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Short communication. Effect of housing system during the finishing period on growth performance and quality fat of Iberian pigs

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Abstract

The objective of this experiment was to study the effect of housing system during the finishing period on growth performance and fat quality of Iberian pigs. Thirty barrows were used. During the finishing period, sixteen pigs were reared indoor and fourten pigs were reared outdoor in paddocks. The pigs housed in outdoor paddocks had higher ($p = 0.0001$) feed average daily intake than those housed reared indoor and tended ($p = 0.087$) to show a worse feed efficiency. The C12:0 and C20:0 proportions in subcutaneous backfat from the pigs housed in outdoor paddocks were lower than those from the pigs housed reared indoor, whereas C17:0, C17:1 and C20:1 proportions tended ($p = 0.09$) to be lower. However, C18:1 n-9 and C18:3 n-3 proportions and C18:1 n-9/C18:0 ratio tended ($p = 0.10$) to be higher in the outdoor pigs than in the indoor pigs. In intramuscular fat from *Longissimus dorsi* muscle the C18:3 n-3 proportion tended ($p = 0.07$) to be higher in outdoor pigs than in indoor pigs. It is concluded that the finishing period of Iberian pigs in outdoor paddocks has a negative effect on feed conversion ratio but may improve the fat quality.

Additional key words: exercise; fatty acid composition; productive results.

Resumen

Comunicación corta. Efecto del sistema de alojamiento durante el periodo de acabado sobre los resultados productivos y calidad de la grasa de cerdos Ibéricos

El objetivo de este experimento fue estudiar el efecto del tipo de alojamiento durante el periodo de acabado sobre los resultados productivos y calidad de la grasa de cerdos Ibéricos. Se utilizaron 30 machos castrados, 16 de los cuales permanecieron durante la fase de acabado en nave cerrada y 14 en parques al aire libre con refugios protectores. Los cerdos alojados en parque tuvieron un consumo medio diario de pienso ($p = 0{,}0001$) superior que los alojados en nave y tendieron ($p = 0{,}087$) a presentar un índice de transformación del pienso peor. En los cerdos que permanecieron durante la fase de acabado en parques, las proporciones de C12:0 y C20:0, observadas en la grasa dorsal subcutánea, fueron significativamente más bajas que en los cerdos acabados en nave cerrada y las proporciones de C17:0, C17:1 y C 20:1 tendieron ($p = 0{,}09$) a ser menores. Sin embargo, la proporción de C18:1 n-9 y la relación C18:1 n-9/C18:0 tendieron ($p = 0{,}10$) a ser mayores en los cerdos acabados en parques que los acabados en nave. En la grasa intramuscular del músculo *Longissimus dorsi* la proporción de C18:3 n-3 tendió ($p = 0.07$) a ser mayor en los cerdos acabados en parques que en los acabados en nave. Se concluye que el acabado de cerdos Ibéricos en parques al aire libre empeora el índice de transformación del pienso, pero puede mejorar la calidad de la grasa.

Palabras clave adicionales: composición de ácidos grasos; ejercicio; índices técnicos.

In the last years, more than two million Iberian pigs have annually beed slaughtered in Spain, from which about 15% were fattened under free-range conditions and the other 85% were reared indoor and fed mixed diet (Daza and López-Bote, 2008). The most of Iberian pigs reared indoor remain their whole life physically inactive confined in high density pens. Nowadays, in pig production there is increasing interest in alternative husbandry systems, which include outdoor housing and increasing available floor space and therefore, increasing the exercise possibilities (Millet *et al*., 2005). This is also the case of the Iberian pig reared indoor. The relation between pig physical activity and performance and meat quality traits is controversial. Whereas some studies find no differences in performance or

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meat quality because of physical activity (Gentry *et al*., 2002), however other reports have observed that exercise affects to meat quality (Gevering *et al*., 1998). It is known that the acceptability and quality of the products from Iberian pig are mainly attributed to differences in the fatty acid composition of adipose tissue. On the other hand, some experiments have reported a positive effect of exercise on human health due to that exercise may play an important role in several aspects of lipid metabolism such as lipolityc activity, oxidation, and elongation and desaturation of fatty acids (Petridou *et al.*, 2005; Votruba *et al*., 2005; Bergouignan *et al*., 2006). To our knowledge there is not enough information on the possible effect of exercise on fatty acid composition of adipose tissue from Iberian pig reared indoor and fed mixed diets. Therefore, the aim of this experiment was to study the influence of housing system applied during the fattening period on growth performance and fat quality of Iberian pigs.

The experiment was carried out in the *Centro de Pruebas de Porcino* (Hontalbilla, Segovia, Spain) of *Instituto Tecnológico Agrario de Castilla y León* (ITACyL). Thirty barrows Iberian pigs with an average inicial live weight of 61.62 kg (pooled SEM = 3.21 kg) were used. The experimental design observed two different housing systems:

— Sixteen pigs were randomly distributed in four similar pens (four pigs per pen) into an indoor experimental housing facility provided of dynamic ventilation. Each pen had straw bedding, one «feeding trough» and one «drinking trough». The available surface per pig was 1.1 m^2 (indoor treatment).

— Fourteen pigs were randomly distributed into two outdoor paddocks (seven pigs per paddock). Each paddock had one «feeding trough» and one «drinking trough» separated 100 m, thus forcing pigs to walk at least 200 m daily. The available surface per pig was 1,430 m^2. The paddocks disposed of one shelter in order to protect to the pigs of unfavourable climatic factors (outdoor treatment).

Visual observation indicated that pigs maintained outdoor walked and moved frecuently, whereas those maintained in confinement remained lying most the day.

The pigs were fed with two commercial feeds. A growing feed (3.07 Mcal of metabolizable energy kg^{-1}, 14.5% crude protein, 0.8% lysine and 5.0% crude fat) was given during 33 days from the beginning of experiment to when the pigs achieved 83.23 kg (SEM = 2.19 kg). After a finishing feed that contained 3% of oleine of olive oil (3.30 Mcal of metabolizable energy kg^{-1}, 13.8% crude protein, 0.7% lysine and 7% crude fat) was given until when the pigs were slaughtered with a live weight of 148.33 kg (SEM = 3.86 kg). Before the beginning of experimental period all pigs received the same feeding and management. The experimental period passed from May to September of year 2008**.** Records were made of individual pig weight to calculate the average daily gain (ADG) and average daily feed intake (ADFI) per pen on days 0 (beginning of experiment), 33, 64, 95 and 124 (end of experiment). Therefore, feed conversion ratio (FCR) was calculated per pen from ADG and ADFI. Pigs were slaughtered at a local slaughterhouse located in Segovia (Spain). Individual carcass weight was recorded. Ten pigs per treatment were radomly selected for studying fatty acid composition of subcutaneous and intramuscular fat. Samples of subcutaneous backfat and *Longissimus dorsi* muscle at the level of the last rib were taken for fatty acid analysis. *Longissimus dorsi* samples were vacuum-packaged in low oxygen permeable film and stored at –20°C until required for fat extraction.

Lipids from subcutaneous backfat were extracted by the method proposed by Bligh and Dyer (1959) and intramuscular fat from *Longissimus dorsi* muscle was obtained according to Marmer and Maxwell (1981) method. Fat extracts were methylated in the presence of sulphuric acid and identified using a 6890 Agilent (Avondale, PA, USA) gas chromatograph.

The data were analysed as a completely randomized design by using the GLM procedure of SAS (1999). Housing system (indoor vs outdoor) was the effect studied. A simple regression procedure was carried out to quantify the relationship between pigs weight (W) and AFDI and FCR.

Growth performances according to housing system are shown in Table 1. The housing system had not significant effect on final weight, ADG, carcass weight and carcass yield. However, outdoor pigs had higher AFDI than indoor pigs (3.43 *vs* 3.23 kg) and tended ($p = 0.087$) to present FCR less favourable (5.15 *vs* 4.63 kg kg^{-1}).

In order to quantify the relations between AFDI and W according to housing system simple regression equations were calculated. Such relations responded to a double inverse functions of structure: $AFDI_i = 1/[0.24 (\pm 0.13) + 6.68 (\pm 1.16)/W_i]$ ($R^2 = 0.34$, RSD = 0.04, $p = 0.0001$, N = 64) for indoor pigs, and $AFDI_o = 1/[0.14 (\pm 0.011) + 15.05 (\pm 1.06)/W_o]$ ($R^2 = 0.79$, RSD = 0.02, $p = 0.0001$, N = 56)) for outdoor pigs.

Table 1. Effect of housing system (HS) on growth performance

HS	N	n	W_i (kg)	W_f (kg)	ADG (kg)	AFDI (kg)	FCR (kg kg^{-1})	W_c (kg)	CY (%)
Indoor	16	4	61.40	150.17	0.697	3.23	4.63	118.63	78.90
Outdoor	14	2	61.88	146.23	0.666	3.43	5.15	117.63	80.40
SEM			3.21	3.86	0.03	0.031	0.21	3.25	0.67
$p <$			0.92	0.48	0.48	0.0001	0.087	0.83	0.18
p cov			—	0.0001	0.47	0.67	0.47	—	0.17

N: number of pigs. n: number of replicates per treatment. W_i: initial weight. W_f: final weight. ADG: average daily gain. AFDI: feed average daily intake. FCR: feed conversión ratio. W_c: carcass weight. CY: carcass yield. SEM: standard error of the mean. For W_f Wi was used as covariate (cov).

As expected, the relation between W and AFDI was positive, but when the regression equations slopes were compared the AFDI per weight increase kilogram was higher ($p = 0.0001$) in outdoor than in indoor pigs. Also the relations between W and FCR responded to double inverse functions and were positive, but these relations were not significant ($p = 0.23$). The exercise influence on performances is controversial due to the different exercise level and climatic conditions. Thus, some experiments (Gentry *et al*., 2002; López-Bote *et al*., 2008) did not find moderate exercise effect on productive results and carcass traits, but other studies (Bee *et al*., 2004; Daza *et al*., 2006; Lebret *et al*., 2006) observed ADG reduction and AFDI and FCR increase in outdoor pigs due to that the differences of exercise or climatic conditions between outdoors and indoors pigs were more important.

The subcutaneous backfat from the outdoor pigs had lower C12:0 and C20:0 proportions and tended ($p = 0.10$) to have lower C17:0, C17:1, C18:3 n-3 and C20:1 proportions than those from the indoor pigs (Table 2). However, C18:1 n-9 proportion and C18:1 n-9/ C18:0 ratio (calculated to estimate the activity of the delta-9 desaturase enzyme) tended ($p = 0.10$) to be higher in subcutaneous backfat from the outdoor pigs than those from the indoor pigs**,** which suggests that the exercise may have a positive effect on the delta-9 desaturase activity. The housing system had not significant effect on the fatty acid composition of intramuscular fat from *Longissimus dorsi* muscle (Table 3). Only the C18:3 n-3 proportion tended ($p = 0.07$) to be higher in outdoor than in indoor pigs. The light increase of C18.1 n-9 proportion in subcutaneous backfat from outdoor pigs can be explained because the moderate exercise increases the delta-9 desaturase activity (Kouba *et al.,* 1997) and may decrease the lipogenic enzymes activity (Fiebig *et al.,* 1998). Rey *et al*. (2006) and Daza *et al*. (2007) observed that subcutaneous backfat and intramuscular fat from exercised Iberian pigs reared under free-range conditions had higher C18:1 n-9 and MUFA proportions than those from the unexercised pigs fed with acorn under reared indoor conditions**.** Since as Wood *et al.* (2008) have reported that low values of ratio SFA/PUFA in adipose tissue have a beneficial effect on human health, the subcutaneous and intramuscular fat SFA/PUFA ratios were calculated (Tables 2 and 3). In the present experiment

Table 2. Fatty acid composition (%) of subcutaneous backfat according to housing system

Fatty acid	Indoor	Outdoor	SEM	*p*-values
C12:0	0.076	0.056	0.0053	0.037
C14:0	1.30	1.25	0.046	0.44
C16:0	23.10	22.90	0.037	0.83
C16:1[1]	2.22	2.09	0.10	0.36
C17:0	0.27	0.21	0.021	0.09
C17:1	0.26	0.21	0.022	0.09
C18:0	11.85	11.11	0.35	0.14
C18:1 n-9	50.53	52.18	0.60	0.10
C18:2 n-6	8.09	8.02	0.25	0.84
C18:3 n-3	0.56	0.48	0.030	0.10
C 20:0	0.28	0.19	0.02	0.007
C 20:1	1.43	1.20	0.085	0.074
SFA	36.88	35.72	0.64	0.25
MUFA	54.44	55.68	0.61	0.17
PUFA	8.65	8.50	0.28	0.70
C18:1n-9/C18:0	4.28	4.90	0.24	0.10
C16:1/C16:0	0.096	0.091	0.0045	0.46
MUFA/SFA	1.48	1.57	0.047	0.20
SFA/PUFA	4.28	4.28	0.17	0.99

[1] Sum of C16:1 n-9 and C16:1 n-7 proportions. Ten pigs per treatment were used. SFA, MUFA and PUFA: sum of all saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. SEM: standard error of mean. The number of replicates used for indoor and outdoor treatments were 4 and 2 respectively.

Table 3. Fatty acid composition (%) of intramuscular fat from *Longissimus dorsi* muscle according to housing system

Fatty acid	Indoor	Outdoor	SEM	*p*-values
C12:0	0.10	0.096	0.0046	0.55
C14:0	1.53	1.49	0.052	0.58
C16:0	25.67	25.38	0.36	0.57
C16:1[1]	4.81	4.46	0.25	0.35
C17:0	0.083	0.086	0.0081	0.73
C17:1	0.13	0.12	0.015	0.89
C18:0	10.96	11.14	0.26	0.63
C18:1 n-9	52.79	52.89	0.42	0.87
C18:2 n-6	2.89	3.22	0.29	0.44
C18:3 n-3	0.14	0.16	0.008	0.07
C 20:0	0.18	0.20	0.014	0.29
C 20:1	0.71	0.75	0.04	0.46
SFA	38.53	38.39	0.55	0.87
MUFA	58.43	58.21	0.51	0.76
PUFA	3.03	3.38	0.29	0.41
C18:1n-9/C18:0	4.84	4.77	0.14	0.70
C16:1/C16:0	0.18	0.17	0.011	0.43
MUFA/SFA	1.52	1.52	0.035	0.97
SFA/PUFA	13.08	12.18	0.81	0.43

[1] Sum of C16:1 n-9 and C16:1 n-7 proportions. Ten pigs per treatment were used. SFA, MUFA and PUFA: sum of all saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. SEM: standard error of mean. The number of replicates used for indoor and outdoor treatments were 4 and 2 respectively.

the housing system had not significant influence on SFA/PUFA ratio obtained in subcutaneous and intramuscular fat.

The relationships between C18:1n-9 and C18:0 proportions in subcutaneous backfat according to housing system were:

Indoor pigs: C18:1 n-9 = 56.84 – 0.53 C18:0 (R^2 = 0.24, RSD = 0.90, p = 0.10)

Outdoor pigs: C18:1 n-9 = 75.08 – 2.06 C18:0 (R^2 = 0.76, RSD = 1.42, p = 0.0009)

These relations indicate that the C18:0 proportion reduction in subcutaneous backfat led to higher increase of C18:1 n-9 proportion in outdoor than in indoor pigs, which suggests a higher activity of delta-9 desaturase enzyme in outdoor than in indoor pigs.

On the other hand, it has been reported that exercised pigs had higher C18:2n-6, C18:3n-3 and PUFA in intramuscular fat when compared with sedentary pigs (Daza *et al*., 2009), and the increase more marked was for the C18:n-3 (and in this case, the most affected parameter was the C18:3n-3). However, according to the review from Gondret *et al.* (2005) muscle lipids from pigs are not modified by expanded indoor area. In the present experiment the C18:2 n-6, C18:3 n-3 and PUFA proportions increase in intramuscular fat from outdoor pigs were of 11.4%, 14.3% and 11.5% respectively when compared with indoor pigs. It is concluded that the finishing period of Iberian pigs in outdoor paddocks has a negative effect on FCR but may improve the fat quality.

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