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The inclusion of Duroc breed in maternal line affects pork quality and fatty acid profile

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ABSTRACT

The aim of this study was to evaluate the effect of including different percentages of Duroc (D) breed in maternal line [Landrace (LR) × Large White (LW); LR × (LW × D); LR × D] and gender on meat quality and intramuscular (IMF) and subcutaneous (SCF) fatty acid composition. No significant differences were found among dam lines in ultimate pH, L^* values and drip and cooking losses. There were higher percentages of saturated fatty acids in LR × D and LR × (LW × D) lines and higher percentages of polyunsaturated fatty acids in LR × LW line in IMF and SCF. Also, LR × D line produced pork with a lower Warner–Bratzler shear force values and higher IMF content and potential of lipid oxidation. Furthermore, the L^*, a^* and b^* values and drip loss were greater in pork from entire males than females. The IMF and SCF of females were more monounsaturated and less polyunsaturated than those from entire males.

1. Introduction

There are many factors that influence final meat quality, *e.g.* animal nutrition, transport, handling, and stunning, but it is well-known that breed can affect pork quality (Armero et al., 1999; Gil et al., 2008; Pascual et al., 2007; Šimek, Grolichová, Steinhauserová, & Steinhauser, 2004). Thus, breed comparisons are performed quite often when meat quality is a significant consideration (Mörlein, Link, Werner, & Wicke, 2007). The most common crossbreeding used in the intensive pig production in Spain is a three-way cross where the sow is an F1 Landrace × Large White crossbreed and the terminal sire involves well conformed breeds (Oliver et al., 1994), such as Pietrain, Belgian Landrace and Large White. However, the interest in other breeds as a means of increasing heterosis and facilitating development of specialized sired and dam lines has increased (Edwards, Wood, Moncrieff, & Porter, 1992). The Duroc breed, which was introduced in Europe mainly due to its higher intramuscular fat content compared to other breeds (Barton-Gade, 1987), has been used in different pig breeding programmes in Spain. Firstly, Duroc breed is used as a terminal sire when fattening pigs are produced; this breed has an excellent growth rate and resistance to environmental conditions, being free of the halothane gene, and abundant intramuscular fat (Armero et al., 1999; Suzuki, Shibata, Kadowaki, Abe, & Toyoshima, 2003), thereby improving the quality of fresh and dry-cured pork products. Secondly, Duroc breed was introduced to improve the growth characteristics of the Iberian pig, which is recognized to produce high quality processed pork products in the national market (Oliver et al., 1994).

Pig breeders and production systems have worked diligently towards higher production efficiency through genetic and feeding strategies and, as a result, carcass leanness has been increased, but some meat quality alterations (less intramuscular fat, lower water holding capacity of the muscle, lighter and tougher meat, *etc.*) have also occurred (Sosnicki, Pommier, Klont, Newman, & Plastow, 2003). Therefore, quantifying the effect that long-term intensive selection for increased carcass leanness has had on meat quality characteristics, some researchers (Schwab, Baas, Stalder, & Mabry, 2006) have recommended that selection practices should emphasise on pork quality (in addition to lean percentage) in commercial breeding programmes. For this reason, maintaining acceptable meat quality in the pork industry is becoming a relevant issue. Future success for the industry will require the production of consistent and predictable high product quality to ensure customer satisfaction. The target should be to combine efficient growth with the best possible meat quality or alternatively the aim can be described as optimizing meat quality with the lowest cost production (Plastow et al., 2005).

Nowadays the pig carcass price is determined according to carcass classification methods or/and objective methods (for example: Fat-o-meater) whereby a good score is obtained when the backfat is reduced and a good conformation provides a high percentage of valuable cuts (Armero et al., 1999). For this reason, Pietrain pigs are used as terminal sires, but these animals can have a high susceptibility to stress, and decrease in technological and eating quality of pork. Many researchers have studied the effect of incorporating Duroc breed as sire

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line in crossbreeding on pig performance, meat quality and/or fatty acid composition (Alonso, Campo, Español, Roncalés, & Beltrán, 2009; Armero et al., 1999; Channon, Kerr, & Walker, 2004; Cilla et al., 2006; Latorre, Lázaro, Gracia, Nieto, & Mateos, 2003; Morcuende, Estévez, Ramírez, & Cava, 2007; Ramírez & Cava, 2007a). But only a few researchers (Blanchard, Warkup, Ellis, Willis, & Avery, 1999; Mörlein et al., 2007; Oliver et al., 1994) have focused on the effect of the inclusion of Duroc breed in maternal line in crossbreeding among white breeds to improve meat quality without decreasing lean growth.

The objective of this study was to evaluate the effect of including different percentages of Duroc (D) breed in the maternal line (0%, 25% and 50%), as well as the effect of gender of animals, on meat quality, intramuscular and subcutaneous fatty acid composition and shear force in pork, as well as to examine the relationships among these traits.

2. Materials and methods

The pigs used for this trial were cared in accordance with the guidelines from the Spanish Ministry of Agriculture (Boletín Oficial del Estado (BOE), 2007).

2.1. Animals and sampling

The experiment included a total of 59 pigs [29 entire males (EM) and 30 females] born from different dams inseminated with semen from the same Belgian Pietrain genetic line (n = 1). The maternal line changed depending on the inclusion of different percentages of the same Duroc pure line in the commercial crossbreeding (Landrace (LR) × Large White (LW)): a) 0% Duroc (LR × LW), b) 25% Duroc (LR × (LW × D)) and c) 50% Duroc (LR × D). During the growing-finishing period, all pigs were fed the same basal finisher diet (50% corn, 15.73% wheat, 8.01% soybean meal (47% CP), 7.72% sunflower meal (34% CP), 7.17% lupin, 3.89% rapeseed meal (34% CP), 2.12% palm kernel expeller, 2% animal fat (tallow–lard mix that had a 3/5 acidity grade) and a vitamin/mineral source). The diet contained 16.6% crude protein, 5.33% crude fat, 0.95% lysine, and 14.37 MJ/kg digestible energy. Pigs had *ad libitum* access to feed and water. All groups of pigs were raised under similar conditions for 190 ± 5 days and transported to the farm to the slaughterhouse at approximately the same live weight, and at the same day. Animals were transported by truck (farms were located within 2 h of the slaughterhouse) in the evening and slaughtered the following morning after a resting period of 8 h and a total fasting period of 12 h. Twenty animals (n = 10 females; n = 10 entire males) from each one of the three maternal lines were randomly selected among 250 pigs (per crossbreeding) and slaughtered on the same day in a commercial facility. Pigs were stunned with CO_2; following exsanguination, the carcasses were scalded, dehaired and eviscerated. The hot carcass weights had a mean value of 92.3 ± 3.9 kg [(a) LR × LW = 90.7 ± 4.5 kg; (b) LR × (LW × D) = 93.4 ± 2.5 kg; (c) LR × D = 92.3 ± 4.5 kg]. These carcasses included the head, skin, fore and hind trotters and did not include flare fats. No significant differences were found among crossbreeds in hot carcass weight values.

The *Longissimus thoracis et lumborum* (LTL) was removed from each carcass immediately after quartering, 1–2 h after slaughter according to practise of the slaughterhouse. Also, a sample of subcutaneous fat (SCF) (outer and inner layers) was taken at the level of the thoracic ribs and frozen immediately. After 48 h at 4 ± 1 °C in a cooling chamber (airspeed: 1 m/s; 90% relative humidity), the LTL was sectioned into 2 cm-thick boneless pork chops from the caudal end for: potential of lipid oxidation, intramuscular fat (IMF) content, fatty acid composition, drip loss and muscle colour measurements. Also, a 6 cm-thick section was removed for Warner–Bratzler measurements. All samples (except those for colour and drip loss) were placed in vacuum bags and frozen at −20 °C until analysis.

2.2. pH measurement

Ultimate pH (pHu) of the LTL was measured using a portable pH meter equipped with a glass electrode Crison PH 25 (Crison instruments, Barcelona, Spain) at 48 h postmortem (p.m.). Each value was the mean of four measurements (in the middle of the muscle) that were carried out on *Longissimus* between the sixth and seventh thoracic (two measurements) and between the second and third lumbar (two measurements) vertebrae before slicing.

2.3. Instrumental measurement of colour

A Minolta CM-2002 (Osaka, Japan) spectrophotometer was used to measure colour at the surface of a 2 cm-thick boneless loin chop at 48 h p.m. exposed to air for 2 h. The illuminant used was D65 and the standard observer position was 10°. The parameters registered were CIE L^* (lightness), a^* (redness), and b^* (yellowness). Also, the hue angle ($h°$) and chroma (C^*) indexes were calculated as: $h° = \tan - 1 (b^* / a^*)$, expressed in degrees, and $C^* = (a^{*2} + b^{*2})^{1/2}$. Each value was the mean of ten observations on the same chop, avoiding areas with excess fat.

2.4. Drip and cooking losses

A 2-cm-thick chop was weighed and placed on a supporting mesh in a sealed plastic container (with no contact between sample and container). After a storage period of 24 and 72 h at 4 ± 1 °C, the samples were taken out of the container, dabbed lightly on filter paper and weighed again. Drip loss was expressed as a percentage of the initial weight, based on Honikel (1998). Furthermore, cooking loss was determined in LTL chops that were weighed before and after grilling for Warner–Bratzler shear force determinations.

2.5. Potential of lipid oxidation

Potential of lipid oxidation was measured by the 2-thiobarbituric acid (TBA) method of Pfalzgraf, Frigg, and Steinhart (1995). Meat samples of 10 g were taken and homogenized with 10% trichloroacetic acid using an Ultra-Turrax T25 (Janke & Kunkel, Staufen, Germany). Samples were centrifuged at 4000 rpm for 30 min at 10 °C and the supernatants filtered through quantitative paper. Two millilitres of the filtrates were taken and mixed with 2 ml of TBA (20 mM), homogenized and incubated for 20 min in boiling water. Absorbance was measured at 532 nm. The TBA-reactive substances (TBARS) values were calculated from a standard curve of malondialdehyde, and expressed as mg malondialdehyde/kg sample.

2.6. Intramuscular and subcutaneous fat and fatty acid analysis

After LTL and SCF samples were fast-thawed in tap water (4 h, without losing vacuum), they were ground and 10 g of sample were weighted. The fat was extracted in chloroform-methanol (1:1 v/v), with 2,6-ditert-butyl-4-methylphenol (BHT) (1 g/10 ml methanol) as antioxidant (Bligh & Dyer, 1959). One millilitre of chloroform phase was used to assess the percentage of intramuscular fat (IMF) by drying at 100 °C for 20 min; the results were expressed as the weight percentage of wet muscle. The rest was evaporated in a sand bath under nitrogen gas at 50 °C. The methyl esters from fatty acids (FAMES) were formed using a KOH solution in methanol and collected in hexane for analysis by gas chromatography. The FAMES were analysed in a gas chromatograph HP-6890 II (Hewlett-Packard, Waldbronn, Germany) using a capillary column SP-2380 (100 m × 0.25 mm × 0.20 μm), and oven temperature programming as follows: column temperature was set at 140 °C, then raised at a rate of 3 °C/min from 130 to 158 °C, and 1 °C/min to 165 °C, kept for 10 min, raised at 165 to 220 °C and kept constant for 50 min. Nitrogen was used as a gas carrier at a constant flow rate