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Effect of reducing and replacing pork fat on the physicochemical, instrumental and sensory characteristics throughout storage time of small caliber non-acid fermented sausages with reduced sodium content

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ABSTRACT

The effect of pork fat reduction (from 44% to 20% final fat content) and its partial substitution by sunflower oil (3% addition) on the physicochemical, instrumental and sensory properties throughout storage time of small caliber non-acid fermented sausages (*fuet* type) with reduced sodium content (with partial substitution of NaCl by KCl and K-lactate) and without direct addition of nitrate and nitrite (natural nitrate source used instead) was studied. Results showed that sausages with reduced fat (10% initial fat content) and with acceptable sensory characteristics can be obtained by adding to the shoulder lean (8% fat content) during the grinding, either 3.3% backfat (3% fat content) or 3% sunflower oil, both previously finely comminuted with lean. Furthermore, sunflower oil showed to be suitable for partial pork backfat substitution in very lean fermented sausages, conferring desirable sensory properties similar to those of sausages with standard fat content. The sensory quality of the sausages was maintained after three-month cold storage in modified atmosphere.

1. Introduction

Fermented sausages are meat products with high animal fat and sodium chloride (NaCl) contents, with fat values of 30–50% in *salami* (Jiménez-Colmenero, 2000) and 42% in small caliber non-acid fermented sausage *fuet* type (Spanish Food Composition Database [BEDCA], 2007), and with NaCl levels of 3.4–5.2% in *salami* (Dellaglio, Casiraghi, & Pompei, 1996) and around 3.7% in *fuet* (Zurera-Cosano et al., 2011). In most Western countries, intake of both saturated fat and sodium is higher than recommended (European Food Safety Agency (EFSA), 2005; World Health Organization [WHO], 2003), posing a threat to public health, especially because of their relationship with adverse cardiovascular effects including coronary heart disease, stroke and hypertension (European Food Safety Authority, 2010; Kannel, 1996; Law, 1997). According to the recommendations of the World Health Organization (WHO) (2003), the daily fat intake should be less than 30% of the total calories, and the intake of saturated fatty acids and cholesterol should be reduced. Likewise, the mean daily sodium intakes are in excess of dietary needs (about 1.5 g sodium/day in adults) (European Food Safety Authority, 2005). These recommendations have contributed to an increasing interest on healthier diets among consumers and to the development of reduced fat meat products by the meat industry. Nevertheless, it is difficult to reduce fat and NaCl levels in fermented sausages because they are essential ingredients. In sausage manufacture, fat affects important technological functions like water release during drying (Wirth, 1988), and sensory properties such as flavor and texture (Mendoza, García, Casas, & Selgas, 2001). Accordingly, fat reduction can adversely affect the acceptability of meat products (Giese, 1996). Different vegetable oils, i.e. olive, soybean, and linseed oils, have been used as fat substitutes in fermented sausages such as *salami*, *chorizo de Pamplona*, and *cervelat* (Dutch style fermented sausage) obtaining acceptable products (Ansorena & Astiasarán, 2004; Del Nobile et al., 2009; Muguerza, Ansorena, & Astiasarán, 2003; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasaran, 2001; Pelser, Linssen, Legger, & Houben, 2007; Severini, De Pilli, & Baiano, 2003; Valencia, Ansorena, & Astiasarán, 2006). In a previous study (Mora-Gallego et al., 2013) sunflower oil (5%) was used as fat substitute in reduced fat non-acid fermented sausages with standard NaCl content that showed good instrumental texture and sensory properties. Concerning NaCl, it is an essential ingredient that contributes to improve the water holding capacity, color, fat binding properties, flavor and shelf-life of processed meat products (Ruusunen & Puolanne, 2005). The preservative effect of NaCl is mainly due to its ability to lower water activity (Marsh, 1983; Sofos & Raharjo, 1994; Wirth, 1989). The reduction of sodium in meat products is possible from both technological and sensory viewpoints (Askar, El-Samahy, & Tawfik, 1994; Gelabert, Gou, Guerrero, & Arnau, 2003; Gou, Guerrero, Gelabert, & Arnau, 1996; Kim & Brewer, 1996). Potassium chloride (KCl) and potassium lactate (K-lactate) have been proposed as NaCl substitutes in fermented sausages with satisfactory results regarding sensory attributes and consumer acceptability (Gelabert et al., 2003; Gou et al., 1996; Guàrdia, Guerrero, Gelabert,

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Gou, & Arnau, 2006, 2008), but the drying process could be affected (Arnau, Muñoz, & Gou, 2012; Muñoz, Arnau, Costa-Corredor, & Gou, 2009). Regarding the shelf-life of meat products, lipid oxidation is a major concern in food technology due to the loss of quality associated to this process, with negative effects on flavor, texture, mouth feel, juiciness and overall sensation of lubricity (Muguerza, Fista, Ansorena, Astiasaran, & Bloukas, 2002; Navarro, Nadal, Izquierdo, & Flores, 1997). High fat contents and prolonged storage times result in high lipolytic activity and lipid oxidation that can affect the color of fermented sausages (Soyer & Ertas, 2007). Packaging in modified atmosphere (vacuum and gas packaging) has been introduced as a commercial practice for the retail selling of dry fermented sausages to increase their shelf-life (Rubio, Martínez, García-Cachán, Rovira, & Jaime, 2008).

This work aims to assess the effect of pork fat reduction and its substitution by sunflower oil on the physicochemical, instrumental and sensory properties throughout storage time of small caliber non-acid fermented sausages (*fuet* type) with reduced sodium content (with partial substitution of NaCl by KCl and K-lactate) and without direct addition of nitrate and nitrite.

2. Materials and methods

2.1. Sausage preparation and drying

Two replicates of the experiment were carried out. Pork-shoulder lean (8% fat content) and backfat (89% fat content) were purchased at a local supplier. For each replicate, three batches (15 kg/batch) of small caliber non-acid fermented sausages (*fuet* type) were manufactured using pork-shoulder lean and three different added fat contents: 20% backfat (which corresponds to 17.8% added fat; BF20), 3.3% backfat (which corresponds to 3% added fat; BF3) and 3% sunflower oil (SO3). The BF20 batch (20% backfat) was prepared by mixing and mincing the backfat together with the shoulder lean (both at −1 °C ± 1 °C) through a 5 mm plate. In the case of the BF3 batch (3.3% added backfat) 0.5 kg of backfat was minced in a bowl chopper (Dito-Sama K55, Dito-Sama S.A., Aubusson, France) with 1 kg of shoulder lean (without salt addition) for 2 min until forming a finely comminuted paste that was later added to the rest of the shoulder lean of the batch and ground through a 5 mm plate. The same process was carried out for the SO3 batch in which 0.45 kg of sunflower oil (3%) was added as backfat substitute and minced together with 1 kg of shoulder lean in a bowl chopper and then ground with the rest of lean. The sunflower oil used was Koipesol (Koipesol Semillas S.A., Sevilla, Spain). The following additives and ingredients per kilogram of mixture were added to the ground mixtures of lean and fat and mixed under vacuum for 3 min in a mixer (Tecmaq20): 14 g NaCl (which represents a 30–35% NaCl reduction with respect to the NaCl added to a standard product: 20–22 g/kg; Mora-Gallego et al., 2013; Guàrdia et al., 2008), 4.22 g potassium chloride (15% equimolar NaCl substitution regarding a standard product with 22 g/kg NaCl), 13.25 g potassium lactate (78% purity; PURAC bioquímica, S. A., Montmeló, Barcelona, Spain) (21% equimolar NaCl substitution regarding a standard product with 22 g/kg NaCl), 3 g white pepper, 30 g lactose, 2 g dextrose, 10 g water and 2.20 g Natplus 223 (a natural flavoring containing Swiss chard and carrot juice concentrate powder; Chr. Hansen S. L., Barcelona, Spain) as a natural source of nitrate instead of direct addition of nitrate and nitrite. Also, a microbial starter Lyocarni SBI-77 (*Staphylococcus xylosus*, *Staphylococcus carnosus*, *Lactobacillus sakei*) (Sacco srl, Cadorago, Italy) with nitrate reductase activity was added (0.2 g/kg). The meat mixture was stuffed into Ø 38 mm pork natural casings and dipped in a *Penicillium candidum* suspension (PC HP 6 LYO 10 D, DANISCO; Grama Aliment SL, Les Preses, Spain), which is a general practice in the industry to obtain the typical external appearance of the product. The sausages were stored in a drying room: 1 day at 15 ± 1 °C and 90 ± 2.5% relative humidity (RH), and 2 days at 20 ± 1 °C and 90 ± 2.5% (fermentation stage) to allow the mold growth. Subsequently, drying was carried out at 13 ± 1 °C and with decreasing RH from 85% to 75% ± 2.5% until reaching a weight loss of approx 49%. Once the sausages of each batch reached the target final weight loss, they were packaged in polyamide–polyethylene bags with modified atmosphere (MAP; 80% N_2:20% CO_2) and stored at 3 °C for one month for moisture equalization before analysis (time = 1 month). A subsample of the sausages continued the storage at 3 °C in MAP up to three months to evaluate the product characteristics during shelf-life (time = 3 months).

2.2. Instrumental color analysis

Instrumental color measurements were carried out with 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). Color measurements were performed on five sausages per batch and averaging eight readings on new cut surfaces per sausage.

2.3. Instrumental texture analysis

2.3.1. Texture Profile Analysis (TPA)

A RT/5 Universal MTS Texture Analyzer (Sistemas de Ensayo de Materiales, S.A., Barcelona, Spain) was used to perform the Texture Profile Analysis or TPA (Bourne, 1978). Specimens (15 mm height) were compressed twice to 75% of their original height. Force–time curves were recorded at a crosshead speed of 1 mm/s. The following TPA parameters were obtained: springiness, hardness (N/cm^2), cohesiveness and chewiness (N/cm^2). The mean of three specimens per sample was used for statistical analyses. Hardness values were corrected for the different sample areas and expressed as N/cm^2. Chewiness (N/cm^2) was calculated as follows: corrected hardness × cohesiveness × springiness (Bourne, 1978).

2.3.2. Stress relaxation test (SR)

Stress relaxation (SR) test was performed on all the samples with the same equipment used for the TPA test. Specimens (15 mm height) were compressed to 25% of their original height at a crosshead speed of 1 mm/s. The force versus time after the compression was recorded at 2 and 90 s (relaxation time). The relaxation curves obtained for each specimen were normalized, i.e., the force decay $Y(_t)$ was calculated as follows:

$$Y_{(t)} = \frac{F_0 - F_{(t)}}{F_0},$$

where F_0 (N) is the initial force and $F(_t)$ is the force recorded after t seconds of relaxation. F_0, F_2 and F_{90} values were corrected for the different sample areas and expressed as N/cm^2. The force decay values at 2 s (Y_2) and 90 s (Y_{90}) were calculated (Morales, Guerrero, Serra, & Gou, 2007). The mean of three specimens per sample was used for statistical analysis. After texture analysis the specimens were minced, vacuum-packed and kept frozen at −18 °C for further physicochemical analysis.

2.4. Physicochemical analysis

The pH was measured in the meat mixture before stuffing and in sausages during the drying process (3 days, 7 days and in the final product). A pH penetration electrode (Crison 52-32) on a portable pH-meter (CRISON PH 25, Crison Instruments S.A., Alella, Spain) was used. The pH of the final product was measured in a homogenized sample solution (5 g sample/20 ml ultrapure H_2O) (Choi et al., 2009). Water activity (a_w) measurement was carried out at 25 °C with an AquaLab Series 3 instrument (Lab-Ferrer, Cervera, Spain). After measuring a_w, the moisture content of the samples (%) was immediately determined by drying until reaching constant weight (Association of Official Analytical Chemists [AOAC], 1990).