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Sensory characterisation and consumer acceptability of potassium chloride and sunflower oil addition in small-caliber non-acid fermented sausages with a reduced content of sodium chloride and fat

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ABSTRACT

The effect of the simultaneous reduction of fat proportion (from 20% to 10% and 7%) and added salt (from 2.5% to 1.5%) and the subsequent addition of 0.64% KCl and sunflower oil (1.5% and 3.0%) on the physicochemical, instrumental colour and texture, sensory properties and consumer acceptability of small caliber non-acid fermented sausages (*fuet* type) was studied.

This simultaneous reduction of fat and salt increased weight loss, moisture, water activity (a_w), redness, instrumental texture parameters (hardness, chewiness and cohesiveness), sensory attributes (darkness, hardness, elasticity) and the consumer acceptability. The subsequent addition of 0.64% KCl to the leanest batch decreased the a_w and barely affected instrumental texture parameters and consumer acceptability. Subsequent sunflower oil addition decreased hardness, chewiness and cohesiveness and increased crumbliness and oil flavour which may decrease the consumer acceptability. The simultaneous reduction of fat and NaCl with the addition of 0.64% KCl was the preferred option by the consumers.

1. Introduction

Many traditional fermented meat products with typical sensory characteristics are produced in Mediterranean countries. Among their traditional sausages, *fuet* is a type of small caliber non-acid fermented sausage from Catalonia (Northeast of Spain) made with pork meat, pork fat, and salt along with dextrose, nitrate, nitrite and pepper.

Dry-fermented sausages are meat products with high-fat and sodium contents. From a physiological approach, fat is a source of vitamins and essential fatty acids and constitutes the most concentrated source of energy in the diet (9.1 kcal/g). However, a high-fat intake is related to obesity, high levels of cholesterol and coronary heart diseases. For this reason, health organisations all over the world have promoted lowering the intake of total fat as a means of preventing heart disease (AHA, 1986; Department of Health, 1994; NCEP (National Cholesterol Education Program), 1988). Likewise, worldwide sodium intake is higher than the recommended level (European Food Safety Authority, 2005). Excessive fat and sodium intake has been linked to cardiovascular diseases including hypertension, stroke, and coronary heart disease (Dahl, 1972; Enser, Hallett, Hewitt, Fursey, & Wood, 1996; Kannel, 1996; Law, 1997). Based on this scientific information, consumers and the meat industry have become more aware of the benefits of healthier diets with reduced amounts of fat and salt.

Reducing fat is a complex issue in meat products, especially in dry-fermented sausages, as it affects important technological functions conferred by fat, such as the control of water release during drying (Wirth, 1988), and sensory attributes, i.e., flavour and texture (Bloukas, Paneras, & Fournitzis, 1997; Mendoza, García, Casas, & Selgas, 2001). Several studies have shown that pork fat can be reduced and substituted with vegetable oils, such as olive, sunflower, soy, and linseed oils, in fermented sausages while still obtaining adequate technological characteristics and acceptable sensory ratings (Del Nobile et al., 2009; Mora-Gallego et al., 2013; Mora-Gallego, Serra, Guàrdia, & Arnau, 2014; Muguerza, Ansorena, & Astiasarán, 2003; Olivares, Navarro, Salvador, & Flores, 2010; Pelser, Linssen, Legger, & Houben, 2007).

In contrast, NaCl is an essential ingredient in processed meat products, contributing to the water-holding capacity, colour, fat binding properties and flavour (Guàrdia, Guerrero, Gelabert, Gou, & Arnau, 2008). Moreover, salt decreases water activity (a_w) and this significantly affects the shelf-life (Sofos, 1984; Wirth, 1989). Potassium chloride (KCl) has similar functional properties to sodium chloride (NaCl) but has a different sorption isotherm than NaCl (Comaposada, Arnau, & Gou, 2007), and its addition to meat products is limited by its bitter taste. Nevertheless, it has been demonstrated that a reduction in NaCl and its partial substitution by KCl is possible in fermented sausages from a technological and sensory point of view (Gelabert, Gou, Guerrero, & Arnau, 2003; Gou, Guerrero, Gelabert, & Arnau, 1996; Guàrdia et al., 2008).

The aim of this study was to evaluate the effect of the simultaneous reduction of fat and salt and the subsequent addition of KCl and

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sunflower oil on the quality and consumer acceptability of small-caliber non-acid fermented sausages (*fuet* type).

2. Materials and methods

2.1. Sausage preparation and drying

A total of seven batches of small-caliber non-acid fermented sausages (*fuet* type) were prepared using two different raw materials commonly used in the meat industry for *fuet* production (pork-lean trimmings and pork-shoulder 3D). Shoulder 3D is a raw material (shoulder) deboned, rindless and without subcutaneous and intermuscular fat (3D). Pork-lean trimmings were composed of a mixture of fresh boneless pork ham trimmings and fresh boneless pork shoulder trimmings, which were weighed in appropriate amounts to achieve a lean:fat proportion of 90:10 (LT10) or 80:20 (LT20) depending on the target chemical fat level composition.

Table 1 shows the composition of each batch. A control batch (CT) with 2.5% NaCl was prepared with pork-lean trimmings LT20. The other six batches were prepared with 1.5% NaCl and with or without the addition of KCl (0.64% KCl, equivalent to equimolar substitution of 0.5% NaCl) and with or without the addition of sunflower oil, as described below. Two of the batches were prepared with pork-lean trimmings LT10 without the addition of KCl (batch L) and with the addition of KCl (batch L-KCl). The remaining four batches were prepared with pork-shoulder lean (S7, with 7 ± 1% of fat) without the addition of KCl (batch S), with KCl (batch S-KCl), with KCl and 1.5% sunflower oil (batch S-KCl-1.5SO) and with KCl and 3% sunflower oil (batch S-KCl-3SO).

The experimental design was intended to test the effects of the fat content of the raw material (lean trimmings LT20 and LT10, and shoulder lean), the addition of KCl (0.64%) and, the addition of sunflower oil (1.5 and 3%) to the leanest batch with KCl. The chosen sunflower oil was Borgesol (Borges Mediterranean Group, S. L. U., Reus, Tarragona, Spain) because of its neutral flavour. Two replicates of the experiment were carried out. For each replicate, the lean trimmings and shoulder from 12 animals were purchased at a local supplier. Each type of raw material was roughly minced (5 cm) and homogenised. Mixtures of 15 kg/batch were prepared. The meat was minced through a 5 mm plate, and the sunflower oil was added directly to the mixer. The following additives were added per kilogramme of the meat and fat mixture: 25 g of NaCl (CT batch), 15 g of NaCl (the rest of the batches), 6.4 g of KCl (for batches with KCl), 2 g of black pepper, 3 g of dextrose, 0.15 g of sodium nitrite and 0.15 g of potassium nitrate. Microbial starter Lyocarni SBI-77 (*Staphylococcus xylosus*, *Staphylococcus carnosus*, *Lactobacillus sakei*) (Sacco srl, Cadorago, Italy) was added (0.2 g/kg). The mixtures were mixed for 3 min at 0 °C using a mixer (model 35P, Tecnotrip S.A., Terrassa, Spain). The initial water and fat contents in the raw meat mixtures (before stuffing) for each batch were estimated by near infrared spectroscopy (Association of Official Analytical Chemists [AOAC], 2007) using a FoodScan™ Lab (Foss Analytical, Denmark). The *fuets* were stuffed with a vacuum stuffer into Ø 38 mm natural pork casings, immersed in a water bath containing a suspension of *Penicillium candidum*, and then hung and stored at 3 °C for 24 h. Thereafter, *fuets* were dried under the following conditions: 7 days at 14–16 °C and 80–85% relative humidity (RH) until the *fuets* were covered with mould, and then, at 12–14 °C and 70–75% RH until the end of the drying. The final water content on a defatted–desalted-dry-matter basis ($\dot{X}_{DFDSDM}$) was estimated from the initial composition of each raw material mixture and the weight loss of the sausages.

The industrial fermented sausage processors usually adjust the final weight losses of their products as a function of their fat content, because the fat tissue has a very low water content in comparison to lean tissue. Moreover, the water content influences the textural properties of cured lean meat (Ruiz-Ramírez, Arnau, Serra, & Gou, 2005). The objective of the experimental design was to achieve similar water content in the lean portion of the final product in all the batches. Therefore, all batches were dried in order to achieve the same water content in the lean portion, which was estimated with $\dot{X}_{DFDSDM}$. When the batch with the highest drying rate, i.e., the L batch, achieved an optimal level of dryness according to the external appearance and tactile texture of the sausages, the $\dot{X}_{DFDSDM}$ of this batch was stated as the target value for all the batches. A target weight loss for each batch was established *a priori* in order to achieve the target $\dot{X}_{DFDSDM}$. The pH was measured in *fuets* during the drying process (1 day, 7 days and at the end of process). A penetration electrode (Crison 52–32) on a portable pH-meter (CRISON PH25, Crison Instruments S.A., Alella, Spain) was used. Once the sausages of each batch reached the target weight loss, they were packaged (5 *fuets*/bag) in polyamide–polyethylene bags (Combivac 90, Sistemes d'Embalatge, Aiguaviva, Girona) with modified atmosphere (80% N_2: 20% CO_2) using a Tecnotrip EV-13 packaging machine (Tecnotrip, S.A., Terrassa, Barcelona) and stored at 3 °C for one month before analysis.

2.2. Instrumental colour analysis

Instrumental colour measurements were carried out with a colorimeter Konica Minolta Chroma Meter CR-400 (AQUATEKNICA, S.A., Valencia, Spain) with illuminant D65 (2° standard observer and specular component included) in the CIE-LAB space: L^* (lightness), a^* (redness) and b^* (yellowness) (Commission Internationale de l'Éclairage [CIE], 1976). Colour measurements were performed on five sausages per batch and replicate. Eight measurements on internal sections just after cutting were averaged per sausage.

2.3. Texture Profile Analysis (TPA)

A RT/5 Universal MTS Texture Analyser (Sistemas de Ensayo de Materiales, Barcelona, Spain) was used to perform the Texture Profile Analysis or TPA (Bourne, 1978) on 5 *fuets* per batch and replicate. Specimens (15-mm height) were compressed twice to 75% of their original height. Force-time curves were recorded at a cross-head speed of 1 mm/s. The following TPA parameters were obtained: springiness,

Table 1
Composition of the batches of *fuets* (small-caliber non-acid fermented sausages).

	Fuet batch						
	CT	L	S	L-KCl	S-KCl	S-KCL-1.5SO	S-KCL-3SO
Raw material	LT20[1]	LT10[2]	S7[3]	LT10	S7	S7	S7
NaCl (%)	2.5	1.5	1.5	1.5	1.5	1.5	1.5
KCl (%)	–	–	–	0.64	0.64	0.64	0.64
Sunflower oil (%)	–	–	–	–	–	1.5	3.0
Fat content[4] (%)	$33.2^{a} \pm 0.64$	$18.6^{b} \pm 0.07$	$15.1^{c} \pm 0.57$	$17.4^{bc} \pm 0.77$	$12.9^{d} \pm 0.11$	$16.44^{c} \pm 0.28$	$16.3^{c} \pm 0.45$

[abcd]Within row, least-squares means with a common letter are not significantly different ($P > 0.05$).
[1] LT20: lean trimmings (approx. 20% fat).
[2] LT10: lean trimmings (approx. 10% fat)
[3] S7: shoulder 3D (approx. 7% fat).
[4] Fat content at the end of the process.