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Effects of genotype, salt content and calibre on quality of traditional dry-fermented sausages

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ABSTRACT

The increasing demand for traditional food products is concomitant with higher nutritional and health concerns. The effect of genotype, salt content and calibre on physicochemical, microbiological and texture parameters, along with sensory acceptability, was studied on low-salt Portuguese traditional dry-fermented sausages. A few significant differences were found in different microbial counts between different pork genotypes' sausages. Lauric and stearic fatty acids showed significantly higher values for hybrid genotype products, while contents in gadoleic, heneicosanoic, linoleic and linolenic acids were higher in Alentejano pork sausages. Unexpectedly, there are no significant differences between genotypes for oleic acid, although lower contents were found in the Alentejano genotype. Texture Profile Analysis revealed significant differences in hardness, adhesiveness, resilience and chewiness between genotypes, with Alentejano pork sausages being softer and thus easier to chew. Salt reduction does not negatively affect the quality and acceptability of sausages. Furthermore, the use of hybrid genotype meat does not mischaracterise a product traditionally made exclusively of Alentejano pig meat.

1. Introduction

The manufacture of dry-fermented sausages represents an important part of the European meat industry, particularly in Mediterranean countries, such as Portugal, Spain, France, Italy and Greece (Comi et al., 2005; Talon et al., 2012). In Portugal, the production of a wide variety of Portuguese traditional dry-cured sausages amounted to 78,933 t in 2011 (INE., 2012). Such products are highly appreciated by consumers and are considered of high sensory quality.

Meat salting and ripening by dehydration are two of the oldest methods of preservation, with modification and increase of its organoleptic properties (Farkas, 2007; Montville & Chikindas, 2007). Dry-fermented meat products have often been accused of having high salt and fat contents (Desmond, 2006; Muguerza, Gimeno, Ansorena, & Astiasarán, 2004). Therefore, nutritional and health concerns have evidenced the need to reduce salt concentrations or replace NaCl by salt substitutes, such as KCl or $MgSO_4$ (Aaslyng, Vestergaard, & Koch, 2014; O'Flynn, Cruz-Romero, Troy, Mullen, & Kerry, 2014; Rubio, Jofre, Aymerich, Guardia, & Garriga, 2014). The World Health Organisation (WHO) recommends daily salt intake values of 5 g, which corresponds to less than 2 g of sodium, and at least 3.51 g potassium (WHO., 2003).

Microbiological, physicochemical and/or sensory characteristics of different Mediterranean dry-cured sausages have been studied by several authors. High counts of lactic acid bacteria (LAB) and coagulase-negative staphylococci (CNS) are usually present in traditional fermented sausages, resulting in slightly acidic products (pH 5–6) with good sensory characteristics (Comi et al., 2005; Drosinos et al., 2005; Perez-Cacho, Galan-Soldevilla, Crespo, & Recio, 2005).

Fatty acid composition is a common way to evaluate the quality and nutritional value of dry-fermented sausages, mainly due to

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health concerns about the quality of the consumed fat (Horcada et al., 2013; Jiménez-Colmenero, Triki, Herrero, Rodríguez-Salas, & Ruiz-Capillas, 2013; Qiu, Zhao, Sun, Zhou, & Cui, 2013).

In Mediterranean regions, dry-fermented sausages are traditionally manufactured with pure breed Mediterranean pork meat giving these products particular sensory characteristics and fatty acid composition. In South Portugal, the Alentejano pork is used, however alternatives have been searched in order to reduce production costs without affecting the products' characteristics and consumers' acceptability.

Texture Profile Analysis (TPA) parameters as well as sensory attributes have been evaluated before on dry-fermented meat products (Olivares, Navarro, Salvador, & Flores, 2010; Rubio et al., 2007) with good correlations between both approaches (Elias et al., 2014).

The aim of the present study was to evaluate the effect of genotype, salt content and calibre on the physicochemical, microbiological, texture and sensory parameters in Portuguese traditional dry-fermented sausages. To our knowledge, this is the first comprehensive study on Portuguese dry-cured meat sausages, considering the three factors mentioned above with an attempt to use a hybrid Iberian × Duroc pig breed and low salt content.

2. Materials and methods

2.1. Sausage technology and sampling procedures

For this study, 10 reproductive boars of the "Alentejano" breed were obtained from "Herdade dos Bispos e Outeiro" (Beja, Portugal). The pigs were fed on commercial feed (26% corn, 20% wheat, 15% barley, 13% wheat bran and 11% soy pomace, among other minor components) ("Alirações", Alcochete, Portugal) without access to "Montanheira". At slaughtering, boars were approximately five years old and carcasses weighed around 150 kg.

Two Portuguese dry-fermented sausages, namely "Chouriço Preto" (CP) and "Paio Preto" (PP) were used. CP has a horseshoe shape with a variable diameter around 30 mm, whereas PP has a cylindrical shape, a variable length between 20 and 30 cm and a variable diameter near 45–50 mm. Their calibre is irregular, because natural casings are used. The production process involves mechanically mincing meat, previously cut into cubes measuring approximately 25 mm and mixed with red pepper (*Capsicum annuum* L.) paste (2.5%), water reconstituted dried blood powder (2:1 (w/v)) (4%), garlic (*Allium sativum* L.) paste (1%), disodium diphosphate (0.03%), pentasodium triphosphate (0.03%), $NaNO_3$ (0.02%), KNO_3 (0.008%) and KNO_2 (0.007%). Red pepper and garlic pastes contain 17% NaCl. Salt was added in order to obtain approximately 3% and 5% total chlorides in the final product. The mixture of meat and other ingredients was stored under controlled conditions at 5 °C and 90% relative humidity during 48 h for ripening. Afterwards, this meat batter was stuffed into natural casings made from the pig's small intestine, with a diameter of 36–38 mm for CP, and the pig's large intestine (rectum), with a diameter of 50–55 mm for PP. The drying operation occurs in two phases: sausages are dried first in a smoking room for 48 h at 18–24 °C and a relative humidity of 30–60%, with smoke generated by burning oak wood (*Quercus ilex* L.), the conditions inside the smoking room being influenced by environmental conditions through the chimney; and secondly in cure chambers under controlled conditions at 9 °C and 80–85% relative humidity during around 14 days for CP and 30 days for PP. After processing, sausages were vacuum-packaged in polyamide/polyethylene co-extruded film bags using the packing machine 700 STE-XL (Turbovac, The Netherlands) at the production plant in order to be transferred to the laboratory. Once in the lab, sausages were immediately used for pH, a_w and chlorides measurements, microbiological counts, fatty acids profile, texture profile analysis (TPA) and sensory evaluation.

Three independent batches were prepared with two different genotypes, an Alentejano pig breed and a hybrid Iberian × Duroc pig breed; two different salt contents in the final product (3 and 5% NaCl); and two products with different calibres (small-CP and large-PP).

2.2. pH, a_w and chlorides determination

After removing the sausage casings, pH was determined in accordance with the ISO 2917 (1999) using a pH-meter (Crison 507, Barcelona, Spain). Water activity (a_w) measurements were carried out using a hygrometer (Hygroskop Rotronic DT, Zurich, Switzerland) with a WA-40 probe at 25 °C. Total chlorides were quantified according to the ISO 1841 (1996).

2.3. Microbiological analysis

In general, the microbiological methods used have been adapted from a previous study (Talon et al., 2007). For microbial counts, 10 g of each sample were homogenized for 90 s in a Stomacher Masticator (IUL Instruments, Spain) with 90 mL peptone water (Scharlau, Spain) and serial tenfold dilutions were made and pour-plated. Total mesophiles counts were made in Tryptone Glucose Extract Agar (Scharlau, Spain), incubating at 30 °C during 48 h; LAB counts in Man, Rogosa and Sharpe (MRS) Agar (Scharlau, Spain), at 30 °C for 48 h under anaerobic conditions in an AnaeroJar (Oxoid, UK) using an AnaeroGen sachet (Oxoid, UK); enterococci counts, in Slanetz and Bartley Agar (Biokar, France), at 37 °C for 48 h; CNS counts, in Mannitol Salt Agar (MSA) (Biokar, France), at 37 °C for 48 h; yeasts and moulds in Rose Bengal Chloramphenicol (Scharlau, Spain), at 25 °C for 48 h. For *Escherichia coli* counts, inoculum was plated in Tergitol 7 (Biokar, France) supplemented with triphenyltetrazolium chloride (TTC) (Biokar, France) and incubated at 44 °C for 24 h. For all microbial counts, the results were expressed as log cfu g^{-1} means ± standard deviation.

For the detection of *Salmonella*, 25 g of each sample were homogenized with 225 mL peptone water (Scharlau, Spain) and incubated at 37 °C for 18 h. Following this pre-enrichment period, 0.1 mL was inoculated in Rappaport Vassiliadis Broth (Scharlau, Spain) and 1 mL in Muller-Kauffmann Tetrathionate (MKTT) Broth (Scharlau, Spain) supplemented with iodine solution and Brilliant Green-Novobiocin (Scharlau, Spain) and incubated at 41.5 °C and 37 °C, respectively. After 24 h selective enrichment, cultures were streaked onto Xylose Lysine Deoxycholate (XLD) Agar (Scharlau, Spain) and Hektoen Enteric Agar (Scharlau, Spain) plates, incubating at 37 °C for another 24 h. Both media were checked for the existence of typical colonies, which were smeared onto the surface of a Kligler Iron Agar (Oxoid, UK) slope and the butt stabbed. Positive results were confirmed by serology with the *Salmonella* O Antiserum Poly A-I & Vi (Becton, Dickinson and Company, USA).

2.4. Fatty acids profile

Each sausage was cut into pieces and grounded in a mechanical mill, then lyophilized and placed in a glass flask and stored at 4 °C until use. For the extraction of fatty acids, the sausage samples were extracted using a Dionex 100 accelerated solvent extractor (ASE) (Dionex Corporation, USA) by means of the following procedure: aliquots (approximately 300 mg) of sausages was combined with 6 g of drying agent, diatomaceous earth (Dionex Corporation, USA), and the mixture was transferred to a 34 mL stainless steel extraction cell fitted with two cellulose filters. The total lipid sample was then extracted with a mixture of chloroform/methanol (60:40 (v/