Effect of feeding level during the period previous to free-range fattening on growth and carcass characteristics in Iberian pigs

A. Daza[1], A. Mateos[1], A. I. Rey[2] and C. J. López Bote[2]

[1] *Departamento Producción Animal. Escuela Técnica Superior de Ingenieros Agrónomos.*
Universidad Politécnica. 28040 Madrid. Spain
[2] *Departamento Producción Animal. Facultad de Veterinaria. Universidad Complutense. 28040 Madrid. Spain*

Abstract

This study was principally undertaken to provide information of the influence of feeding level during the period prior to fattening on growth and carcass traits of Iberian pigs finished under free-range conditions with acorns and grass. During the period prior to fattening, a group of 11 pigs (high feeding level, H) was fed with 70 g feed kg^{-1} $LW^{0.75}$ (live weight) and another group of 11 pigs (low feeding level, L) was fed with 50 g feed kg^{-1} $LW^{0.75}$. The pigs average daily gain for prior to fattening, free-range and whole periods were: 385.4 and 168.9 (P < 0.001), 508.4 and 582.1 (P < 0.05) and 430.5 and 320.5 (P < 0.05) g day^{-1} in H and L pigs respectively. The H and L pigs' slaughter weights were 166.2 and 138.4 kg (P < 0.01). Feeding level during the period prior to the fattening period had no significant effect on backfat thickness and *Longissimus dorsi* (LD) area measured at the level of the last rib, LD intramuscular fat percentage and carcass hams, forelegs, loins, sirloin and total cut amounts. The correlation coefficients between pig growth rate during the whole period and carcass hams, forelegs and total cut amount were 0.95, 0.92 and 0.95 respectively. The interaction between the feeding level prior to the free-range period and carcass weight was studied for carcass traits.

Additional key words: carcass traits, compensatory growth, prior to free-range feeding level.

Resumen

Efecto del nivel de alimentación administrado durante la premontanera sobre el crecimiento y características de la canal de cerdos ibéricos

El objetivo principal de este estudio fue analizar el efecto del nivel de alimentación de premontanera sobre el crecimiento y características de la canal de cerdos ibéricos cebados en montanera exclusiva. Un grupo de 11 cerdos fue diariamente alimentado con 70 g de pienso por kg de peso metabólico durante la premontanera (nivel de alimentación alto, A) y otro grupo de 11 cerdos con 50 g de pienso por kg de peso metabólico (nivel de alimentación bajo, B) durante el mismo periodo. La ganancias medias diarias durante la premontanera, montanera y periodo total fueron: 385,4 *vs* 168,9 g (P < 0,001), 508,4 *vs* 582,1 g (P < 0,05) y 430,5 *vs* 320,5 g (P < 0,05), respectivamente, en los cerdos A frente a los B. Los pesos al sacrificio de los cerdos alimentados con el nivel A y B fueron 166,2 y 138,4 kg respectivamente. El nivel de alimentación de premontanera no tuvo influencia significativa sobre el espesor de grasa dorsal, área del músculo *Longissimus dorsi* (LD), medidos a nivel de la última costilla, porcentaje de grasa intramuscular del LD y cantidades de jamón, paleta, lomo, solomillo y total de partes nobles de la canal. Los coeficientes de correlación entre la ganancia media diaria durante el periodo total experimental y las cantidades de jamón, paleta y total de partes nobles de la canal fueron 0,95, 0,92 y 0,95, respectivamente. Este trabajo estudia la interacción entre el nivel de alimentación de premontanera y el peso canal para las características de la canal.

Palabras clave adicionales: calidad de la canal, crecimiento compensatorio, nivel de alimentación en premontanera.

Introduction

The Iberian pig is a native breed from the southwest Iberian Peninsula traditionally fed under free-range conditions during the late finishing period in a Mediterranean forest ecosystem with acorn and grass fully available. Quality characteristics of these pigs are highly recognized for the market. The commercial weight at slaughter of the Iberian pig ranges from 140 to 180 kg. Prior to the finishing phase, they are fed with mixed diets for 5-6 months, in confinement or under outdoor conditions (Daza, 2001).

In pigs fed under intensive conditions, it has been shown that the feeding level during the period previous to the late fattening phase influences growth at fattening and carcass characteristics at slaughter (Critser *et al.,* 1995; Lovatto *et al.,* 2000; Daza *et al.,* 2003). However, to our knowledge, there is not information available of the effect of feeding during the growing period on performance and carcass characteristics in pigs fed extensively. This is a matter of interest, since feed intake, exercise, and many other aspects linked to extensive feeding have been reported to affect carcass and meat quality characteristics, and this in turn may be influenced by the amount feed provided during the period before the late fattening phase (López Bote, 1998).

The objective of this study was to assess the effect of feed restriction during the period prior to the fattening period on growth during fattening phase under free-range conditions and on carcass characteristics in Iberian pigs.

Material and Methods

Animals and diets

Twenty two Iberian barrows of the Torbiscal line (El Deheson del Encinar, Junta de Comunidades de Castilla-La Mancha, Oropesa, Toledo, Spain) with an average initial live weight of 55.07 kg (standard error of mean, SE = 0.80 kg) were used. A group of 11 pigs weighting 54.75 ± 2.69 kg was fed a feeding level (FL) of 70 g feed kg^{-1} $LW^{0.75}$ (high feeding level, H) during the period prior to the fattening period under free-range conditions (164 days from May to November) and another group of 11 pigs weighting 55.40 ± 2.81 kg was fed a feeding level of 50 g feed kg^{-1} $LW^{0.75}$ (low feeding level, L) for the same period. Ingredients and major nutrients of the experimental diet are shown in Table 1. During fattening, all pigs were fed under free-range conditions for a period of 95 days in a *Quercus ilex* forest with fully available acorns and grass. The stocking rate in the free-range feeding phase was 0.7 pigs ha^{-1}.

Measurements and analysis

The chemical composition of the diet was determined according to AOAC (2000) procedures.

On all pigs, measurements were obtained at the beginning of the free-range period and 16 h before slaughter by a real-time ultrasound apparatus (Kretz Tecnick INC, 600 V-V232, Sonovet, Austria). The

Table 1. Ingredients and analysed chemical composition (g kg^{-1} feed) of the diet provided during the feeding period previous to the free-range fattening phase[1]

Ingredients		Nutrients	
Barley	704.6		
Wheat bran	25.5	Crude protein	160.3
Soybean meal - 44	86.8	Crude fat	49.4
Sunflower meal - 30	121.7	Crude fibre	66.4
Lysine supplement	1.3	Lysine	7.7
Lard	30.0	Calcium	7.0
Calcium carbonate	7.0		
Dicalcium phosphate	13.0		
Sodium chloride	3.0		
Mineral/vitamin mix	7.0		

[1] Calculated digestible energy 13.05 MJ kg^{-1} feed.

ultrasonic measurements of *Longissimus dorsi* (LD) muscle area (cm^2) and backfat area (cm^2) were taken at the level of the last rib. Pigs were slaughtered at a local slaughterhouse at an average weight of 166.20 (H pigs) and 138.40 kg (L pigs) (SE = 4.8 kg). Slaughter (SW), cold carcass (CW), hams, forelegs, loins and sirloin weight were recorded. Moreover in each carcass, chops from the LD muscle were cut at the level of the last rib in order to draw on a semitransparent paper that was then used for determinate measurements of backfat thickness and subcutaneous backfat and LD muscle area. The measurements taken were:

FT_1 = fat thickness (in cm) taken perpendicularly to dorsal mid line at the level of the last rib.

FT_2 = fat thickness (in cm) taken at 6 cm off dorsal mid line at the level of the last rib.

FT_3 = fat thickness (in cm) measured at the lateral edge of LD muscle from the skin to the muscle.

SFA = subcutaneous backfat area (in cm^2) between LD muscle superior face, the skin internal face and the lines corresponding to the measurements FT_1 and FT_3.

LDA = LD muscle area (in cm^2) taken at the level of the last rib.

The LD muscle intramuscular fat was obtained according to the method developed by Marmer and Maxwell (1981).

Statistical analysis

The effect of the feeding level prior to the fattening period on the productive results of the pigs was studied by means of an analysis of covariance:

$$Y_{ij} = \mu + (FL)_i + a\,W + \varepsilon_{ij}$$

where: *Y* = data observed for pig *j* of the treatment *i*; μ = general average; (*FL*) = treatment feeding level during the period previous to the free-range fattening period (high H *vs* low L) (*i* = 1, 2); *a* = coefficient of partial regression between *W* and *Y*; *W* = covariate initial weight of the pigs for the average daily gain (ADG), LD muscle area and subcutaneous backfat area at the beginning of free-range period for lean and backfat areas average daily gain during free-range period, slaughter weight (SW) for carcass weight (CW) or carcass weight for carcass characteristics; ε = residual error.

Shaphiro and Wilk (1965) test (PROC UNIVARIATE) was used to evaluate the normal distribution of the data. With data that were not normally distributed the transformation arc sin $(x/100)^{0.5}$ was carried out. Covariance analysis was carried out according to procedure GLM given in SAS (1999). The correlation coefficients between carcass cut yield and average daily gain, carcass yield and carcass fat and lean measurements were calculated using procedure CORR given in SAS. The interaction between the treatment and carcass weight for the carcass traits and cut yield was studied by means of simple regression by comparison of slopes according to the Student's «t» test.

Results and Discussion

The average daily gain of pigs for the prior to free-range (ADG_1), free-range (ADG_2) and whole (ADG_3) periods according to prior to fattening period feeding level (FL) are shown in Table 2. As expected a significant effect of FL was observed for ADG_1. The pigs fed high feeding level (H) had higher ADG_1 than pigs fed low feeding level (L). The pigs initial weight at the beginning of the prior to fattening phase had not significant (P > 0.05) effect on daily growth during this period. However, in the free-range period the L pigs grew significantly more (P < 0.05) than the H pigs. In a number of experiments carried out in pigs maintained in confinement, it has been observed that restricting the amount of feed given to pigs during their growth period leads to a greater feed consumption and daily growth during the fattening period (Lovatto *et al.,* 2000; Daza *et al.,* 2003). According to our information, this is the first time that compensatory growth has been observed in pigs produced under free-range conditions. Compensatory growth in pigs produced under confinement has been related to some metabolic adaptation of animals fed a low level of nutrition that permits them to use nutrients more efficiently during a limited period of time following the end of the restriction period (Critser *et al.,* 1995; Skiba *et al.,* 2001; Daza *et al.,* 2003; Whang *et al.,* 2003). However, in pigs fed extensively a higher mobility (due to lower live weight) and less limitation to feed rejection may be involved. However, in the L pigs, the increase in weight during free-range phase was not enough to compensate for the difference in LW between the experimental

Table 2. Influence of prior to free-range period feeding level (FL) on growth of Iberian pigs

FL	W_1 (kg)	W_2 (kg)	W_3 (kg)	ADG_1 (g)	ADG_2 (g)	ADG_3 (g)
High (H)	54.7	117.9	166.2	385.4	508.4	430.5
Low (L)	55.4	83.1	138.4	168.9	582.1	320.5
SE	0.8	5.0	4.9	30.0	28.2	27.8
Significance		***	**	***	*	*

W_1 = initial weight; W_2 = final weight at prior free-range period; W_3 = weight at slaughter; ADG_1 = average daily gain for prior to fattening period; ADG_2 = average daily gain for free-range period; ADG_3 = average daily gain for total period; H = 70 g feed kg^{-1} $LW^{0.75}$ day^{-1}; L = 50 g feed kg^{-1} $LW^{0.75}$ day^{-1}; SE = standard error of mean; *: $P < 0.05$, **: $P < 0.01$, ***: $P < 0.001$.

groups. Considering the whole experimental period, the ADG_3 was lower ($P < 0.001$) for restricted pigs (L) prior to the free-range period compared to those fed a high feeding level (H). This result was due to the fact that L pigs were subjected to severe restriction during prior to the free-range period compared with the H pigs restriction (Critser *et al.,* 1995; Daza *et al.,* 2003). The initial weight of pigs at the beginning of the free-range

phase had no influence on average daily gain during this period (ADG_2) ($P > 0.05$).

Carcass characteristics according to the prior to fattening period FL are shown in Table 3. The LD muscle area and backfat thickness obtained in this study are in agreement with those observed by De Pedro (1987) and Dobao *et al.* (1987), although the LD muscle intramuscular fat (LDIF) percentage was higher

Table 3. Carcass traits according to prior to free range feeding level (FL)[1]

Variable[2]	FL		SE
	High (H)	Low (L)	
Longissimus dorsi area (LDA) (cm^2)	24.96	25.32	0.73
FT_1 (cm)	7.12	7.16	0.26
FT_2 (cm)	6.26	6.45	0.34
FT_3 (cm)	7.59	8.14	0.28
SFA (cm^2)	91.87	93.76	4.66
Longissimus dorsi intramuscular fat (LDIF) (%)	7.05[a]	5.36[b]	0.37
Carcass weight (kg)	121.06[a]	117.91[b]	0.44
Carcass yield (%)	78.32	78.30	0.18
Hams weight (kg)	21.06	20.52	0.55
Forelegs weight (kg)	14.00	13.83	0.39
Loins weight (kg)	3.45	3.46	0.087
Sirloin weight (kg)	0.492	0.482	0.014
Total cuts (kg)	39.01	38.30	1.01
% hams to carcass weight	17.72	17.28	0.25
% forelegs to carcass weight	11.77	11.63	0.17
% loins to carcass weight	2.91	2.92	0.07
% sirloin to carcass weight	0.41	0.41	0.017
% total cuts to carcass weight	32.84	32.25	0.46

[1] Are least square means. SE = standard error of mean. [2] For each variable, means with different superscripts differed $P < 0.05$. LDA = LD muscle area measured at the level of the last rib. FT_1 = fat thickness measured perpendicularly to the dorsal mid line at the level of the last rib. FT_2 = fat thickness measured at 6 cm of the dorsal mid-line at the site of the last rib. FT_3 = fat thickness measured between the skin and the distal end from dorsal mid line of the LD muscle. SFA = subcutaneous fat area between LD muscle face, the skin internal face and the lines corresponding to FT_1 and FT_3.

than that found by Benito *et al.* (1998) and Muriel *et al.* (2004) in Iberian pigs of the Torbiscal line with approximately the same slaughter weight. The hams, forelegs and loins amounts observed in this work were similar to those reported by Benito *et al.* (1998) in Iberian pigs of the Torbiscal line, although Dobao *et al.* (1987) observed lower amounts of these carcass cuts probably due to the fact that the slaughter weight was lower than in our experiment.

No differences (P > 0.05) were observed for the carcass characteristics, except for the CW (121.1 *vs* 117.9 kg, P < 0.05) between H and L pigs when either SW or CW were used as covariates (Table 3). This indicates that the prior to fattening FL had not significant effect on carcass traits. Only SW and CW influenced (P < 0.05) most carcass characteristics. Thus, an increase in SW or CW produces an increase in subcutaneous backfat thickness, backfat area, LDIF percentage and carcass cuts (P < 0.05). These results are in agreement with those found by Cisneros *et al.* (1996), Leach *et al.* (1996), Weatherup *et al.* (1998) and Latorre *et al.* (2003a,b, 2004) in selected pigs produced under confined conditions and to those observed by De Pedro (1987), Dobao *et al.* (1987), Mayoral *et al.* (1999), Pérez (2004) and Daza *et al.* (2005) in free-range Iberian pigs.

However, the slaughter and carcass weight had no significant influence on LD muscle area (LDA) measured at the level of the last rib, which may be attributed to the LDA compensatory growth occurring in L pigs during the free-range period.

It is interesting to note that the LD muscle initial area at the beginning of the free-range period affected the average daily gain of LDA during the free-range phase (P < 0.001). As LD initial muscle area increased, the average daily gain of LDA significantly decreased during the free-range period. The average daily gain of LDA during the free-range period was 0.0222 and 0.108 cm^2 day^{-1} for H and L pigs respectively. Nevertheless, when LD muscle initial area was introduced as a covariate in the statistical model, no significant difference in average daily gain of LDA was found between H and L pigs (0.0716 *vs* 0.0586 cm^2 day^{-1}, SE = 0.014).

The subcutaneous backfat initial area at the beginning of the free-range period showed no influence on the average daily gain of backfat area during the free-range phase (0.702 and 0.698 cm^2 day^{-1} were obtained for H and L pigs respectively, SE = 0.041). Freitas (1998) observed a compensatory growth of both lean and fat during the fattening phase in Iberian pigs restricted during the growth period, but in this study the restricted and non-restricted pigs had the same slaughter weight because the restriction used was more moderate than the one used in this experiment.

Correlation coefficients between weights and percentages of carcass cuts and growth carcass yield and fat and lean measurements are presented in Table 4.

Table 4. Partial correlation coefficients between carcass cut yield and average daily total gain (ADG$_3$), carcass yield (CY) and fat and lean measurements of carcass

Variable	ADG$_3$ (g)	CY (%)	SFA (cm^2)	FT$_1$ (cm)	FT$_2$ (cm)	FT$_3$ (cm)	LDA (cm^2)
Hams (kg)	0.95****	0.47*	0.63**	0.41	0.37	0.64**	–0.18
Forelegs (kg)	0.92****	0.52*	0.56**	0.24	0.24	0.53*	–0.16
Loins (kg)	0.70***	0.64**	0.30	0.23	–0.018	0.28	0.38
Sirloin (kg)	0.29	0.12	0.17	0.04	–0.047	0.23	–0.09
Total cuts (kg)	0.95****	0.52*	0.59**	0.38	0.30	0.59**	–0.15
Hams (%)	–0.69***	–0.84****	–0.76***	–0.74***	–0.62**	–0.53*	–0.21
Forelegs (%)	–0.66***	–0.71***	–0.84****	–0.85****	–0.82****	–0.68***	0.20
Loins (%)	–0.71***	–0.33	–0.80****	–0.64**	–0.75***	–0.70***	0.18
Sirloin (%)	–0.66***	–0.50*	–0.57**	–0.50*	–0.49*	–0.41	–0.02
Total cuts (%)	–0.75***	–0.78***	–0.86****	–0.83****	–0.77***	–0.66***	–0.16

Total cuts = Hams + Forelegs + Loins + Sirloin. ADG$_3$ = Average daily growth (g day^{-1}) during the whole experimental period. CY = Carcass yield. SFA = subcutaneous fat area between LD muscle face, the skin internal face and the lines corresponding to FT$_1$ and FT$_3$. FT$_1$ = fat thickness measured perpendicularly to the dorsal mid line at the level of the last rib. FT$_2$ = fat thickness measured at 6 cm of the dorsal mid-line at the site of the last rib. FT$_3$ = fat thickness measured between the skin and the distal end from dorsal mid line of LD muscle. LDA = LD muscle area measured at the level of the last rib. *: P < 0.05, **: P < 0.01, ***: P < 0.001, ****: P < 0.0001.

The weights and percentages of carcass cuts were not significantly (P > 0.05) correlated with LDA. However, positive correlation coefficients between carcass total cuts and variables ADG_3, CY, FA and FT_3 were observed (P < 0.05), while significant (P < 0.05) negative correlation coefficients between carcass cut percentages and variables ADG_3, CY, FA, FT_1, FT_2 and FT_3 were found. Some of these results are in disagreement with De Pedro (1987), who reported a significant correlation coefficient between carcass loin amount and LDA, a negative relationship between carcass trimmed ham and foreleg amount and backfat thickness and no significant effect of carcass yield on carcass ham, foreleg and loin amount. However, Latorre *et al.* (2003a,b, 2004), in heavy selected pigs produced under confinement conditions, and Pérez (2004), in Duroc × Iberian pigs, observed a significant positive relationship between carcass yield and backfat thickness with carcass ham and foreleg amount, but a significant negative relationship between carcass yield and backfat thickness with carcass ham and foreleg percentages.

No significant correlation between LDA at slaughter and the variables ADG_3, SW, CW and SFA were found in the study. Kunev *et al.* (1998) observed not significant differences in selected pigs of 100 to 120 kg of body weight for the eye - muscle area.

A high foreleg:ham ratio is interesting for the meat processing industry in Spain (Esparrago *et al.,* 2001). The Iberian pig industry is especially interested in an increase of foreleg weight. No significant (P > 0.05) difference between H and L pigs for foreleg:ham ratio was observed (0.667 *vs* 0.671, SE = 0.0052). No significant (P > 0.05) relation between foreleg:ham ratio and SW, CW, carcass yield, ADG_1, ADG_2, ADG_3, carcass cuts amounts and fat and lean measurements were found in this study. As shown in Table 4 a high

correlation coefficient (r = 0.92) between ADG_3 and carcass foreleg amount was found. The foreleg growth seems to be related to the ADG_1. The correlation coefficient values between carcass foreleg amount and ADG_1 were of 0.84 and 0.57 for H and L pigs respectively, while the correlation coefficients obtained between carcass foreleg amount and ADG_2 were lower (0.38 and 0.49 for H and L pigs respectively).

The LDIF percentage is a meat quality characteristic of high importance in the Iberian pig (López Bote, 1998). Therefore, regression equations to quantify the effect of ADG_3, SW, CW and SFA on LIDF percentage were calculated (Table 5). It can be observed that as the independent variables ADG_3, SW, CW or SFA increased, the dependent variable LIDF percentage increased according to a curvilinear function. Mayoral *et al.* (1999) observed a slight change in LDIF in Iberian pigs from 120 to 150 kg of live weight. Moreover, Weatherup *et al.* (1998) did not observe a clear effect of backfat increase on the intramuscular fat content of LD muscle in selected pigs.

The interaction between prior to fattening period feeding level and carcass weight for the variables carcass cut amount and percentage and SFA is shown in Table 6.

The relationship between carcass hams, forelegs, sirloin and total cut amount and carcass weight showed a curvilinear response in both H and L pigs. However the relationship between carcass loin amount and carcass showed a linear response in H pigs and a curvilinear response in L pigs.

The relationship between carcass hams, forelegs and total cuts percentages and carcass weight showed a curvilinear and linear functions in H and L pigs respectively, while the relationship between carcass loins and sirloin percentages and CW showed a curvilinear response both in H and L pigs.

Table 5. Regression equations of average daily gain for total period (ADG_3) (kg), slaughter (SW) and carcass (CW) weights (kg) and subcutaneous fat area (SFA) (cm^2) on *Longissimus dorsi* muscle intramuscular fat (LDIF) percentage

Regression equation	R^2	Significance	RSD
LDIF (%) = –6.375 + 34.486. ADG_3 – 21.199. $(ADG_3)^2$	0.39	**	2.99
LDIF (%) = –22.52 + 0.321. SW – 0.0009. $(SW)^2$	0.39	**	1.80
LDIF (%) = –13.061 + 0.263. CW – 0.0008. $(CW)^2$	0.34	**	1.58
LDIF (%) = 0.8094 + 0.0878. (SFA) – 0.0003. $(SFA)^2$	0.16		1.66

Regression equations of LDIF on ADG_3, SW, CW and SFA variables according to prior to free-range period feeding level were not significant (P > 0.05). RSD = residual standard deviation.

Table 6. Interaction analysis between the prior to fattening period feeding level (FL) and slaughter weight for the variables carcass cut amount and percentages and subcutaneous fat area (SFA) by simple regression

FL	Regression equation	R^2	Significance	RSD
High	Hams (kg) = 0.0024[a]. (CW)^2 – 0.5326[a]. CW + 50.485	0.90	***	0.60
Low	Hams (kg) = 0.0004[b]. (CW)^2– 0.0067[b]. CW + 15.028	0.63	**	1.88
High	Forelegs (kg) = 0.0019[a]. (CW)^2– 0.4108[a]. CW + 36.051	0.88	***	0.58
Low	Forelegs (kg) = –0.0007[b]. (CW)^2 + 0.2022[b]. CW– 1.065	0.61	**	1.04
High	Loins (kg) = 0.0185. CW + 1.208	0.50	*	0.70
Low	Loins (kg) = 0.0015. (CW)^2 – 0.326.CW + 20.54	0.23		1.39
High	Sirloin (kg) = 0.00005[a]. (CW)^2– 0.0096[b]. CW + 0.953	0.69	**	0.57
Low	Sirloin (kg) = 0.0005[b]. (CW)^2– 0.1157[b]. CW + 6.948	0.48	*	0.88
High	Total cuts (kg) = 0.0045[a]. (CW)^2– 0.9788[a]. CW + 91.593	0.88	***	1.30
Low	Total cuts (kg) = 0.0018[b]. (CW)^2– 0.246[b]. CW + 41.442	0.80	***	0.88
High	Hams (%) = 0.0022. (CW)^2– 0.6464. CW + 63.081	0.81	***	0.93
Low	Hams (%) = 27.063–0.0861. CW	0.72	***	0.57
High	Forelegs (%) = 0.0016. (CW)^2–0.4424. CW + 41.85	0.57	**	0.45
Low	Forelegs (%) = 18.26–0.0587. CW	0.65	**	0.46
High	Loins (%) = 0.0002. (CW)^2–0.0627[a].CW + 7.367	0.24		1.98
Low	Loins (%) = 0.0018. (CW)^2– 0.4231[b]. CW + 27.142	0.61	**	0.48
High	Sirloin (%) = 0.00004[a]. (CW)^2– 0.0117[a]. CW + 1.2121	0.34		0.57
Low	Sirloin (%) = 0.0006[b]. (CW)^2– 0.1368[b]. CW + 8.263	0.74	***	0.13
High	Total cuts (%) = 0.0041. (CW)^2– 1.1633. CW + 113.51	0.72	***	1.06
Low	Total cuts (%) = 51.89–0.1732. CW	0.86	***	0.74
High	SFA (cm^2) = –385,45 + 6.57.(CW) – 0.0214. (CW)^2	0.55	**	3.22
Low	SFA (cm^2) = –72.175 + 1.431. CW	0.49	*	4.65

Within each carcass cut, slopes with different lettering differed ($P < 0.05$). *: $P < 0.05$, **: $P < 0.01$, ***: $P < 0.001$. RSD = residual standard deviation.

The positive regression coefficient of the quadratic term and the negative regression coefficient of the linear term were significantly ($P < 0.05$) higher in H than in L pigs for carcass hams and total cuts. The curvilinear relationships between CW and carcass forelegs were different in H and L pigs and the positive regression coefficient of the quadratic term and the negative regression coefficient of the linear term was lower in H than in L pigs for carcass sirloin amount ($P < 0.05$).

The negative regression coefficient of the linear term was lower in H than in L pigs for carcass loin percentage, while the positive regression coefficient of the quadratic term and the negative regression coefficient of the linear term were lower ($P < 0.05$) in H than in L pigs for carcass sirloin percentage.

A linear increase in the ham and foreleg amount and a linear decrease in the ham and foreleg percentages for CW was observed by Cisneros *et al.* (1996), Leach *et al.* (1996), and Latorre *et al.* (2003a,b, 2004) in heavy selected pigs, Mayoral *et al.* (1999) and Espárrago *et al.* (2001) in Iberian pigs and Pérez (2004) in Duroc × Iberian pigs.

The relationship between SFA and CW adjusted to a curvilinear function in H pigs and to a linear function in L pigs (Table 6). This indicates that an increase in CW produces a reduction in the SFA increase rate in H, but not in L pigs.

It can be concluded that a severe feed restriction during the period prior to the free-range fattening phase leads to incomplete compensatory growth during the free-range phase and, consequently, a reduction in SW and CW and a lower production of carcass cut amount. Since carcass total cut has a curvilinear response to increases in CW, it may be of interest for Iberian pig producers and industry to reduce the pig slaughter weight.

Acknowledgements

References

AOAC, 2000. Official methods of analysis. Arlington, VA.

BENITO J., VÁZQUEZ C., MENAYA C., FERRERA J.L., GARCÍA-CASCO J.M., SILIÓ L., RODRIGÁÑEZ J., RODRÍGUEZ M.C., 1998. Evolución de los parámetros productivos en distintas líneas de cerdo ibérico. IV Simposio Internacional del Cerdo Mediterráneo. November, Évora, Portugal.

CISNEROS F., ELLIS M., Mc KEITH F.K., Mc CAW J., FERNANDO R.L., 1996. Influence of slaughter weight on growth and carcass characteristic, commercial cutting and curing yields, and meat quality of barrows and gilts from two genotypes. J Anim Sci 74, 925-933.

CRITSER D.J., MILLER P.S., LEWIS A.J., 1995. The effects of dietary protein concentration on compensatory growth in barrows and gilts. J Anim Sci 77, 1769-1776.

DAZA A., 2001. Sistemas de explotación. In: Porcino ibérico: aspectos claves (C. Buxadé., A Daza, eds). Mundi Prensa, Madrid, pp. 151-175.

DAZA A., RODRIGUEZ I., OVEJERO I., LÓPEZ-BOTE C.J., 2003. Effect of pig performance of feed restriction during the growth period. Span J Agric Res 1(4), 3-8.

DAZA A., MATEOS A., LÓPEZ CARRASCO C., OVEJERO I., LÓPEZ-BOTE C.J., 2005. Effect of feeding system of the growth and carcass characteristics of Iberian pigs, and the use of ultrasound to estimate yields of joints. Meat Sci (in press).

DE PEDRO E., 1987. Estudio de los factores sexo y peso de sacrificio sobre las características de la canal del cerdo ibérico. Doctoral Thesis. E.T.S. de Ingenieros Agrónomos. University of Córdoba. Spain.

DOBAO M.T., RODRIGÁÑEZ J., SILIÓ L., TORO M.A., DE PEDRO E., 1987. Crecimiento y características de la canal en cerdos ibéricos, Duroc Jersey × Ibérico y Jiaxing × Ibérico. Invest Agr: Prod San Anim 2(1), 9-23.

ESPÁRRAGO F., CABEZA DE VACA F., MOLINA M.R., GUIJARRO J.L., 2001. La industria del cerdo ibérico In:

Porcino ibérico: aspectos claves (C. Buxadé, A. Daza, eds). Mundi Prensa, Madrid. pp. 535-588.

FREITAS A.A.B., 1998. Influencia do nivel e regime alimentarem em pre - acabamiento sobre crescimento e desenvolvimento do porco alentejano e suas repercussoes sobre o acabamento em montanheira e com alimento comercial. Doctoral Thesis. University of Évora. Portugal.

KUNEV T., BENKOV B., GERMANOVA L., BOICHEV B., 1998. Study on optimal slaughter weight of four - breed crossbred pigs (Danube White × Landrace) × (Hampshire × Piétrain). Zhivotnov" dni Nauki 35(5), 7-11.

LATORRE M.A., MEDEL P., FENTETAJA A., LÁZARO R., MATEOS G.G., 2003a. Effect of gender, terminal sire line and age at slaughter on performance, carcass characteristics and meat quality of heavy pigs. Anim Sci 77, 33-45.

LATORRE M.A., LÁZARO R., GRACIA M.I., NIETO M., MATEOS G.G., 2003b. Effect of sex and terminal sire genotype on performance, carcass characteristics and meat quality of pigs slaughtered at 117 kg body weight. Meat Sci 65, 1369-1377.

LATORRE M.A., LÁZARO R., VALENCIA D.G., MEDEL P., MATEOS G.G., 2004. The effect of gender and slaughter weight on the growth performance, carcass traits and meat quality characteristics of heavy pigs. J Anim Sci 82, 526-533.

LEACH L.M., ELLIS M., SUTTON D.S., Mc KEITH, WILSON R.S., 1996. The growth performance, carcass characteristics and meat quality of halothane carrier and negative pigs. J Anim Sci 74, 934-943.

LÓPEZ BOTE C.J.,1998. Sustained utilization of the Iberian pig breed. Meat Sci 49, 17-27.

LOVATTO P.A., SAUVANT D., MILGEN J. VAN, 2000. Étude et modelisation du phénoméne de croisance compensatrice chez le porc. XXXII Journées de la Recherche Porcine en France. 3-5 February, Vol. 32. pp. 241-246.

MARMER W.N., MAXWELL R.J., 1981. Dry column method for the quantitative extraction and simultaneous class separation of lipids from muscle tissue. Lipids 16, 365-371.

MAYORAL A.I., DORADO M., GUILLÉN M.T., ROBINA A., VIVO J.M., VÁZQUEZ C., RUIZ J., 1999. Development of meat and carcass quality characteristics in Iberian pigs reared outdoors. Meat Sci 52, 315-324.

MURIEL E., RUIZ J., VENTANAS J., PETRÓN M.J., ANTEQUERA T., 2004. Meat quality characteristics in different lines of Iberian pigs. Meat Sci 67, 299-307.

PÉREZ M., 2004. Influencia del sexo, programa de alimentación y el peso al sacrificio sobre la productividad y calidad de la canal y de la carne en cerdos Retinto Ibérico por Duroc. Trabajo Fin de Carrera. E.T.S. de Ingenieros Agrónomos. Universidad Politécnica de Madrid. Spain.

SAS, 1999. SAS User's guide. SAS Institute, Cary, N.C.

SHAPHIRO S.S., WILK M.B., 1965. An analysis of variance test for normality. Biometrika 52, 591-612.

SKIBA G., FANDREJEWSKI H., RAJ S., WEREMKO D., 2001. The performance and body composition of growing pigs during protein or energy deficiency and subsequent realimentation. J Anim Feed Sci 10, 663-647.

WEATHERUP R.N., VEATTIE V.E., MOSS B.W., KILPATRICK D.J., WALKER N., 1998. The effect of increasing slaughter weight on the production performance and meat quality of finishing pigs. Anim Sci 67, 591-600.

WHANG K.Y., KIM S.W., DONOVAN S.M., MC KEITH F.K., EASTER R.A., 2003. Effects of protein deprivation on subsequent growth performance, gain of body components, and protein requirements in growing pigs. J Anim Sci 81, 705-716.