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Influence of acorn size on growth performance, carcass quality and fatty acid composition of subcutaneous and intramuscular fat from Iberian pigs fattened in confinement

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Abstract

The main objective of this experiment was to asses the effect of acorn size consumed during the fattening period (90.1-137.9 kg) on growth performance, carcass characteristics and fat quality from Iberian pigs. Two groups of eight barrows were located in individual cages and fed *ad libitum* with acorns in confinement. One group of pigs received acorns of large size (average weight 4.26 g) and the other one acorns of small size (2.49 g). The pigs that received small acorns had lower average daily intake (5.5 kg) than those pigs given large acorns (5.7 kg) and consequently, weight average daily gain and carcass weight were significantly lower (0.7 *vs* 0.6 kg and 111.1 *vs* 106.2 kg respectively). The acorn size had not significant influence on major fatty acids proportions contained in subcutaneous fat and intramuscular *Longissimus dorsi* muscle.

Additional key words: acorn intake, fat quality, productive results.

Resumen

Influencia del tamaño de la bellota sobre los resultados de crecimiento, calidad de la canal y composición en ácidos grasos de la grasa subcutánea e intramuscular de cerdos Ibéricos cebados en estabulación

El objetivo principal de este experimento fue investigar la influencia del tamaño de bellota consumida durante el periodo de cebo (90,1-137,9 kg) sobre los resultados productivos, calidad de la canal y de la grasa de cerdos Ibéricos. Dos grupos de ocho cerdos Ibéricos machos castrados fueron alojados individualmente en estabulación y alimentados *ad líbitum* sólo con bellota. Un grupo recibió bellotas de tamaño grande (4,26 g) y el otro de tamaño pequeño (2,49 g). Los cerdos que fueron alimentados con bellotas pequeñas tuvieron una ingestión media diaria de bellota inferior (5,5 kg) que los que fueron alimentados con bellotas grandes (5,7 kg) y, como consecuencia, menor ganancia media diaria de peso (0,7 *vs* 0,6 kg), y peso canal (111,1 *vs* 106,2 kg). El tamaño de bellota consumida no tuvo influencia significativa sobre las proporciones de los principales ácidos grasos contenidas en la grasa dorsal subcutánea y en la intramuscular del músculo *Longissimus dorsi.*

Palabras clave adicionales: calidad de la grasa, ingestión de bellota, resultados productivos.

Introduction[1]

Acorns from *Quercus* gender trees is the essential food for the Iberian pigs that are fattened under free-range conditions. The quality of the elaborated products (ham, foreleg, loin, sirloin, etc.) obtained from Iberian pig depends principally on acorn consumption and composition. Although it has been previously shown that acorn composition is very variable (López-Bote *et al*., 2001), there is not to our knowledge available

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[1] Abbreviations used: DM (dry matter), MUFA (monounsaturated fatty acids), PUFA (polyunsaturated fatty acids), RSD (residual standard deviation), SAT (saturated fatty acids), SEM (standard error of mean).

information on the effect of acorn characteristics on meat quality parameters in Iberian pig. This is an important issue for producers and meat quality control, and may be the responsible for many cases of inaccurate classification of pigs according to their feeding system.

Acorn size is very variable according to the trees and years and it has been reported to be affected by several factors such as the tree age, year, weather conditions, tree sanitary status, etc. (Vázquez, 1998). Therefore, the main objective of this experiment was to asses the effect of acorn size consumed during the fattening period on growth performance, carcass characteristics and major fatty acids proportions in subcutaneous backfat and intramuscular *Longissimus dorsi* muscle.

Material and Methods

Animals and experimental design

Sixteen Iberian barrows of the Torbiscal line (El Dehesón del Encinar, Junta de Comunidades de Castilla-La Mancha, Oropesa, Toledo, Spain) of the same age with an average initial live weight of 90.1 kg [pooled standard error of mean (SEM) = 3.5 kg] were randomly distributed in two groups of eight pigs each. The two groups of pigs were located in individual cages and fed *ad libitum* in confinement either with acorns of large size (eight pigs) or small size (the other eight pigs). Acorns were previously selected according to their size from different trees located in El Dehesón del Encinar (Oropesa, Toledo, Spain).

Measurements and analysis

Physical characteristics of *Quercus rotundifolia* acorns samples consumed by the pigs were determined using a calibre (height and width of acorn) and scale (weight of the acorns, seeds and peels) as measurement tools of high precision (0.1 mg). Chemical composition of acorns given during the fattening period was carried out according to AOAC (1990). Fatty acids of acorns were analysed by the one-step procedure described by Sukhija and Palmquist (1988) in lyophilised samples. Methylated fatty acid samples were identified by gas chromatography as described elsewhere (Rey and López-Bote, 2001) using a 6890 Hewlett Packard gas chromatograph and a 30 m × 0.32 mm × 0.25 μm cross – linked polyethylene glycol capillary column.

Pigs were slaughtered at a local slaughterhouse at an average weight of 137.9 kg (pooled SEM = 4.3 kg). In the slaughterhouse, carcass weight, carcass inner length (from the internal first rib to the pubic symphysic), ham and foreleg weights, ham perimeter (at the biggest diameter), ham length (from the pubic symphisic to the tibio-tarsic articulation) and backfat thickness (at the level of the last rib) were taken.

A piece of backfat from the last rib was removed and separated into inner and outer layers which were independently analysed for fatty acid composition. A piece of the *Longissimus dorsi* muscle of each pig, at the level of the last rib was taken to determine the intramuscular fat content and for fatty acid composition. Lipids from subcutaneous fat were extracted by the method proposed by Bligh and Dyer (1959), while neutral and polar lipids from muscle samples were obtained according to the procedure developed by Marmer and Maxwell (1981). Fat extracts were methylated and analysed by gas chromatography as described by Rey and López-Bote (2001).

Statistical analysis

The individual pig was the experimental unit for analysis of all data. Statistical analysis were performed by means of analysis of variance and covariance using the general linear model procedure contained in SAS (1999). The effect studied was the acorn size. For growth performance the model used was: $y_{ij} = \mu + as_i + \alpha iw + \varepsilon_{ij}$ [where y = observed data; μ = general mean; as = fix effect acorn size (i = large and small acorn); αiw = partial regression coefficient between y and w; ε = residual error] When initial weight as covariate was not statistically significant ($P > 0.05$) it was removed from the model.

The model for carcass characteristics and fatty acid composition was $y_{ij} = \mu + as_i + \varepsilon_{ij}$. Data are presented as the mean and pooled SEM. A regression procedure was also carried out to study the relationships among several physical characteristics of the acorns. Statistical significance was set at $P < 0.05$.

Results and Discussion

Table 1 shows the physical characteristics and chemical composition of acorn according to their size. The average

Table 1. Physical characteristics and chemical composition of large and small acorns

Acorns	n	Large	n	Small	SEM
Height (cm)	34	3.56[a]	32	3.06[b]	0.060
Width (cm)	34	1.71[a]	32	1.46[b]	0.024
Acorn weight (g)	34	4.26[a]	32	2.49[b]	0.098
Seed weight (g)	34	3.38[a]	34	1.91[b]	0.086
Peel (g)	34	0.88[a]	34	0.58[b]	0.026
Seed (%)	34	79.19[a]	34	76.67[b]	0.64
Peel (%)	34	20.80[a]	34	23.33[b]	0.64
Dry matter (DM, g kg^{-1} feed)	8	655.43	8	673.12	61.01
Crude protein (g kg^{-1} DM)	8	52.01	8	48.52	6.21
Crude fat (g kg^{-1} DM)	8	83.23	8	92.03	12.89
Crude fibre (g kg^{-1} DM)	8	17.21	8	16.32	2.76
Ash (g kg^{-1} DM)	8	16.59	8	17.04	1.80
Nitrogen free extractives (g kg^{-1} DM)	8	830.96	8	826.09	26.72
Fatty acids (g/100 g fatty acids)					
C14:0	8	0.14	8	0.13	0.0035
C16:0	8	10.82[a]	8	10.12[b]	0.14
C18:0	8	3.64	8	3.39	0.16
C18:1 n-9	8	52.67[a]	8	54.98[b]	0.51
C18:1 n-7	8	0.29	8	0.31	0.045
C18:2 n-6	8	13.88	8	14.01	0.47
C18:3 n-3	8	0.74	8	0.77	0.03
C20:0	8	0.34	8	0.31	0.02

n = number of observations. Means with different superscript differed $P < 0.05$. SEM: standard error mean.

weight of the large and small acorns were 4.26 and 2.49 g respectively. Vázquez (1998) observed weights between 1.5 and 5.0 g in *Q. rotundifolia* acorn. The seed and peel percentages found in our experiment are in agreement with those observed by López *et al*. (1984) and Vázquez (1998). The seed percentage was higher while peel was lower in the large acorns when compared with the small ones. Chemical composition of acorns agrees with that found by Rey *et al*. (1997, 2006) and Daza *et al.* (2005). No significant differences were observed in the chemical composition between large and small acorn except for the proportion of C16:0 and C18:1 n-9 fatty acids. The C18:1 n-9 proportion was significantly higher in small than in large acorn, while the C16:0 proportion was lower in the small than in the large one.

Several relationships between physical characteristics of acorns are presented in Table 2. As expected, positive relations among acorn weight and height and width were observed. The relationship between seed or peel weight and acorn weight, as well as peel weight and seed weight could be adjusted to quadratic functions. Moreover, a negative linear relation between peel percentage and acorn weight was observed. There is not, to our knowledge, references in the bibliography that studied the relationships shown in Table 2.

Table 2. Relationships between physical characteristics on acorn

Regression equation	R^2	RSD	P <
Acorn weight (g) = –5.85 + 3.71 Width (cm) + 1.01 Height (cm)	0.80	0.48	0.00001
Peel weight (g) = –0.22 + 0.43 Acorn weight (g) – 0.039 Acorn $weight^2$ (g)	0.67	0.12	0.00001
Seed weight (g) = 0.24 + 0.56 Acorn weight (g) + 0.040 Acorn $weight^2$ (g)	0.98	0.09	0.00001
Peel weight (g) = –0.20 + 0.57 Seed weight (g) – 0.073 Seed $weight^2$ (g)	0.57	0.14	0.00001
Seed weight (g) = –2.0 + 10.3 Peel weight (g) – 5.02 Peel $weight^2$ (g)	0.55	0.60	0.00001
% peel = 27.39 – 1.57 Acorn weight	0.18	3.56	0.0004

R^2: determination coefficient. RSD: residual standard deviation.

Table 3. Effect of acorn size on growth performance of Iberian pigs

Acorn size	Initial weight (IW) (kg)	Final weight (kg)	Average daily gain (kg)	Acorn average daily consumption (kg)	Feed conversion efficiency (kg kg^{-1})	Carcass weight (kg)
Large	90.5	141.5	0.7	5.7	8.5	111.1
Small	89.7	134.3	0.6	5.5	9.8	106.2
SEM	3.50	1.04	0.02	0.03	0.26	1.21
P <	0.8700	0.0029	0.0029	0.0410	0.0047	0.0130
P value covariable IW		0.00001	0.10	0.00001	0.0001	0.00001
Partial regression coefficients with IW		0.836	–0.00213	0.0441	0.109	0.683

SEM: standard error of mean.

The influence of acorn size on growth performance is shown in Table 3. The pigs given small acorns had lower average daily intake than the pigs given large acorns. Consequently, average daily weight gain, slaughter and carcass weight were significantly lower in pigs that consumed small acorns than those that consumed large ones. Moreover, the pigs given small acorns had a feed conversion ratio worst than those that consumed large acorns. According to Dobao *et al.* (1988) Iberian pigs fattened under free-range conditions had an acorn average daily intake between 6 and 10 kg, which are higher values to those observed in our experiment. This different intake can be explained because the pigs in the present study were confined and consequently with a little exercise during the finishing period.

The effect of acorn size on carcass characteristics is presented in Table 4. Differences were not statistically significant (P < 0.10), however the pigs given large acorns had a trend to have higher values of carcass inner depth, ham and ham + foreleg weights. Average daily feed consumption was statistically different between both groups of pigs (5.7 *vs* 5.5 kg, SEM = 0.03, P < 0.04, for pigs fed small and large acorns respectively). However, the intramuscular fat percentage of *Longissimus dorsi* muscle tended to be higher, but not significantly different (P < 0.08), in pigs that received small acorns than in those that consumed large acorns.

Table 4. Influence of acorn size on carcass characteristics of Iberian pigs

Acorn size	Large	Small	SEM	P <
Carcass yield (%)	78.5	79	0.27	0.21
Carcass inner length (cm)	78.9	77.0	0.81	0.10
Ham length (cm)	42.0	41.9	0.30	0.95
Ham perimeter (cm)	69.2	68.4	0.56	0.30
Ham weight (kg)	12.4	11.6	0.29	0.07
Foreleg weight (kg)	9.1	8.8	0.22	0.34
Ham + Foreleg weight (kg)	21.6	20.5	0.48	0.10
Foreleg/ham ratio	0.73	0.76	0.013	0.17
Fat thickness (mm)	43.7	45.7	0.89	0.13
Intramuscular fat from *Longissimus dorsi* (%)	4.7	5.6	0.32	0.08

SEM: standard error of mean.

Table 5. Effect of the acorn size of the fatty acid composition at slaughter of the outer and inner layers of the subcutaneous backfat from Iberian pigs

Acorn size	Large	Small	SEM	P <
Outer layer				
C16:0	19.19	19.62	0.30	0.34
C18:0	9.12	9.00	0.33	0.80
C18:1 n-9	52.59	52.07	0.39	0.39
C18:2 n-6	9.20	8.92	0.30	0.51
Σ SAT	30.13	30.38	0.63	0.79
Σ MUFA	58.93	58.94	0.57	0.99
Σ PUFA	10.94	10.68	0.35	0.62
Σ n-6	9.34	9.05	0.30	0.51
Σ n-3	1.60	1.63	0.065	0.75
Σ n-6/Σ n-3	5.85	5.55	0.16	0.21
Inner layer				
C16:0	20.29	20.42	0.28	0.75
C18:0	10.75	10.32	0.34	0.40
C18:1 n-9	50.14	50.05	0.60	0.92
C18:2 n-6	9.88	9.99	0.32	0.81
Σ SAT	32.98	32.59	0.57	0.65
Σ MUFA	55.49	55.72	0.62	0.80
Σ PUFA	11.53	11.69	0.37	0.77
Σ n-6	10.03	10.15	0.33	0.81
Σ n-3	1.50	1.54	0.053	0.59
Σ n-6/Σ n-3	6.71	6.60	0.16	0.65

SEM: standard error of the mean. SAT: saturated fatty acids. MUFA: monounsaturated fatty acids. PUFA: polyunsatured fatty acids.

No significant differences in the fatty acids profile of the subcutaneous backfat inner and outer layers at slaughter (Table 5) and neutral and polar lipids from *Longissimus dorsi* muscle (Table 6) between pigs fed either large or small acorns were observed. The feeding differences between pigs fed with large or small acorns, during fattening period, were not sufficiently important to observe significant variations in the fatty acids patterns in the subcutaneous backfat outer and inner layers as well as in the intramuscular neutral and polar lipids from *Longissimus dorsi* muscle. When the feeding changes are small the fatty acids profile of subcutaneous and intramuscular fat does not vary (Ruiz *et al*., 1998; Warnants *et al*., 1999; Rey *et al*., 2006).

Conclusion and implications

It is concluded that Iberian pigs fed small acorns during the fattening period reduced the average daily intake and consequently lower growth performances were detected. However, the acorn size did not significantly affect either the carcass characteristics or the subcutaneous fat and intramuscular lipids. So, feeding Iberian pigs with acorns of different physical and chemical composition did not modify meat quality parameters, and hence, did not affect the classification of the pigs according to their feeding system (nowadays based in the fatty acid profile).

Table 6. Effect of the acorn size on the fatty acid composition of the intramuscular *Longissimus dorsi* muscle (neutral and polar lipids) from Iberian pigs

Acorn size	Large	Small	SEM	P <
Neutral lipids				
C16:0	25.04	25.39	0.49	0.62
C18:0	11.46	11.81	0.55	0.67
C18:1 n-9	48.30	47.14	0.62	0.23
C18:2 n-6	3.07	3.11	0.17	0.88
Σ SAT	38.33	39.10	0.93	0.58
Σ MUFA	57.83	56.80	0.74	0.35
Σ PUFA	3.84	4.10	0.31	0.57
Σ n-6	3.24	3.49	0.26	0.53
Σ n-3	0.61	0.62	0.048	0.91
Σ n-6/Σ n-3	5.34	5.64	0.11	0.11
Polar lipids				
C16:0	21.79	22.26	0.35	0.37
C18:0	9.11	9.43	0.25	0.39
C18:1 n-9	32.61	32.55	1.28	0.98
C18:2 n-6	18.33	17.23	1.21	0.54
Σ SAT	32.25	33.09	0.54	0.30
Σ MUFA	40.23	40.69	1.41	0.82
Σ PUFA	27.51	26.22	1.77	0.62
Σ n-6	25.17	24.02	1.61	0.63
Σ n-3	2.34	2.20	0.18	0.61
Σ n-6/Σ n-3	10.87	10.99	0.49	0.87

SEM: standard error of the mean. SAT: saturated fatty acids. MUFA: monounsaturated fatty acids. PUFA: polyunsatured fatty acids.

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