diets. The 10% P diet determined body weights always lower than the 13% P and 16% P diets, but the difference decreased in the middle of the trial period. The pigs fed 13% P and 16% P diets showed the same growth rate. Moreover, through the whole growth period, the 8% P diet produced higher fat thickness than the other three diets which showed similar results. The 8% P diet determined the highest FCIs. The 16% P diet showed the best feed conversion until approximately 70 kg of l.w., but after this weight it became progressively

less efficient than the 10% P and 13% P diets. Consequently, the cumulative intake of that diet was the lowest only for the first 60 kg of gain. The 10% P diet gave the best FCI starting from 80 kg of l.w. In consideration of the cost of protein feed and the need to reduce N pollution, the 10% P diet could be the optimal compromise for growth-fattening in the Cinta Senese pig, certainly over 70 kg of l.w.

Introduction

Even though protein requirements in the pig have been widely studied (see review of Whittemore *et al.*, 2001), the genetic improvement in swine demands a continuous calibration of diet to avoid both deficiency and excess of protein input, since excess is also counterproductive for both growth and feeding efficiency (Campbell *et al.*, 1984; Hansen and Lewis, 1993; Nieto *et al.*, 2002, 2003; Barea *et al.*, 2006, 2007). Moreover, the excess of protein increases feeding costs and determines higher N pollution in the environment because of the higher excretion of protein which remains unused in the syntheses (Whittemore *et al.*, 1995; Dourmad *et al.*, 1999).

The recent recovery of the Italian autochthonous pig breeds, with a low potential for lean growth and high adipogenic capacity (Franci *et al.*, 2001; Gandini *et al.*, 2001), suggests the need to determine, also in these strains, the adequate amount of protein in the diet since it is difficult for the standard requirements recommended for the improved genetic types to be applied (ARC, 1981; NRC, 1998). Moreover, these pigs are often reared in extensive systems on natural pasture. Diet composition can, therefore, vary to compensate for the nutritive characteristics of natural resources rich in fibre and low in protein, avoiding the use of amino acid integration in the case of an organic system and of the feeding system for the "Suino Cinto Toscano" POD, as prescribed by European regulations (European Commission, 2008; INEQ, 2007; respectively). In these, the most common rearing systems of the breed, optimal formulation of diet can be difficult, even using vegetal feed with high biological protein value, such as soybean meal.

In the Iberian pig, a Spanish autochthonous breed, some studies tested the protein requirement from 15 to 50 kg (Nieto *et al.*, 2002) or from 50 to 100 kg of l.w. (Barea *et al.*, 2006), but there is no information on the subsequent fattening period. Nevertheless, this

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Key words: Dietary protein, Growth rate, Feed conversion, Cinta Senese, Pig.

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pig is usually slaughtered at a live weight of approximately 150 kg. These studies indicated that the optimal protein content of diet should be 13% and 9.5% on DM, until 50 kg, and from 50 to 100 kg of l.w., respectively. High protein content, as applied on the improved pig, had some depressive effects on growth and feed efficiency of the Iberian pig (Nieto *et al.*, 2003; Barea *et al.*, 2006). However, there is no information of this kind available on local Italian pigs which belong to the same Mediterranean pig type as the main Iberian strains (Delgado *et al.*, 2001). Within the Italian breeds, Cinta Senese is the most widespread and several productive traits have been studied (Acciaioli *et al.*, 2002; Franci *et al.*, 2005; Pugliese *et al.*, 2005). Some information on its digestive capability and ability to utilize protein was obtained with in cage experiments (Acciaioli *et al.*, 2003a, 2003b; Pianaccioli *et al.*, 2004), but there are no findings able to provide field indications about dietary protein content.

This study aimed to provide first indications on the protein requirement of Cinta Senese pigs according to the current rearing system, testing the effect of various dietary protein contents on the *in vivo* performance during the growing-fattening period.

Materials and methods

Sixty Cinta Senese pigs were equally distributed in four experimental dietary groups, balanced for sex and live weight. Before the trial, pigs were maintained in the same conditions and the trial was preceded by a 10 d period of adaptation to experimental diets. Each group was subdivided in two pens of approximately 20 m² each, again balanced for sex and homogeneous for l.w., and containing the 7 heaviest (3 gilts and 4 barrows) and the 8 lightest (4 gilts and 4 barrows) subjects (pen density: 7N and 8N, respectively) to reduce pen competitiveness. At the beginning of the trial, pigs were approximately 130 d old and weighed an average 46.6 kg. Groups were fed four diets, named 8% P, 10% P, 13% P, 16% P, with different protein content (approximately 8 %, 10 %, 13 % and 16 %, respectively) and with similar ME content (Table 1). Feeding occurred twice a day. Diets were formulated with the aim of covering a wide range of protein content and so an unusual ingredient for the pig, such as wheat straw, was used to make up the diets with a lower protein content than that of cereals. Moreover, to simulate the usual feeding regimen of the Cinta Senese pig, which is often in natural pasture (often feeding on acorns and chestnuts which have a low protein content) with a moderate supplement of farm vegetable resources (sometimes in an organic rearing regimen), no amino acidic integration was provided. Therefore, diets also differed in lysine and methionine content (Table 1).

Diets were administered to groups during the entire trial period with no differentiation between the growing and fattening periods. Feed was given in a controlled dose of 90 g/kg of metabolic weight until 80 kg l.w. and 80 g/kg subsequently, calculated on the average pen weight, until a maximum of 2.5 kg/d *pro capite*. The effective amount of feed distributed per box was recorded daily. Since no residues were left, the ration was considered totally ingested. Ration adjustment occurred every three or four weeks when subjects were individually weighed and controlled for backfat thickness (10 to 13 records per subject). The latter was measured using an ultrasound apparatus at two locations: at last thoracic vertebra and at gluteus medius, four centimeters lateral to the medial line. The trial lasted an average 250 d and finished when animals reached the target slaughter weight of 145 kg, remaining on trial no longer than 289 d.

Statistical analysis

Data were analyzed using SAS Proc GLM

(SAS, 2007). For the repeated measurements, such as weight and backfat thickness during growth, the following model was used:

$$Y_{ijklm} = \mu + D_i + G_j + N_k + S_{ijkl} + b_1 X_{ijklm} + E_{ijklm}$$

Where

Y = mth observation of the ith subject of kth pen density, jth gender and ith dietary group;

D = diet effect (i = 1...4);

G = gender effect (j = 1, 2);

N = pen density effect (k = 1, 2);

S = subject effect within diet, gender and pen density;

X = independent variable (weight or age) tested up to the third degree;

E = error random effect

Data relative to feed intake per pen were used to calculate the food conversion index (FCI) during the sub-periods delimited by the two successive records of body weight. The average FCI per pen was then referred to as the average pen weight of the pertinent sub-period. Since pigs were slaughtered when they reached the target weight, the number of animals in the pens decreased progressively because of the individual variability in growth rate, and so the feed intake records were considered useful only while pens contained all the pigs initially allocated to them. Data were analyzed with the model:

$$Y_{ijk} = \mu + D_i + P_j + b_j X_{ijk} + E_{ijk}$$

Where

Y = kth observation of the jth pen of the ith dietary group;

D = diet effect (i = 1...4);

P = pen effect within diet;

X = independent variable (average weight per pen and per sub-period) tested up to the third degree;

E = error random effect

A similar model was used to test the relationship between the cumulative feed intake and the body weight gained on trial.

The previous models were employed to provide estimates of the dependent variable at specific values of the independent variable (age on trial or weight). Student's t-test was used to statistically test the differences between the obtained l.s. means (\pm s.e.).

Results

The initial conditions of the experimental subjects are reported in Table 2. Pigs were distributed in the four dietary groups according to similarity of body weight. This also meant they had similar backfat thickness. Also, the characteristics of the piglets of the two genders were

similar whereas the 8N pens contained lighter animals than the 7N ones, with no significant difference in fatness.

The growth rate of the pigs is expressed by the weight reached at specific ages on trial (Table 3), estimated along the individual relationships weight/age. The 8% P diet determined lower weights than the other diets since during the first phases of the trial, after 250 d, it produced pigs 20 kg lighter than those produced by the two diets with the highest protein contents. The 10% P diet determined body weights always lower than the 13% P and 16% P diets, but the difference was high in the first phase and decreased in the middle of the experimental period. The pigs fed 13% P and 16% P diets showed the same body weights at all ages.

Differences between genders are always in favor of barrows, also considering possible feeding competitiveness since each pen contained animals of both sexes.

The effect of the diets on the growth rate is summarized in Figure 1 which shows the trend of the instantaneous average daily gain obtained as first derivative of the weight/age relationships. The Figure highlights: i) the continuous worst performance of the 8% P diet; ii) the slow growth rate during the first 50-60 days and the subsequent higher growth determined by the 10% P diet; iii) the similar results produced by the diets at 13% and 16% of protein content.

Results for fatness, measured as backfat thickness, have been reported in relation both to age on trial (Table 4) and to body weight (Table 5). In the former case, the experimental diets behaved in a similar manner with sporadic differences at 100 and 150 days when the 13% P diet showed the highest thickness, at least in absolute value. As this concerns the gender effect, barrows showed the highest body fatness at almost all ages. The situation changes when the body weight is considered the variable of reference (Table 5). The 8% P diet produced, throughout the whole growth period, fatter pigs than the other three groups that showed the same results. As far as gender is concerned, females had thicker backfat at the highest body weight than barrows.

As reported in the Materials and methods section, data of feed intake and of FCI were considered *per pen* and *per sub-period* and recorded only until the pen maintained all the initial animals. So the upper limit of the investigated weight range was approximately 120 kg. Tables 6 and 7 show the trend of FCI with body weight increase and the cumulative amount of feed ingested according to weight gain on trial, respectively. The 8% P diet



appeared to have the poorest performance and determined the highest instantaneous FCI at all body weights, so that approximately 35 % more of this diet was administered than the other diets in order to achieve a 70 kg weight gain. The 16% P diet showed the best feed conversion until approximately 70 kg of l.w., but it became progressively less efficient than the other two diets (10% P and 13% P). Consequently, the cumulative intake of this feed was the lowest only for the first 60 kg of gain, corresponding to an average final weight of 100 kg. The 10% P diet gave the best FCI starting from 80 kg of l.w., at least in absolute value, as a consequence of the highest growth rate during the intermediate phase of the trial (Figure 1). This fact determines a progressive improvement of the overall efficiency of this diet, in relation to the other diets with higher protein content, with the lowest amount of feed employed to gain 80 kg in the trial.

Discussion

The Cinta Senese pig is reared in a free range system by exploiting natural resources (grass, acorn, chestnut and root) but usually, during some seasons and/or growing periods, it is widely supplemented with feed of commercial or farm origin (mixtures, cereals, etc.). Unfortunately, the effective protein requirement in the breed has still not been determined even if it is probably lower than that of the improved pig, as was reported for the Iberian pig, another breed with a low potential for lean tissue deposition (Nieto *et al.*, 2002; Barea *et al.*, 2007). The present trial was designed to provide first indications on the growth performance of the breed as determined by different protein levels in the diets, from well in excess to marginal deficiency. As in other similar experiments on pigs belonging both to improved and unimproved breeds (Campbell *et al.*, 1984; Hansen and Lewis, 1993; Barea *et al.*, 2006.), in this trial, a wide range of protein content has been tested starting from a value lower than that of cereals (8%). To reach this level, diets were diluted with straw meal instead of the maize starch used in other trials (Campbell *et al.*, 1984; Le Bellego *et al.*, 2001; Barea *et al.*, 2006). This aimed to both simulate the feeding habit of a breed that always has natural resources rich in fibre at its disposal (grass, roots, etc.), and to avoid the use of high energy diets, unsuitable in the feeding of typically obese pigs. Moreover, owing to the impracticality of individual penning and feeding, in this experiment

Table 1. Composition and nutritive properties of the diets.

| | Diet | | | |
|------------------------------------|-------|-------|-------|-------|
| | 8%P | 10%P | 13%P | 16%P |
| Ingredients, % | | | | |
| Maize | 67 | 60 | 52 | 43 |
| Barley | 18 | 18 | 18 | 18 |
| Soybean meal | 0 | 7 | 15 | 24 |
| Wheat straw meal | 12 | 12 | 12 | 12 |
| Mineral vitamin premix | 3 | 3 | 3 | 3 |
| Proximate analysis, % as-fed basis | | | | |
| Moisture | 11.83 | 11.89 | 11.50 | 11.22 |
| Crude protein | 7.81 | 10.26 | 13.02 | 16.46 |
| Ether extract | 1.81 | 1.65 | 1.68 | 1.74 |
| Crude fibre | 6.55 | 6.74 | 6.83 | 7.32 |
| Ash | 4.50 | 4.98 | 5.17 | 5.85 |
| Lysine* | 0.21 | 0.37 | 0.57 | 0.79 |
| Methionine* | 0.14 | 0.17 | 0.20 | 0.24 |
| M.E.*, MJ/kg | 12.92 | 12.86 | 12.78 | 12.70 |

*determined as sum of the tabulated values of the ingredients.

Table 2. Initial body weight and backfat thickness (mean of two locations) of experimental pigs.

| | Diet | | | | Gender | | Pen density | | RSD |
|-----------------------|------|------|------|------|--------|------|-------------------|-------------------|-----|
| | 8%P | 10%P | 13%P | 16%P | Barrow | Gilt | 8N | 7N | |
| Weight, kg | 46.4 | 46.7 | 47.7 | 46.6 | 47.0 | 46.7 | 43.4 ^a | 50.3 ^b | 5.1 |
| Backfat thickness, mm | 13.6 | 14.0 | 14.3 | 13.5 | 14.0 | 13.7 | 13.5 | 14.2 | 1.7 |

^{a,b}within criterion means with different letters differ (P< 0.05).

Table 3. Estimates of body weight (kg) at specific days of trial according to the individual regression lines within diet (l.s. means ± SE).

| Days on trial | Diet | | | | Gender | |
|---------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 8%P | 10%P | 13%P | 16%P | Barrow | Gilt |
| 20 | 52.0±0.28 ^a | 53.1±0.28 ^b | 55.9±0.29 ^c | 55.5±0.28 ^c | 54.2±0.19 | 54.0±0.2 |
| 50 | 64.1±0.30 ^a | 67.5±0.31 ^b | 71.1±0.31 ^c | 70.6±0.31 ^c | 68.8±0.21 ^a | 67.9±0.23 ^b |
| 100 | 84.7±0.30 ^a | 93.2±0.30 ^b | 96.2±0.30 ^c | 95.4±0.30 ^c | 93.9±0.20 ^a | 90.8±0.22 ^b |
| 150 | 104.0±0.31 ^a | 117.5±0.33 ^b | 119.1±0.33 ^c | 118.3±0.33 ^c | 117.5±0.23 ^a | 112.0±0.23 ^b |
| 200 | 120.0±0.31 ^a | 136.3±0.32 ^b | 138.0±0.33 ^c | 137.8±0.32 ^c | 136.1±0.22 ^a | 130.0±0.23 ^b |
| 250 | 130.5±1.0 ^a | 145.7±1.11 ^b | 151.1±1.20 ^c | 152.2±1.16 ^c | 146.7±0.82 ^a | 143.0±0.79 ^b |

^{a,b,c}within criterion means with different letters differ (P< 0.05).

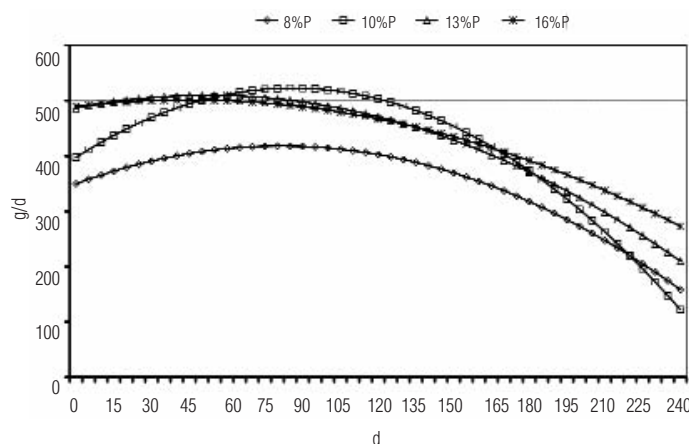


Figure 1. Trends of growth rate (g/d) in the trial period (d) of the pigs fed the four diets, obtained as first derivative of the weight/age relationships.

distribution between pens of the two initial batches of animals was homogeneous for weight, regardless of sex, to limit feeding competitiveness within the pen. This option did not allow the nutritive requirements of females and barrows to be estimated separately. These requirements differ at least in the improved breeds where gilts showed a better use of protein for body growth than barrows (Hansen and Lewis, 1993; Critser *et al.*, 1995). However, this experimental scheme is in accordance with the actual rearing system of the Cinta Senese pig which groups barrows and gilts together. Finally, the same diet was used from 50 kg to slaughter, according to the actual feeding system of the breed, but the continuous study of individual growth within each diet allows the optimal modification of the dietary protein content for the Cinta Senese during the whole growing-fattening period to be estimated.

Given the above considerations, results highlighted that the diet with the lowest protein content (8%) is unsuitable for the Cinta Senese pig as it gave the worst performances for growth and feed efficiency through the whole period studied. So this diet seems comparatively inadequate also in this breed, in spite of its low potential for lean tissue deposition, using 36% more feed than the other three diets for an increase of approximately 80 kg of body weight. Diets at a similar low protein level have not been tested in the improved pig breeds, at least in the examined literature (Hansen and Lewis 1993; Chen *et al.*, 1995; Critser *et al.*, 1995; Tuitoek *et al.*, 1997; Chen *et al.*, 1999) but they were used in trials involving local pigs, such as the Iberian breed. In this pig, growing between 50 and 100 kg l.w., a diet with 8.4% of ideal protein produced better results in ADG and food/gain than the other tested diets (12.8%, 10.6% and 6.2% of CP) (Barea *et al.*, 2006). This disagrees in part with the present trial, in which a similar protein level (8%) produced the worst performance and the achievement of 10% of CP seems mandatory to obtain adequate results. However, it must be remembered that the present trial did not use ideal protein since it aimed to simulate the current feeding system of the Cinta Senese, generally based on farm ingredients without amino acid integration, often in respect of the rules of an organic system (European Commission, 2008) or of the Consortium "Suino Cinto Toscano" PDO (INEQ, 2007). Moreover, in the experiment reported by Barea *et al.* (2006), diets with the lowest protein content produced the fattest carcasses, in agreement with the present results relative to backfat thickness. However, it must be noted that the better diet

Table 4. Estimates of backfat thickness (mm) (average of two localizations) at specific days of trial according to the individual regression lines (l.s. means \pm SE).

| | Diet | | | | Gender | |
|---------------|------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|------------------------------|
| | 8% P | 10% P | 13% P | 16% P | Barrow | Gilt |
| Days on trial | | | | | | |
| 50 | 16.8 \pm 0.35 | 17.2 \pm 0.35 | 17.9 \pm 0.35 | 17.3 \pm 0.35 | 17.6 \pm 0.24 | 17.0 \pm 0.25 |
| 100 | 21.6 \pm 0.38 ^a | 21.8 \pm 0.40 ^a | 23.0 \pm 0.39 ^b | 22.4 \pm 0.39 ^{ab} | 22.7 \pm 0.27 ^a | 21.7 \pm 0.29 ^b |
| 150 | 27.4 \pm 0.38 ^a | 27.7 \pm 0.39 ^{ab} | 28.7 \pm 0.38 ^b | 28.3 \pm 0.39 ^{ab} | 28.6 \pm 0.26 ^a | 27.4 \pm 0.28 ^b |
| 200 | 34.2 \pm 0.40 | 34.9 \pm 0.41 | 34.9 \pm 0.42 | 35.0 \pm 0.42 | 35.4 \pm 0.29 ^a | 34.1 \pm 0.30 ^b |
| 250 | 41.9 \pm 0.79 | 43.4 \pm 0.86 | 41.7 \pm 0.91 | 42.6 \pm 0.89 | 42.9 \pm 0.62 | 41.8 \pm 0.6 |

^{a,b}within criterion means with different letters differ (P<0.05).

Table 5. Estimates of backfat thickness (mm) (average of two localizations) at specific body weights according to the individual regression lines (l.s. means \pm SE).

| | Diet | | | | Gender | |
|-----------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| | 8% P | 10% P | 13% P | 16% P | Barrow | Gilt |
| Body weight, kg | | | | | | |
| 60 | 15.9 \pm 0.44 | 15.8 \pm 0.47 | 15.9 \pm 0.53 | 15.5 \pm 0.53 | 15.9 \pm 0.33 | 15.7 \pm 0.37 |
| 80 | 21.4 \pm 0.43 ^a | 19.3 \pm 0.44 ^b | 19.5 \pm 0.44 ^b | 19.0 \pm 0.44 ^b | 19.8 \pm 0.30 | 19.9 \pm 0.32 |
| 100 | 29.6 \pm 0.47 ^a | 24.2 \pm 0.48 ^b | 24.4 \pm 0.47 ^b | 24.0 \pm 0.46 ^b | 25.2 \pm 0.33 | 25.9 \pm 0.33 |
| 120 | 40.5 \pm 0.86 ^a | 30.5 \pm 0.42 ^b | 30.4 \pm 0.42 ^b | 30.6 \pm 0.43 ^b | 32.2 \pm 0.39 ^a | 33.8 \pm 0.41 ^b |
| 140 | 54.0 \pm 1.82 ^a | 38.2 \pm 0.51 ^b | 37.6 \pm 0.50 ^b | 38.6 \pm 0.59 ^b | 40.7 \pm 0.67 ^a | 43.5 \pm 0.77 ^b |

^{a,b}within criterion means with different letters differ (P<0.05).

Table 6. Estimates of instantaneous Feed Conversion Index (kg of feed/kg of weight gain - pen base record) at specific body weights according to the pen regression lines (l.s. means \pm SE).

| | Diet | | | |
|-----------------|------------------------------|-------------------------------|-------------------------------|------------------------------|
| | 8% P | 10% P | 13% P | 16% P |
| Body weight, kg | | | | |
| 60 | 4.76 \pm 0.22 ^a | 4.22 \pm 0.22 ^a | 4.27 \pm 0.24 ^a | 3.47 \pm 0.25 ^b |
| 70 | 4.54 \pm 0.23 ^a | 3.90 \pm 0.24 ^{ab} | 4.11 \pm 0.23 ^{ab} | 3.63 \pm 0.23 ^b |
| 80 | 4.83 \pm 0.22 ^a | 3.74 \pm 0.23 ^b | 4.12 \pm 0.22 ^b | 3.90 \pm 0.23 ^b |
| 90 | 5.53 \pm 0.24 ^a | 3.83 \pm 0.22 ^b | 4.34 \pm 0.21 ^b | 4.33 \pm 0.22 ^b |
| 100 | 6.55 \pm 0.24 ^a | 4.26 \pm 0.24 ^c | 4.80 \pm 0.23 ^{bc} | 4.94 \pm 0.23 ^b |
| 110 | 7.76 \pm 0.30 ^a | 5.10 \pm 0.24 ^c | 5.56 \pm 0.24 ^{bc} | 5.76 \pm 0.23 ^b |
| 120 | 9.07 \pm 0.79 ^a | 6.43 \pm 0.26 ^b | 6.65 \pm 0.25 ^b | 6.82 \pm 0.32 ^b |

^{a,b,c}within criterion means with different letters differ (P<0.05).

Table 7. Estimates of cumulative feed efficiency [feed intake (l.s. means \pm SE in kg) employed for a specific weight gain in pigs of the four dietary treatments].

| | Diet | | | |
|-----------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| | 8% P | 10% P | 13% P | 16% P |
| Body weight, kg | | | | |
| 10 | 54.22 \pm 1.63 ^a | 46.84 \pm 1.72 ^b | 42.16 \pm 1.92 ^b | 36.03 \pm 1.92 ^c |
| 20 | 101.86 \pm 1.72 ^a | 87.41 \pm 1.71 ^b | 83.94 \pm 1.67 ^b | 73.36 \pm 1.67 ^c |
| 30 | 147.46 \pm 1.59 ^a | 124.30 \pm 1.74 ^b | 122.94 \pm 1.71 ^b | 109.68 \pm 1.71 ^c |
| 40 | 195.82 \pm 1.55 ^a | 160.76 \pm 1.55 ^b | 162.37 \pm 1.53 ^b | 147.79 \pm 1.53 ^c |
| 50 | 251.73 \pm 1.78 ^a | 200.02 \pm 1.58 ^c | 205.43 \pm 1.54 ^b | 190.46 \pm 1.55 ^d |
| 60 | 320.00 \pm 1.65 ^a | 245.32 \pm 1.80 ^b | 255.32 \pm 1.75 ^c | 240.47 \pm 1.74 ^b |
| 70 | 405.43 \pm 2.17 ^a | 299.90 \pm 1.75 ^c | 315.23 \pm 1.70 ^b | 300.60 \pm 1.69 ^c |
| 80 | 512.00 \pm 6.21 ^a | 366.98 \pm 1.64 ^b | 388.38 \pm 1.64 ^c | 373.64 \pm 2.05 ^d |

^{a,b,c,d}within criterion means with different letters differ (P<0.05).



(8.4% CP) tested by Barea *et al.* (2006) had the same ME content of our 8% diet (14.6 MJ/kgDM) but almost three times the lysine content (0.57 *vs* 0.21).

The comparison among the three other diets showed that, as regards growth rate, the best performances were reached in the same manner with the two diets at the highest protein content, while the carcass adiposity was similar for all the three diets. So, a 13% protein content in the diet, almost as in this formulation, seems to be the optimal level for the Cinta Senese pig during the growing and fattening period, representing an adequate compromise between performance and protein use. Still, the study of instantaneous FCI and cumulative feed intake (Tables 6 and 7) provides more details on the effective modification of these diets through the growth and fattening period of the breed. The 16% P diet seems preferable during growth up till 70 kg of l.w., but subsequently it is better to use diets with a lower protein content, down to 10% P. In fact, the 10% P diet gave the best FCI starting from 80 kg of l.w. and, overall, the least amount of feed intake to produce 80 kg of weight gain on trial.

These results are in general agreement with the literature which demonstrates that, in growing swine given limited amounts of feed, protein in excess of requirements impaired growth and feed efficiency. This happened both in the improved breeds (Campbell *et al.*, 1984; Hansen and Lewis, 1993), and in the local pig (Barea *et al.*, 2006), identifying the optimal CP level at 16-18% for the former, and at 10-11 % for the latter, during growth up till 100 kg l.w. According to these Authors, the growth-decreasing effect of high protein diets may be due to their reduced NE value that is associated with increased protein levels. Excess protein intakes probably determine a higher rate of protein turnover and thus higher rates of heat production which reduces the efficiency of ME utilization.

Conclusions

In spite of the limitations discussed above (group penning and feeding, use of non-ideal protein), the trial provides first indications on the protein requirement of the Cinta Senese pig during the growing and fattening phases, at least in usual rearing and feeding conditions. A diet with 8% of protein is to be considered inadequate even for this breed with a low potential for lean tissue deposition. Diets with protein content above the 10%, up to 16%, determined similar growth rate, feed conver-

sion index and body fatness, evaluated as back-fat thickness. However, the complete picture obtained modifying the results on instantaneous FCI and cumulative feed intake suggests that a high protein diet (16% of CP) is really only useful up to 70 kg l.w. Considering the cost of high protein feed and the need to reduce N pollution in the environment, the 10% P diet, at least in the tested formulation, can probably be considered the optimal compromise for the growth-fattening of the Cinta Senese pig, certainly over 70 kg of live weight.

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