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# Effect of the use of entire male fat in the production of reduced salt fermented sausages

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ABSTRACT

The effect of the use of entire male fat and salt reduction in dry fermented sausages was evaluated. Four different sausage formulations were manufactured with back fat from gilt or entire male and two different salt contents. The physicochemical parameters, sensory characteristics, texture, lipid composition, volatile compounds and boar taint compounds were analysed. The use of entire male fat produced the highest weight losses producing high hardness and chewiness while salt reduction produced a decrease in hardness. Entire male sausages had the lowest oxidation values due to the low content of C18:2n6 while salt reduction did not affect the oxidation process. Boar taint odour was due to the presence of androstenone and skatole but entire male fat sausages had different generations of volatile compounds. The presence of androstenone was perceived by consumers as abnormal odours but also other sausage characteristics such as texture (high hardness) and oxidation were detected due to the different chemical compositions of entire males versus gilts.



## 1. Introduction

Castration of male piglets is a common practise used to reduce boar taint among others effects such as the increase in fat proportion of carcasses and reduction of aggressive and sexual behaviour (Babol & Squires, 1995). However, current animal welfare and the European Declaration to stop surgical castration by the end of 2018 (European Declaration on Alternatives to Surgical Castration of Pigs, 2010) will raise the use of uncastrated males. In addition, EU regulation (Regulation EC No 854/2004, 2004) indicates that meat must be declared unfit for human consumption if it presents organoleptic anomalies, in particular a pronounced sexual odour. Therefore, meat industry needs to know about consumers' perception of boar taint since the use of boar meat may have economic impact.

Boar taint is especially perceived when boar meat is cooked and it is due to the presence of two substances, androstenone and skatole (Babol & Squires, 1995). Due to their hydrophobicity, both compounds are accumulated in the adipose tissue evoking urine and faecal, bitter or manure odours. Although, other compounds have also been reported to contribute to boar taint odour at a lesser extent such as androtenols (Brennan, Shand, Fenton, Nichols, & Aherne, 1986), indole (García-Regueiro & Diaz, 1989), 4-phenyl-3-buten-2-one (Rius Sole & García-Regueiro, 2001), phenolic compounds (Patterson, 1967) or aldehydes and short chain fatty acids (Rius, Hortós, & García-Regueiro, 2005).

Boar taint is related to sexual maturity as androstenone (5α-androst-16-ene-3-one) is a steroid synthesized in boar testes while skatole (3-methyl indole) is a metabolite of the amino acid L-tryptophan produced in the large intestine of pigs (Zamaratskaia, Babol, Andersson, & Lundström, 2004). Skatole concentration depends on the availability of tryptophan and composition and activity of intestinal bacteria. Therefore, skatole concentration can be reduced through the addition in the diet of certain carbohydrates (inulin, raw potato starch, etc), enzymes (Øverland, Kjos, Fauske, Teige, & Sørum, 2011) or sorbent material (Jen & Squires, 2011). However, androstenone concentration cannot be easily reduced; the only way known so far is through genetic selection or manipulation; unless inmunocastration is carried out. A vaccine called Improvac™ is actually available but, lower drip loss and darker meat than entire male have been reported meaning a lower propensity to develop pale, soft and exudative meat (Lundstörm, Matthews, & Haugen, 2009). Nevertheless, consumer perception of boar taint odour should be taken into account, as 99% of consumers are sensitive to skatole (Weiler, Fischer, Kemmer, Dobrowolski, & Claus, 1997) whereas a high number of consumers are anosmic to androstenone. Generally, a higher proportion of women are more sensitive than men as androstenone perception is genetically regulated (Lundstörm et al., 2009).

Several consumer studies evaluated the acceptability of meat from entire male and related to androstenone and skatole levels. Usually these studies were performed in raw or cooked meat being boar taint easily detectable during hot consumption (Babol & Squires, 1995). Regarding meat products, the loss of aroma and taste due to boar taint was more noticeable in cooking than drying and curing processes (Bañón, Costa, Gil, & Garrido, 2003a). In contrast, few studies deal

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with dry fermented sausages. Stolzenbach, Lindahl, Lundström, Chen, and Byrne (2009) studied the effect of boar fat, starter culture and smoke on the sensory quality of Swedish fermented sausages, concluding that the smoking process could mask the odour perception of boar taint as other authors previously reported (Lunde et al., 2008). Smoking practise in dry fermented sausages is common in northern Europe while less common in Mediterranean area where the products are mainly cured and ripened for longer time (Flores, 1997). In a recent study, Meier-Dinkel et al. (2013) determined the effect of label information on overall liking in non-smoke fermented sausages made with pork or boar meat. These authors concluded that label information did not affect the hedonic scores but the sausages made with lower androstenone levels were liked significantly better. In summary, cold consumption, added ingredients or the long ripening time that occurs during manufacturing of dry fermented sausages may be the reasons to partially mask boar taint. But the actual trend to reduce salt content in meat products (Commission European, 2008) affects the generation of volatile compounds and consequently flavour perception in dry fermented sausages (Corral, Salvador, & Flores, 2013). However, nothing is known about the effect of the use of entire male fat in dry fermented sausages and the changes in odour perception due to salt reduction. Furthermore, the purpose of this study was to evaluate the dry fermented sausage quality manufactured with entire male fat and reduced salt content.

## 2. Material and methods

### 2.1. Dry fermented sausage preparation and sampling

Three replicates of the experiment were carried out. For each replicate, four formulations (6 kg/formulation and a total of 24 kg/replicate) of slow fermented sausages were manufactured with back fat from gilt or entire male and different salt contents. The pork's ham lean and fat (bellies boneless and skinless) from twelve different animals per sex were purchased from a local producer (Incarlopsa, Spain) and delivered to IATA-CSIC for processing. Four different fermented sausage formulations were processed at the IATA-CSIC: control formulation with back fat from gilt (C), formulation with entire male back fat (MC) and both formulations with 27 g/kg salt content. Then the same two formulations, gilt back fat (RS) and entire male back fat (MRS), were processed but reduced in 25% salt content using KCl as substitute.

For each of three replications, the ground meat, the lean pork and the pork backfat were ground through a 10 mm diameter mincing plate and vacuum minced with the following additives (g/kg): sodium chloride (27), lactose (20); dextrin (20); glucose (7); sodium ascorbate (0.5); sodium nitrite (0.15); and potassium nitrate (0.15). Pork back fat from entire male and gilt were previously chopped and mixed separately due to variations in androstenone and skatole contents. Also, a commercial starter culture (0.1) SP318 TEXEL SA-301 was added (Danisco, Cultor, Madrid, Spain) containing *Lactobacillus sakei*, *Pediococcus pentosaceus*, *Staphylococcus xylosus* and *Staphylococcus carnosus*. The meat mixture was maintained at 3–5 °C for 24 h and then, was stuffed into 95 mm diameter collagen casings (Fibran, S.A., Girona, Spain). The final weight of each sausage was 700 g. The sausages were dried for 60 days at 10 °C and 70–85% relative humidity (RH). Temperature and RH of the ripening chambers were continuously recorded. In order to control the ripening process, two sausages from each replicate were weighed almost every day to control weight losses. Also, one sausage from each formulation was used to control the pH by introducing a pH meter HI 99163 (Hanna Instruments Inc., Hoonsocket, USA) into the centre of the sausage as described by ISO 2917 (1999).

Within each of the 12 batches ($3 \times 2 \times 2$) produced approximately 8 sausages were obtained in each batch. Two sausages from each batch were randomly chosen at day 0 and the end of ripening (60 d). In each sausage, colour analyses were done and then, 150 g of the sausage was minced and used for moisture, water activity (Aw) and pH analysis. The remaining minced sausage was vacuum packed and frozen at −20 °C for subsequent physicochemical analyses (TBARS, lipid, protein, ion content and fatty acid analyses). From sausages obtained at 60 d, several slices (1 cm thickness) were taken wrapped in aluminium foil, vacuum packaged and stored at −80 °C for volatile analyses. Finally, from each formulation, 2 sausages from each replicate (2 sausages × 3 replicates) were vacuum packed, stored at 4 °C and used for texture and sensory tests in less than 3–4 days.

### 2.2. Physicochemical analysis

The measurement of pH, $a_w$, weight losses, colour (CIELab L*, a* and b*), moisture, protein and fat was carried out as described by Corral et al. (2013). The ion content was determined by ion chromatography (Corral et al., 2013).

Texture profile analysis (TPA) was performed using TA-XT.plus Texture Analyser with Texture Exponent software (version 2.0.7.0 Stable Microsystems, Godalming, UK). At the end of the process, two slices per sausage (3.5 cm diameter and 1.5 cm thick) were compressed twice to 50% of their original height as described by Olivares, Navarro, Salvador, and Flores (2010). TPA curves were obtained and the following parameters calculated: hardness, adhesiveness, springiness, cohesiveness and chewiness.

### 2.3. Lipid profile, lipolysis and lipid autooxidation analysis

Lipid profile was determined by means of total fatty acids which were methylated as described by Berry, Cevallos, and Wade (1965). Fatty acid methyl esters (FAME) were analysed in an Agilent HP 7890B gas chromatograph (GC) equipped with a flame ionisation detector (FID) as described by Corral, Salvador, Belloch, and Flores (2015). For quantification, response factors of the standards with respect to an internal standard (C21:0) were calculated using the standard fatty acid methyl ester solution (FAME mix, Sigma-Aldrich, Germany). The results were expressed as percentage of total fatty acids identified.

Lipolysis was tested by analysis of free fatty acids (FFAs) released throughout ripening process. FFAs were methylated as described by Olivares, Navarro, and Flores (2011) and analysed in a GC-FID (Corral et al., 2015). The results were expressed as mg of fatty acid/100 mg of dry fermented sausage in dry matter.

Lipid autooxidation was measured by the thiobarbituric acid reactive substances (TBARS) method according to Corral et al. (2013). The results were expressed as mg malonaldehyde (MDA)/kg in dry matter.

### 2.4. Volatile compound analysis

#### 2.4.1. Profile and quantification of total volatile compounds

The analysis of volatile compounds in the headspace (HS) of dry fermented sausage was performed by SPME-GC–MS as described by Corral et al. (2015). Five grams of the minced sausage was weighted into a 20 ml HS vial sealed with a PTFE faced silicone septum and 0.75 mg of BHT was added. The vial was equilibrated at 37 °C for 30 min and then, SPME fibre (CAR/PDMS) was exposed to the HS during 2 h at 37 °C. The volatile compounds were desorbed in port injection of GC/MS (HP 7890A/5975C) (Hewlett Packard, Palo Alto, CA) for 5 min at 240 °C (in splitless mode) and equipped with a Gerstel MPS2 multipurpose sampler (Gerstel, Germany). The volatile compounds were separated using a DB-624 capillary column (J&W Scientific, Agilent Technologies, USA) and identified by comparison with mass spectra from the library database (Nist'05), Kovats retention index (Kovats, 1965) and by comparison with authentic standards. The identified volatile compounds were quantified in SCAN mode using either total or extracted ion chromatogram (TIC or EIC) on an arbitrary scale. The results were expressed as abundance units (AU) $10^{-6}$.