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Characterization and differentiation of Italian Parma, San Daniele and Toscano dry-cured hams: A multi-disciplinary approach

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ABSTRACT

This study aimed at characterizing the sensory quality of Italian PDO dry-cured Parma, San Daniele and Toscano hams, applying a multi-disciplinary approach. Ham sensory profile as well as physico-chemical, aromatic, morphological and textural characteristics was investigated. There was a great difference between Toscano ham and Parma and San Daniele hams, which were more similar even though differentiated. Toscano ham showed higher scores for pork-meat odor, saltiness, dryness, fibrousness and hardness; accordingly, this ham was described by a high NaCl content and by high values of instrumental hardness, cohesiveness, gumminess and chewiness. Parma ham was characterized by a cured flavor, whereas San Daniele ham showed a wider fatty area and higher pH values. Parma and San Daniele hams were also described by higher values of sweetness, RGB color values and water activity. Sensory characteristics evaluated by trained assessors were correlated to instrumental measures, indicating that instrumental devices can be effectively applied for dry-cured ham characterization.

1. Introduction

Dry-cured ham is one of the most representative typical meat products in Italy. Parma, San Daniele and Toscano hams are the three main consortia for the production of Italian dry-cured hams labeled with Protected Designation of Origin (PDO). Over 9 million thighs are processed for Parma ham, followed by San Daniele (over 2.5 million) and Toscano (almost 300,000) hams (Pugliese, Sirtori, Calamai, & Franci, 2010).

The specifications established for each PDO product define raw materials and process characteristics, place of origin and some physico-chemical and sensory parameters of the final hams. The transformation of pork meat into ham is mainly due to an increase in salt concentration of the tissue, obtained by curing, and a partial dehydration of the meat which occurs during ripening. The modifications of physico-chemical characteristics such as pH and water activity, together with proteolytic and lipolytic reactions, produce changes in color, taste, flavor and texture, these give rise to the typical characteristics of the final products (Toldrá, 2004). The manufacturing protocols of Parma, San Daniele and Toscano hams follow similar flow-sheets (Fig. 1), but differ in some aspects such as: a) the trimming process, which endows the ham with its typical shape, is performed by removing part of the fat and the skin and influences the following salting phase; b) the salting phase, for San Daniele ham is conducted through a manual rub using sea salt and the thighs are stored at 2–3 °C for a number of days corresponding to the weight in kilograms; for Parma ham the skin is covered with damp sea salt, while the muscular parts are covered with dry salt. The thighs are then refrigerated at a temperature of 1°–4 °C with a moisture level of approximately 80% for about one week and get a second thin coating of salt which is left on for 15–18 days, depending on weight; for Toscano ham, thighs are covered with salt accompanied by pepper and natural flavors. The products are stored at 4 °C and 90% relative moisture for about 3–4 weeks in order to enhance the absorption of the flavors; c) the pressing phase, which is typical of San Daniele, gives the ham its typical "guitar" like shape; d) the ripening phase, which corresponds to minimum 12 months for Parma and Toscano hams and 13 months for San Daniele ham. According to PDO specifications, final products are mainly distinguished by NaCl content, which can vary from a minimum 4.5–4.9% to a maximum 6.4–6.9% in Parma and San Daniele hams, while a maximum value of 8.3% is established for Toscano ham (D.O.P. Prosciutto di Parma, 1992; D.O.P. Prosciutto di San Daniele, 1996; D.O.P. Prosciutto Toscano, 1996).

Dry-cured ham is a complex product, since the variety of processing technologies (conditions for curing, ripening, etc.) as well as the influence of the pigs used as raw material (genetic type, feed, rearing system, etc.) contribute to its quality, especially regarding sensory characteristics (Toldrá, 2004).

Dry-cured ham has been largely studied for its physico-chemical and sensory properties and for the variation of its sensory quality depending

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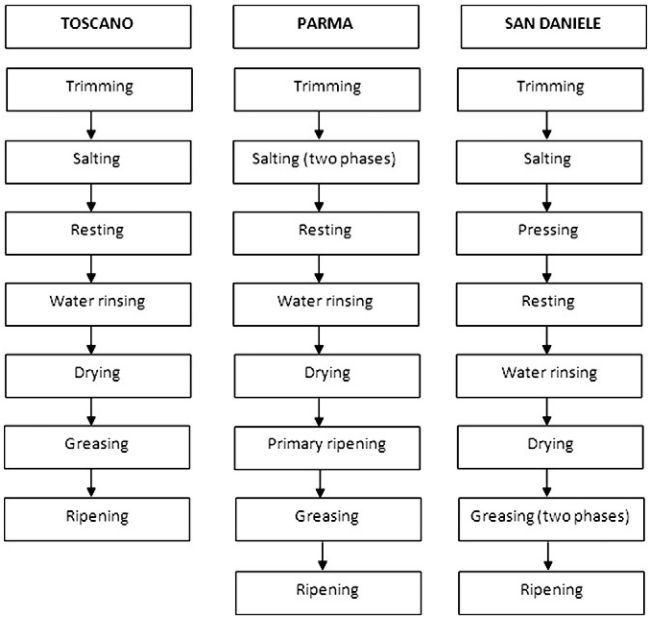

Fig. 1. Parma, San Daniele and Toscano ham process flow diagrams.

on processing technologies (Andrés, Cava, Ventanas, Thovar, & Ruiz, 2004; Costa-Corredor, Serra, Arnau, & Gou, 2009; Flores et al., 2006; Gou, Morales, Serra, Guàrdia, & Arnau, 2008; Huang, Ge, & Huang, 2010; Ruiz-Ramirez, Arnau, Serra, & Gou, 2006; Serra, Ruiz-Ramírez, Arnau, & Gou, 2005). Several studies have also been addressed to the comparison between sensory and instrumental responses considering volatile components, visual and texture properties (Costa-Corredor et al., 2009; García-Gonzáles, Tena, Aparicio-Ruiz, & Morales, 2008). However, these studies did not concern the relationships between appearance, flavor and texture properties and the relevant parameters obtained by instrumental devices. In addition, very few studies have been made on Italian dry-cured hams, even if they are largely known and exported worldwide (Bolzoni, Barbieri, & Virgili, 1996; Careri et al., 1993; Pastorelli et al., 2003).

Therefore, the aim of the present study was to characterize the three main Italian PDO dry-cured hams, applying a multi-disciplinary approach. Besides the definition of the sensory attributes that identify and differentiate the products, the evaluation was performed on the physico-chemical parameters (moisture, water activity, NaCl concentration, pH) as well as the volatile (electronic nose), morphological (Computerized Image Analysis) and instrumental texture (Texture Analyzer) characteristics. The relationship between sensory properties as evaluated by human senses and by instrumental devices was also investigated.

2. Materials and methods

2.1. Dry-cured hams

The research was carried out on 12 dry-cured hams, obtained by processing 12 pig thighs following the different PDO specifications. Pigs belonged to Italian Landrace × Italian Large White cross genotype and were reared on the same farm and fed with a standard cereal-soybean based meal. Pigs were slaughtered under similar and controlled conditions and thighs were evaluated at the plant entrance for their compliance, according to the PDO rules for raw thigh acceptance. Weight and circumference average values (±std) of the 12 thighs were respectively 14.1 ± 1.1 kg and 88.3 ± 2.8 cm. Length average value for Parma and Toscano thighs was 49.0 ± 1.8 cm, whereas the average value for San Daniele thighs was 68.9 ± 1.6 cm due to the presence of the trotter. Processing of dry-cured hams was performed following the three PDO protocols, as summarized in Fig. 1.

At the end of ripening (13 months), the four hams of each PDO were sampled for analysis.

Hams were cut in order to obtain two sections, as shown in Fig. 2. Section 1 was used for chemical and instrumental evaluations and was obtained by cutting a 5 cm thick slice, transversally from the thigh at about 8 cm from the femoral head. Slices were coded, vacuum packed, frozen and stored at −18 °C. Prior to analysis, samples were thawed for 24 h at 4 °C, and the image was acquired for morphological evaluation. The slice was then deboned, and a first 3 mm slice was cut by a slicer and discarded. The image was acquired again for color evaluation, and then 3 slices (about 5 mm) were taken and used for electronic nose (e-nose) and physico-chemical analyses, while 15 mm thick slices were used for instrumental texture evaluation. Section 2 was used for sensory evaluation; it was deboned, coded, vacuum packed and stored at 4 °C for a maximum of 5 days until the tasting session.

2.2. Physico-chemical analyses

Before analysis, the fat was manually removed from the ham slices by a knife and the lean part was homogenized by Waring blender. All determinations were carried out on the homogenized sample, in triplicate.

Moisture content was determined by drying about 3 g of sample to constant weight, following the AOAC procedure (AOAC, 2002).

Water activity was determined by a dew-point hygrometer (AquaLab, Decagon Devices Inc., Pullman, WA, USA) and calibrated with standard solutions ($a_w = 0.984$ and $a_w = 0.760$) at 25 °C.

pH was determined directly on the homogenized sample by a pH meter (PHM62, Radiometer, Copenhagen, Denmark), using an electrode for solid material.

NaCl content was determined as chloride concentration by Volhard titration (AOAC, 1995). Samples were extracted as described by Vestergaard, Erbou, Thauland, Adler-Nissen, and Berg (2005) with minor modifications: briefly, 5 g of homogenized sample was extracted with 100 mL of distilled water at 50 °C during 20 min under stirring. The mixture was centrifuged at 11,000 *g* for 15 min and the supernatant was filtered through a filter paper (Whatman # 4). Ten mL of extract was diluted with about 60 mL of water, 1 mL of 65% HNO_3 was added and the resulting solution was titrated with 0.1 mol/L $AgNO_3$, using an automatic potentiometric titrator (AT-500N, KEM, Kyoto Electronics Mfg. Co. Ltd., Japan), equipped with a combined silver electrode (MC 6091 Ag-9, Radiometer Analytical SAS, Villeurbanne Cedex, France). Results were expressed as NaCl g/100 g.

2.3. Electronic nose analysis

Measurements were performed with Portable Electronic Nose (PEN2) from Win Muster Airsense (WMA) Analytics Inc. (Schwerin, Germany). It consists of a sampling apparatus, a detector unit containing

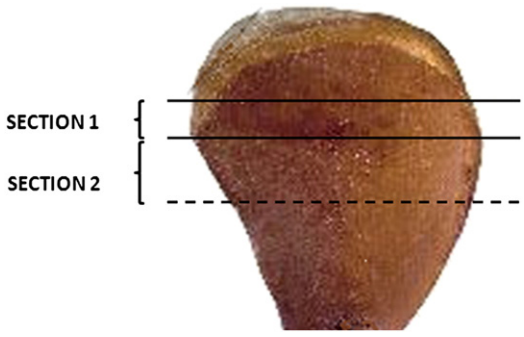

Fig. 2. Schematic representation of ham sampling. Section 1 was used for physico-chemical and instrumental analyses; Section 2 was used for sensory analysis.