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# Physicochemical changes during manufacture and final sensory characteristics of dry-cured Celta ham. Effect of muscle type

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ABSTRACT

The effect of the type of muscle [*semimembranosus* (SM) and *biceps femoris* (BF)] on physicochemical and sensory properties throughout the manufacture of dry-cured Celta ham was studied. A total of 30 Celta hams were taken in the green stage, at the end of the salting stage, after 120 days of post-salting, at the end of drying-ripening stage and after 165 and 330 days of "bodega" step.

Almost all physicochemical properties were affected by muscle type, since BF muscle presented higher values of moisture (52.3 *vs.* 35.8%), intramuscular fat (7.8 *vs.* 5.9% of DM) and NaCl content (15.9 *vs.* 8.5% of DM) than SM muscle of final dry-cured-ham. Instrumental colour parameters were also affected by muscle type, since BF muscle had a higher redness (11.5 *vs.* 8.6) yellowness (8.6 *vs.* 5.3), and lightness (37.1 *vs.* 31.5) compared to those from SM muscle. Muscle type showed an effect of lipid oxidation and both parameters (peroxide value and TBARS index) increased more rapidly during the manufacture in the external muscle (SM) compared to the internal muscle (BF). The results from Warner–Bratzler test suggested an effect of muscle type; SM muscle presented higher shear force values compared to BF muscle. Regarding sensorial analysis, panellists considered SM muscle harder ($P < 0.001$) and lesser juicy ($P < 0.001$) than BF muscle.



## 1. Introduction

Dry-cured ham is a traditional meat product highly appreciated by consumers in Europe and in other countries. Its quality is influenced by several factors, such as rearing system, age of the animals, pig genotype, diet of the animals and processing conditions (Bermúdez, Franco, Franco, Carballo, & Lorenzo, 2012; Carrapiso & García, 2008; Cilla, Martínez, Beltrán, & Roncalés, 2005). On the other hand, a number of important parameters pertaining to the quality of the raw material or dried hams at the stages of processing have been identified, including the pH, instrumental colour, texture, water activity and NaCl concentration.

In Spain, several native pig breeds such as "Chato Murciano", "Gochu Asturcelta", "Negra Canaria", "Negra Mallorquina" and "Celta" are reared at the present. The Celta was the typical pig breed raised on farms in Galicia (northwest Spain) until the middle of the 20th century and from this time it suffered an important recession in numbers due to the introduction of improved breeds and their crosses (Franco, Vázquez, & Lorenzo, 2014). Nowadays, Celta pig is recovering its population and this breed has benefitted from a breeders' association since 1999 (Asociación de Criadores de Ganado Porcino Celta-ASOPORCEL) as well as a Pedigree Book (Diario Oficial de Galicia, 2000, p. 14325). Celta pigs are generally linked to extensive farming where they can offer products characterized by high specificity.

Due to the special characteristics and performances of their carcass and meat, the native pig breeds are highly appreciated for the manufacture of high quality dry-cured meat products and for this reason the production of Celta pigs is mainly focused to the manufacture dry-cured meat products (Lorenzo, Montes, Purriños, Cobas, & Franco, 2012) such as dry-cured ham.

In the ham samples two zones can be distinguished: *biceps femoris* (BF) is covered with the skin and thick layer of fat (and so it is internal) and *semimembranosus* (SM) muscle is superficial with neither skin nor fat cover (and so, external). The SM is an external muscle which has high NaCl content in the first stages of the process and achieves low water content rapidly, whereas the BF is an internal muscle with lower NaCl content during the first stages of the manufacturing process and with higher water content throughout ripening (Morales, Guerrero, Serra, & Gou, 2007).

The aim of this work was to study the effect of muscle type (BF *vs.* SM) on physicochemical and sensorial properties through the

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manufacturing process of dry-cured Celta ham in order to establish scientific basis for improving the quality of this high added value meat product.

## 2. Materials and methods

### 2.1. Experimental design and animal management

Fifteen pigs (castrated males and females) from the Celta breed (Barcina line), all registered in the Record of Births of Stud-Book, obtained from ASOPORCEL (the association of breeders of this pig) were used. The animals were reared in a single group in an extensive system. They were fed ad libitum with commercial concentrate suited to their nutritive needs. Pigs were slaughtered at 12 months with an average live weight of 167.30 ± 11.65 kg in an accredited abattoir (Novafrigsa S.A., Lugo, Spain) using carbon dioxide as stunning procedure. Before slaughtering, they were weighed and transported to the abattoir trying to minimize the stress situations.

### 2.2. Samples

After the refrigeration (24 h at 4 °C), leg were cut from the carcass and hams were trimmed. Thirty raw ham samples (10.80 ± 0.75 kg average weight) were used. Hams were dry-salted with an excess of coarse salt. A heap was formed alternating layers of ham samples and layers of salt. In this way, the samples were totally covered with salt. Salting was carried out during 11 days in a salting room at 2–5 °C and 90–95% relative humidity. After the salting stage, the samples were taken from the heap, brushed, washed, and transferred to a post-salting room where they stayed for 120 days at 3–6 °C and around 85–90% relative humidity. After the post-salting stage, the samples were ripened for 115 days in a room where the temperature was moderately raised up to 30 °C and the relative humidity progressively lowered down to 40% in order to achieve adequate drying of the thighs. Then, the hams were left to mature for 11 additional months ("bodega" step) in a chamber under a temperature range of 12–24 °C and a relative humidity of 70–80%.

Samples were randomly taken from the fresh samples, at the end of the salting stage, after 120 days of post-salting, at the end of drying-ripening stage and after 165 and 330 days of "bodega" step. In each sampling time, a total of five ham samples were analysed. Hams were transported to the laboratory under refrigerated conditions (<4 °C) and analysed at this point. Once in the laboratory, the entire samples were skinned, deboned, and SM and BF muscles were obtained. Samples were divided in two. The first half was used for colour measurement on cut surface, for obtaining pieces of 1 × 1 × 2.5 cm for WB test and for pH measurement. The second half was ground for chemical composition. At the end of process, slices of 2 mm were obtained for sensorial analysis.

### 2.3. Analytical methods

#### 2.3.1. pH, water activity and colour parameters

The pH of samples was measured using a digital pH-metre (Thermo Orion 710 A+, Cambridgeshire, UK) equipped with a penetration probe. Colour measurements were carried out using a CM-600d colorimeter (Minolta Chroma Meter Measuring Head, Osaka, Japan). Each muscle was cut (20 mm) and the colour of the slices was measured three times. CIELAB space: lightness, (L*); redness, (a*); yellowness, (b*) were obtained. Before each series of measurements, the instrument was adjusted using a white ceramic tile. Water activity was determinated using a Fast-lab (Gbx, Romans sur Isére Cédex, France) water activity metre, previously adjusted with sodium chloride solution (2.33 M).

#### 2.3.2. Chemical composition

Moisture, fat, ash and protein (Kjeldahl N × 6.25) were quantified according to the ISO recommended standards 1442:1997 (ISO, 1997), 1443:1973 (ISO, 1973), 936:1998 (ISO, 1998) and 937:1978 (ISO, 1978), respectively. Total chlorides were quantified according to the Carpentier-Vohlard official method (ISO 1841-1:1996).

#### 2.3.3. Warner–Braztler (WB) test

The Texture Analyzer (TA-XT2 of Stable Micro Sistems, UK) was used to perform Warner–Braztler (WB) test. The samples for WB shear test were obtained by cutting samples of approximately 1 × 1 × 2.5 cm (height × width × length) which were completely cut perpendicular to the muscle fibre direction through using a WB shear blade with a triangular slot cutting edge (1 mm thickness) at a crosshead speed of 3.33 mm/s. Maximum shear force (Møller, 1980), firmness (Brady & Hunecke, 1985) and work cut performed to cut the sample were obtained. The first one, shown by the peak higher of the force–time curve, represents the maximum resistance of the sample to the cut. Firmness is represented by the slope from the beginning of the cut up to the highest point of the force–time curve and work cut by the area under the curve.

#### 2.3.4. Lipid oxidation

Peroxide value and TBARS (thiobarbituric acid reactive substances) index were measured to assess primary and secondary lipid oxidation products, respectively. Peroxide value (mEq $O_2$/kg fat) was determined following the AOAC Official Method 965.33 (AOAC, 2007) after extraction of the fat according to Folch, Lees, and Stanley (1957). TBARS index was measured according to the method of Vyncke (1975).

#### 2.3.5. Sensorial analysis

Samples from the two muscles (2 mm of thickness) of the five samples at the end of the manufacture were sensory analysed. Both samples (BF and SM) were tested together. A panel was conducted with eight panellists selected from the Meat Technology Centre of Galicia. The panellists were trained according to the methodology proposed by ISO regulations (ISO 8586:2012) during four months with the attributes and the scale to be used. The samples were individually labelled with three-digit random numbers. Ten sensory traits of dry-cured Celta ham, grouped in appearance (lightness, lean colour, fat yellowness and marbling), odour (intensity, rancidity and cured), taste (saltiness) and lean texture (hardness and juiciness) were assessed according to the methodology proposed by ISO regulations (ISO 3972:1991; ISO 11036:1994; ISO 5496:2006). The attributes definition was explained by Ruiz, Ventanas, Cava, Timón, and García (1998). The intensity of each attribute was expressed on a structured scale from 0 (very low) to 9 (very high). During sensory evaluation, the panellists were situated in private cubicles illuminated with red light, according to ISO regulations (ISO 8589:2007). Water was given to the panellists to clean the palate and remove residual flavours at the beginning of the session and between samples.

### 2.4. Statistical analysis

For the statistical analysis of the results, an analysis of variance (ANOVA) of one way using IBM SPSS Statistics 19.0 program (IBM Corporation, Somers, NY, USA) was performed for all variables considered in the study. For each parameter (individual trait) means were compared in the different sampling times in each muscle, and between muscles in each sampling time. The least