Meat Science 96 (2014) 195–202

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Growth performance, carcass and meat quality of the Celta pig crossbred with Duroc and Landrance genotypes

Daniel Franco [a], José Antonio Vazquez [b], José Manuel Lorenzo [a,*]

[a] Centro Tecnológico de la Carne de Galicia, Rúa Galicia No 4, Parque Tecnológico de Galicia, San Cibrán das Viñas, 32900 Ourense, Spain
[b] Grupo de Reciclado y Valorización de Residuos (REVAL), Instituto de Investigaciones Marinas (CSIC), Vigo, Spain

ARTICLE INFO

Article history:
Received 10 December 2012
Received in revised form 12 June 2013
Accepted 18 June 2013

Keywords:
Celta pig
Crossbreed
Growth curve
Carcass characteristics
Meat quality
Discriminant analysis

ABSTRACT

The Celta pig is a native breed adapted to the north of Spain and extensive production system. The objective was to study the effects of sex and crossbreeding on carcass characteristics and meat quality. Samples were taken from *longissimus dorsi* muscle of 52 pigs of three different groups [Celta pure breed (C), Celta crossed with Landrace (C × L) and Celta crossed with Duroc (C × D)].
Non-significant effects of sex on growth were found for all animals in the trial. Cross with Landrace and Duroc grew faster than Celta pure breed and reached the target carcass weight of 150 kg in the least time (113 and 68 days before, respectively). Concerning carcass characteristics, Duroc cross had better carcass quality (higher killing out percentage, carcass compactness index loin and ham percentage and less fat) than the Celta pure line. Regarding meat quality, crossbreeds had less intramuscular fat, lower shear force and hardness than Celta pure line. With regard to fatty acid profile, there was a predominance of MUFA, followed by SFA and PUFA in all animals. Crossbreeding affected the proportion of oleic acid, having the highest percentages (46.75%) in Duroc cross.

1. Introduction

The Celta pig breed was the typical pig breed raised on farms in Galicia (NW Spain) until the beginning of the 20th century. However, with the arrival of improved breeds and their crosses, Celta pig production was displaced so that the Celta pig is included in the Official Catalogue of Cattle's Breeds of Spain as being in danger of extinction (R.D. 2129/2008). The number of Celta pigs is growing, with about 825 sow and 6270 total animals due to the breeder's association (Lorenzo, García, & Carril, 2012) and the meat industries have again begun to demand traditional product from this breed.

However, scientific information about this breed is scarce and preliminary, with only a few studies on growth rate (Franco, García, et al., 2011; Vázquez, Lorenzo, Fuciños, & Franco, 2012), carcass quality (Lorenzo et al., 2011) meat quality (Franco et al., 2012) and the fatty acid profile of intramuscular and backfat (Bermúdez, Franco, Franco, Carballo, & Lorenzo, 2012; Franco, Escamilla, García, Garcia Fontán, & Carballo, 2006) having been realized.

For many years, one of the main objectives of the swine industry has been to increase the lean-to-fat ratio of pig carcasses (Cameron, 1990) and several factors can be used to modified this ratio, such as genetic (Lo, McLaren, McKeith, Fernando, & Novakofski, 1992), sex and diet (Lawrie, 2006) and age (Berge, Touraille, Boccard, Fournier, & Bayle, 1991). Important improvements in the body composition of pigs have been made through genetic selection (Latorre, Pomar, Faucitano, Gariépy, & Méthot, 2008). Crossbreeding can be used to improve lean growth without decreasing pork eating quality (Lo et al., 1992) but no information exists about the possibilities of crossbreeding in Celta pigs.

Traditionally, pig production in Spain has been based on crossing Landrace × Large White dams with lean sire lines, such as Pietrain (Latorre, Lazaro, Valencia, Medel, & Mateos, 2004). On the other hand, the most common crossbreeding used in Spain for Iberian pig production is the Duroc breed mainly because of its higher intramuscular fat content compared to other breeds (Barton-Gade, 1987) making it suitable for the processing of traditional meat products, especially the production of high quality dry-cured ham (Oliver, Gispert, & Diestre, 1993).

The aim of this research is to describe the effects of crossbreeding (with Landrance and Duroc breed) and gender (castrated males and entire females) on the growth rates and important carcass and meat quality (physicochemical and nutritional) traits.

2. Material and methods

2.1. Experimental design and animal management

A total of 52 pigs [26 entire females (EF) and 26 castrated males (CM)] were divided into three groups according genotype: 16 Celta pigs (C), 20 pigs from Landrace breed crossed with pure Celta (C × L), 16 pigs from Duroc breed crossed with pure Celta (C × D). The pigs in each group were animals with similar live weight at birth. All pure specimens from Celta pìg breed were registered in the Record of Births of

* Corresponding author. Tel.: +34 988 548 277; fax: +34 988 548 276.
E-mail address: jmlorenzo@ceteca.net (J.M. Lorenzo).

0309-1740/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.meatsci.2013.06.024

Stud-Book. Animals were reared in an outdoor system from Porco Celta (Galician Cooperative, located in Goo, O Incio, Lugo, Spain). Animals were fed a commercial feed "ad libitum" with a composition of 17% protein, 2.4% fat and 3250 kcal/kg metabolic energy and access to water. Table 1 shows the chemical composition of the commercial diet. As animals were placed in a natural environment, part of the diet was obtained from the natural vegetation. There were campsite style huts and enough trees to provide shade. The animals were kept, maintained and treated in adherence to accepted standards for the humane treatment of animals. All animals were weighed every 15 days and slaughtered at different ages at a live weight of 165 kg. The standard deviations of this target live weight were 11, 12 and 7.5 kg for pure C, C × L and C × D, respectively.

The day before slaughter, the animals were weighed and transported to the abattoir, with minimal the stress to the animals. Pigs were slaughtered in an accredited abattoir (Matadero Municipal de Sarria, Lugo) using carbon dioxide to stun the animals.

2.2. Carcass measurements

Carcasses were chilled at 4 °C for 24 h and cold carcass weight (CCW) was recorded. On the right half carcass, morphometric parameters (carcass length (CL), hand length (HL), leg length (LL), ham length (HmL), maximum perimeter of the ham (HmP) and wrist perimeter (WP)) were measured using a flexible tape (Peinado, Poto, Gil, & López, 2004). The dorsal fat thickness (DFT) was measured with a flexible tape at the level of the first rib (DFT1), the last rib (DFT2), and in the *gluteus medius* in the area of the thickest dorsal fat (cranial extreme, DFT3), and in the area of the least dorsal fat thickness (DFT4) (Peinado et al., 2004). The killing out percentage was calculated as the CCW expressed as a proportion of the slaughter weight.

The day after slaughter, dissection of the right half-carcass was carried in the Meat Technology Centre pilot plant. Ten joints were obtained (top loin, loin, sirloin, ham, shoulder, belly + bacon, fat, loin bone head and tail) and weighed using calibrated scales sensitive to 50 g (Teaxul, mod. TXL-1075-E, Spain). The day after (48 h post-mortem) a portion of the loin, *longissimus dorsi* (LD), between the fourth and tenth ribs, was taken for meat quality determinations. LD was cut into six steaks, 2.5 cm thick. The first two steaks were used to determine pH, colour and proximate composition. The third and fourth steaks were used to determine water holding capacity and texture parameters, respectively and the fifth was used for fatty acid composition. The dorsal fat was excised for colour measurements. Samples for the texture tests were frozen at −18 °C for 7 days.

Table 1
Chemical composition and fatty acid profile of the commercial concentrate feed.

Chemical composition (%)	
Crude protein	15.3
Ash	5.5
Fat	3.5
Celulose	3.5
Lysine	0.7
Methionine	0.2
Phosphate	0.5
Ca	1.1
Na	0.1
Fatty acid profile (%)	
C16:0	15.56
C16:1	0.12
C18:0	2.63
C18:1*n*9c	25.24
C18:2*n*6c	48.89
C20:0	0.42
C18:3*n*3	6.23
C22:0	0.45
C20:5*n*3	0.11
C24:1	0.19
SFA	19.15
MUFA	25.56
PUFA	55.28
P/S	0.24
n−6/*n*−3	7.70

The concentrate was formulated using the following ingredients (%): 40 wheat, 25.5 barley, 15 soybean flour, 14.6 corn, 1.5 soybean oil, 2 calcium carbonate, 1 dicalcium phosphate and 0.20 sodium chloride.

2.3. Analytical methods

2.3.1. Chemical composition and colour traits

Moisture, fat and protein (Kjeldahl N × 6.25) were quantified according to the ISO recommended standards 1442:1997 (ISO, 1997), 1443:1973 (ISO, 1973), and 937:1978 (ISO, 1978), respectively. The pH and colour were measured according to Franco, Rodríguez, et al. (2011). Heme–iron was measured in duplicate, according to Hornsey (1956) with the following formula (Merck, 1989):

$$\text{Hematin (μg hematin/g muscle)} = \text{Absorbance} \times 342.44$$
$$\text{Heme–iron (mg/100 g meat)} = (\text{Hematin} \times 8.82)/100.$$

2.3.2. Water-holding capacity (WHC)

The WHC was measured in four ways: cooking loss (CL), drip loss (DL) pressing loss (PL) and thawing loss (TL). CL and PL were evaluated according to Franco, Bispo, González, Vázquez, and Moreno (2009). To determine DL, a sample of intact meat, 80–100 g and 1.5 cm thick was weighed and put on top of a net, inside a container which was closed after filling to avoid evaporation. This container was placed in a chamber at 4 °C during 48 h and then re-weighed. DL was calculated as:

$$\text{DL} = \frac{(\text{initial fresh meat weight} - \text{meat after 48 h weight})}{(\text{initial fresh meat weight})} \times 100.$$

To determine TL, samples were weighed and put in vacuum bags, before freezing to await textural analysis. Meat samples were thawed at 4 C during 24 h in the vacuum-packed plastic bag, juice losses were eliminated and the steaks were re-weighed. The percentage TL was calculated as:

$$\text{DL} = \frac{(\text{initial fresh meat weight} - \text{meat after freezing without juice})}{(\text{initial fresh meat weight})} \times 100.$$

2.3.3. Texture analysis: Warner–Bratzler (WB) test and texture profile analysis (TPA)

Steaks were cooked by placing the vacuum bags in a water bath with automatic temperature control (JP Selecta Model Tectron Bio, Spain) to an internal temperature of 70 °C, controlled by thermocouples type K (Comark, PK23M, UK), connected to a data logger (Comark Diligence EVG, N3014, UK). After cooking, samples were cooled at room temperature by placing the bags in a circulatory water bath at 18 °C during 30 min and percentage cooking loss recorded. All samples were cut or compressed perpendicular to the muscle fibre direction at a crosshead speed of 3.33 and 1 mm/s for WB and TPA tests respectively. The texture analyzer (TA-XT2 of Stable Micro Systems, UK) was used in both tests and the analysis was conducted according to AMSA (1995) guidelines. Seven meat pieces, 1 × 1 × 2.5 cm (height × width × length) were removed parallel to the muscle fibre direction and kept at 30 °C (Lady Braun Epilette, CC20, Spain) for 5 min before measurement. Samples were completely cut using a WB shear blade with a triangular slot cutting edge (1 mm thick). Maximum shear force (Møller, 1980), shear firmness (Brady & Hunecke, 1985) and total work performed to cut the