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Abstract. A total of 160 Iberian x Duroc pigs (50% males and 50% females, all castrated) of 40.3±2.7 kg of initial BW was used to study the influence of dietary fat source and feed restriction on carcass and meat quality. There were three experimental periods: (i) grower: 40-80 kg BW, 98 d of trial, with a restricted common diet; (ii) fattening: 80-114 kg BW, four treatments arranged as a 2 x 2 factorial design: *ad libitum* (31d) *vs* restricted (51d) with diets containing Iberian pig lard –IL– *vs* oleic acid enriched sunflower oil –OESO–, and (iii) finisher: 114 kg slaughter, 77d, diets based on IL or OESO *ad libitum*. Total experimental lengths were 206 and 226 d, for pigs fed *ad libitum* and restricted, respectively. At the end of the trial, restricted pigs showed lower backfat depth than pigs fed *ad libitum*. However, pigs restricted in the grower period had better carcass yield than *ad libitum* pigs but no significant differences were found for ham, shoulder and loin yield. In addition, feed restriction decreased L* and b* values of the loin. Finally, the fatty acid profile of the intramuscular fat was not affected by fed restriction and fat source.

Keywords. Iberian pigs – Fat sources – Feed restriction.

Effet des graisses alimentaires et de la restriction sur la carcasse et la qualité des viandes de porc Ibérique

Résumé. *Un total de 160 porcs croisés Ibérique x Duroc (50% mâles et 50% femelles, tous castrés) de 40,3 ± 2,7 kg de poids vif initial ont été utilisés pour étudier l'influence de l'origine des graisses alimentaires et du rationnement sur la carcasse et la qualité de la viande. L'essai a été partagé en trois périodes expérimentales : (i) croissance: 40 à 80 kg de PV, durée de 98 jours, alimentation commune* ad libitum *; (ii) engraissement : 80 à 114 kg de PV, comparaison d'un régime alimentaire contenant de la graisse de porc Ibérique (MAN) vs un régime contenant de l'huile de tournesol riche en acide oléique (GRO), distribués soit* ad libitum *pendant 31 jours soit en rationnement pendant 51 jours ; et (iii) finition: 114 kg de PV à l'abattage, 77 jours, régimes à base de MAN ou de GRO, dans les deux cas,* ad libitum*. La durée totale de l'essai a été de 206 et 226 jours respectivement pour les porcs nourris* ad libitum *et ceux rationnés. À la fin de l'essai, les porcs rationnés ont présenté une épaisseur de gras dorsal inférieure à celle des porcs* ad libitum*. Cependant, les porcs rationnés ont eu un rendement de carcasse supérieur à celui des porcs* ad libitum*, mais aucune différence significative n'a été trouvée pour le jambon, l'épaule et la longe. En outre, le rationnement alimentaire a diminué les valeurs L* et b* de la longe. Enfin, le profil de la graisse intramusculaire en acides gras n'a pas été affecté par le rationnement alimentaire ni par la source de matières grasses.*

Mots-clés. *Porcs Ibériques – Graisses alimentaires – Rationnement alimentaire.*

I – Introduction

Under the current legislation of Spain regarding to Iberian pig production, Duroc sires can be used in the production of Iberian (IB) pigs to improve reproductive performance and feed efficiency, but these pigs must be slaughtered at ages of 10 months or older (Boletín Oficial del Estado, 2007). When IB x Duroc pigs are provided *ad libitum* (AL) access to their feed, they reach excessive BW at that age, with economic disadvantages because of increased fat content and excessive size of the primal cuts. In this sense, one strategy to reduce the growth of animals is the feed restriction. The feeding program used in most farms consists in a restricted feeding during growing period for developing of the bones and improve feed efficiency, and subsequently, *ad libitum* access to a high caloric diet rich in oleic acid to take advantage of compensatory growth until slaughter. However, the restricted feed intake (FI) level may affect the fatty acid (FA) deposition because the endogenous lipid synthesis is reduced (Nürnberg *et al.,* 1998), and compensatory growth could affect carcass and primal cuts yield.

On the other hand, feed is probably the most influential factor on the final quality of meat, since there is a close relationship between feed intake of animal and body composition (Ruiz *et al.,* 2002). Traditionally it was considered that the feed received at the final stage of fattening determined the FA profile of animal fat (Cava *et al.,* 1999). However, that FA profile could be conditioned by feeding during the growing period (López Bote *et al*., 1999 and 2000), and could be an interaction between feed restriction and fat source. Therefore, the aim of the present study was to evaluate the influence of the feed restriction and the fat source on carcass and meat quality of Iberian pigs destined to dry-cured product industry.

II – Materials and methods

1. Experimental design and animals

A total of 160 Iberian x Duroc pigs (50% males and 50% females, all castrated) of 40.3 ± 2.7 kg of initial BW, and 147 d of age was used to study the influence of dietary fat source and feed restriction on carcass and meat quality. Pigs were managed from birth to initiation of the experiment according to standard commercial procedures. Prior the beginning of the trial, animals were allotted in 16 blocks (10 pigs per block) of 250 m^2 according to their BW and sex in order to obtain homogeneous replicates. There were three experimental periods (Table 1): (i) grower: 40-80 kg BW, 98 d of trial, with a restricted common diet; (ii) fattening: 80-114 kg BW, four treatments arranged as a 2 x 2 factorial design: *ad libitum* (AL, 31d) *vs* restricted (FR, 51d) with diets containing Iberian pig lard –IL– *vs* oleic acid enriched sunflower oil –OESO; and (iii) finisher: 114 kg–slaughter, 77 d, diets based on IL or OESO *ad libitum*. Feed restriction was 3% BW of pigs, recalculating the amount of feed every 15 d. With the aim of reach similar final BW between all pigs, the total experimental lengths were 206 and 226 d, for pigs fed *ad libitum* and restricted, respectively.

Table 1. Experimental design of the trial.

Treatment	Fattening (80-114 kg BW)	Finisher (114 kg BW-slaughter)
FR-IL	Restricted -IL-	*Ad libitum* -IL-
AL-IL	*Ad libitum* -IL-	*Ad libitum* -IL-
FR-OESO	Restricted -OESO-	*Ad libitum* -OESO-
AL-OESO	*Ad libitum* -OESO-	*Ad libitum* -OESO-

Grower (40-80kg BW): Restricted -IL-.

2. Experimental diets

All diets were formulated by SAT Villa Vieja and Imasde Agroalimentaria, S.L. and met or exceeded the nutrient requirements of pigs (NRC, 1998) for Iberian pigs. All diets were calculated to be isonutritive except for net energy, due to the replacement of IL by OESO. The composition and the estimated (FEDNA, 2003) or determined (AOAC, 2000) nutrient values of the diets are shown in Table 2. Diets were manufactured by SAT Villa Vieja and were offered in mash form.

3. Carcass traits

At the preplanned slaughter BW (with 206 and 226 d of trial for *ad libitum* and restricted pigs, respectively) all pigs were weighed and identified individually and transported to a commercial abattoir (Jamón y Salud, S.A., Badajoz, Spain) and were stunned with CO_2, exsanguinated and eviscerated. Then all carcasses with the head were weighed individually to obtain carcass yield and backfat (BF) thickness was measured between the third and fourth last ribs on the middle of carcass (skin included).

Table 2. Experimental diets

	40-80 kg BW	80-114 kg BW		114 kg BW-slaughter	
	Common diet	**IL**	**OESO**	**IL**	**OESO**
Ingredients %					
Barley, wheat and corn	71.70	70.10	70.10	77.10	77.10
Soybean meal, 44% CP	20.20	13.90	13.90	11.00	11.00
Wheat bran	4.00	7.80	7.80	4.00	4.00
Iberian lard	1.00	5.00	-	5.00	-
Sunflower meal	-	-	5.00	-	5.00
Calcium carbonate	0.80	0.95	0.95	1.20	1.20
Dicalcium phosphate	1.30	1.25	1.25	1.10	1.10
Sodium chloride	0.40	0.40	0.40	0.40	0.40
L-Lysine 78,8%	0.10	0.10	0.10	-	-
V&M premix	0.50	0.50	0.50	0.20	0.20
Calculated nutrient composition[a], %					
NE, kcal/kg	2.255	2.430	2.450	2.479	2.499
Crude protein, %	17.1	15.3	15.3	14.1	14.1
Lysine, %	0.89	0.77	0.77	0.61	0.61
Ether extract, %	3.1	6.8	6.8	6.8	6.8
Total ash, %	4.7	5.0	5.0	4.9	4.9
Ca, %	0.72	0.76	0.76	0.81	0.81
P Total, %	0.64	0.76	0.63	0.58	0.58
C16:0, %	0.49	1.43	0.52	1.42	0.52
C18:0, %	0.15	0.67	0.21	0.67	0.21
C18:1, %	0.74	2.32	4.10	2.31	4.09
C18:2, %	0.99	1.25	1.09	1.23	1.07
C18:3, %	0.08	0.13	0.09	0.12	0.08
Analyzed composition[b], %					
Crude protein, %	16.2	15.1	14.8	13.4	13.6
Crude fiber, %	4.8	4.9	4.7	4.7	4.7
Ether extract, %	3.1	4.3	4.1	6.0	5.6
Total ash, %	4.5	4.4	4.7	4.6	4.9

[a]According to FEDNA (2003).[b]According to AOAC (2000).

Before quartering carcasses, all hams, shoulders and loins were identified individually. Afterward, hams, shoulders and loins were trimmed of external fat and weighed in order to calculate the yield of primal cuts.

4. Meat quality traits and FA profile

Thirty-two carcasses (sixteen from each treatment, two per block) were randomly selected and *Longissimus dorsi* muscle (LM) samples were taken at the level of the last rib. Meat samples were stored in individual plastic bags and transported to Universidad de Extremadura for subsequent analyses. Instrumental colour (L*, a*, and b*) was determined on one chop of 1 cm of thickness obtained from each sample after a 30 min bloom period. Colour was measured three times per sample using a Minolta Chromameter CR-300 (Minolta Camera Corp., Meter Division, Ramsey, NJ).

Protein content of each sample was determined using the methodology described by Lowry *et al.* (1951). Total lipids of loin samples were extracted with chloroform:methanol (2:1 v/v) according to the method of Folch *et al.* (1957). After solvent evaporation under nitrogen, the neutral lipid (NL) and the polar lipid (PL) fractions were isolated according to the method of Ruiz et al. (2004) using NH2-aminopropyl cartridges. Fatty acid methyl esters (FAMEs) from lipid fractions were obtained by acidic transesterification, following the method described by Sandler and Karo (1992). FAMEs were analysed by gas chromatography, using a Hewlett-Packard HP-5890A gas chromatograph, equipped with an on-column injector and a flame ionisation detector (FID). Individual compounds were identified by comparing their retention times with those of standards (Sigma, St. Louis, MO).

5. Statistical analysis

The individual pig was the experimental unit for analysis of all data. Data were analyzed as a completely randomized design with four treatments in a 2 x 2 factorial arrangement using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC, USA). The model included the feeding regimen (AL *vs* FR), fat source (IL *vs* OESO), and their interactions. Sex of animals was included as fixed effect.

III – Results and discussion

Pigs restricted were slaughtered with 171.5 kg and 226 d of trial (373 d of age), whereas AL pigs were slaughtered with 167.3 kg and 206 d of trial (353 d of age). The effects of feeding program and fat source of the diet on backfat thickness at the level of P2 point and carcass and primal cuts yield are presented in Table 3.

Table 3. Effect of feeding regimen and fat source on backfat (BF) thickness and carcass and primal cuts yields

	BF thickness, mm	Carcass and primal cuts yield			
		Carcass, %	Ham, %	Shoulder, %	Loin, %
Feeding regime					
AL	7.50	79.99	17.17	11.26	3.51
FR	7.08	80.67	17.16	11.29	3.50
Fat source					
OESO	7.25	80.38	17.16	11.25	3.52
IL	7.34	80.28	17.16	11.30	3.49
SEM[1] (n=75)	0.10	0.15	0.11	0.07	0.05
P-value[2]					
Feeding	0.005	0.002	NS	NS	NS
Fat	NS	NS	NS	NS	NS

[1]SEM=Standard error of the mean; [2]Interactions were not significant.

At the end of the trial, restricted pigs showed lower backfat depth than pigs fed *ad libitum* (P<0.01). This result is in agreement with those observed by Daza *et al.* (2007) and Serrano *et al.* (2009). However, in the grower period pigs restricted had better carcass yield than *ad libitum* pigs (P<0.01) but no significant differences were found for ham, shoulder and loin yield. Also, no differences were found between fat sources of the diet for backfat thickness and carcass and primal cuts yield of the IB x Duroc pigs.

The effects of feeding program and fat source of the diet on instrumental colour and chemical composition of the meat are presented in Table 4. Feed restriction decreased L* and b* values of the loin (P<0.01). However, chemical composition of the meat was not affected by the feeding regimen of the animals.

Pigs fed OESO tended to show lower b* value than pigs fed IL (P=0.08). Also, pigs fed OESO showed less protein and fat content on *Longissimus dorsi* than pigs fed IL (P≤0.05).

Table 4. Effect of feeding regimen and fat source on instrumental colour and chemical composition of meat.

	Instrumental colour			**Chemical composition**		
	L*	**a***	**b***	**Moisture %**	**CP %**	**Fat %**
Feeding regime						
AL	50.55	12.78	8.76	68.21	18.74	4.00
FR	46.12	13.96	5.17	69.33	19.38	3.09
Fat source						
OESO	48.17	13.38	6.48	69.00	18.08	2.92
IL	48.50	13.36	7.45	68.53	20.05	4.16
SEM[1] (n=16)	0.92	0.50	0.36	0.59	0.66	0.37
P-value[2]						
Feeding	0.003	NS	<0.001	NS	NS	NS
Fat	NS	NS	*0.076*	NS	0.050	0.029

[1]SEM=Standard error of the mean. [2]Interactions were not significant.

The effects of feeding program and fat source of the diet on fatty acid profile of the neutral and polar fractions of the intramuscular fat of meat are presented in Table 5. Feed restriction tended to decrease the proportion of linolenic acid (C18:3) on the neutral fraction, and the palmitic acid (C16:0) of the polar fraction regarding *ad libitum* feeding (P=0.06). However, feeding regimen did not affect significantly the remaining FA studied of the neutral and polar fractions of the intramuscular fat.

Pigs fed OESO showed a higher proportion of linolenic acid on the neutral fraction (C18:3) than pigs fed IL (P<0.05), but no significant differences were found for the remaining FA of the neutral fraction of intramuscular fat. Also, the inclusion of OESO in the diets increase the proportion of stearic acid (C16:0), and tended to show higher proportion of oleic acid (C18:1) of the polar fraction than diets with IL (P<0.05, and P=0.06, respectively).

Also, a feeding regimen x fat source interaction was found for the proportion of linolenic acid of the neutral fraction of the intramuscular fat (P<0.05). In this sense, while the fat source of the diet did not affect the linolenic acid (C18:3) content in restricted pigs, pigs fed *ad libitum* consuming the IL diet showed greater linolenic acid proportion than pigs fed OESO.

Table 5. Effect of feeding regimen and fat source on fatty acid profile of the neutral and polar fractions of the intramuscular fat of meat

Fatty acid, %	Feeding regimen		Fat source		SEM[1] (n=16)	P-value		
	AL	FR	OESO	IL		Feeding	Fat	Feeding x Fat
Neutral lipids								
Palmitic (C16:0)	24.73	25.14	24.84	25.03	0.23	NS	NS	NS
Palmitoleic (C16:1)	4.46	4.52	4.38	4.61	0.10	NS	NS	*0.077*
Stearic (C18:0)	11.87	12.31	12.18	12.00	0.33	NS	NS	NS
Oleic (C18:1)	53.27	52.49	52.95	52.81	0.37	NS	NS	NS
Linoleic (C18:2)	2.68	2.49	2.65	2.51	0.12	NS	NS	*0.051*
Linolenic (C18:3)	0.16	0.14	0.16	0.13	0.01	*0.063*	0.011	0.023
Polar lipids								
Palmitic (C16:0)	23.78	22.03	22.82	22.99	0.61	*0.057*	NS	NS
Palmitoleic (C16:1)	1.40	1.32	1.30	1.42	0.09	NS	NS	NS
Stearic (C18:0)	9.20	8.68	8.40	9.48	0.33	NS	0.038	NS
Oleic (C18:1)	24.38	23.55	25.11	22.81	0.79	NS	*0.061*	NS
Linoleic (C18:2)	33.87	34.70	34.85	33.72	1.14	NS	NS	NS
Linolenic (C18:3)	0.42	0.48	0.39	0.51	0.06	NS	NS	NS

[1]SEM=Standard error of the mean.

IV – Conclusions

A feed restriction of 3% BW of pigs from 40 to 80 kg is enough to obtain commercial slaughter weights at 10 months of age in IB x Duroc pigs. Moreover, an additional feed restriction until 114 kg BW decrease backfat thickness, improve carcass yield, and modify the instrumental colour of the meat, without affecting primal cuts yield, chemical composition, and FA profile of the meat. However, the whole fattening-finishing period was increased in 20 d. As we expected, the fat source of the diet did not affect backfat depth, carcass traits or instrumental colour of meat, and results in a slight differences in the FA profile of the intramuscular fat of the meat.

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