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Dry-fermented chicken sausage produced with inulin and corn oil: Physicochemical, microbiological, and textural characteristics and acceptability during storage

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ABSTRACT

This study aimed to evaluate the effect of oil content reduction and the addition of inulin as a partial oil substitute on the physicochemical, microbiological, and textural characteristics and acceptability during the storage (4 °C for 45 days) of dry-fermented chicken sausage produced with corn oil. Reducing the oil content did not influence the characteristics evaluated but tended to produce sausage with a dark reddish coloration. The addition of inulin did not change the physicochemical and microbiological parameters or the acceptability of the products, but resulted in an altered texture profile and a tendency toward lighter and less reddish coloration, similar to products with standard oil content. Fermented chicken sausages produced with standard amounts of corn oil, reduced amounts of corn oil, and inulin as a partial oil replacement remained stable without a significant loss of physical, chemical, microbiological, or sensory attributes during storage at 4 °C for 45 days.

1. Introduction

The demand for meat products with lower fat contents or healthier fatty acid compositions has increased in recent years due to new guidelines recommending reduced saturated fat intake and consumers' desire to lose weight (Akesowan, 2008; Archer, Johnson, Devereux, & Baxter, 2004; Colmenero, 2000). Several alternative strategies have been used in the manufacture of these products, such as the substitution of red meat by skinless poultry meat (Andrés, García, Zaritzky, & Califano, 2006; Awonorin, 1993; Yilmaz, Simsek, & Isikli, 2002), the substitution of saturated fat with vegetable oils (Koutsopoulos, Koutsimanis, & Bloukas, 2008; Ospina-E, Cruz-S, Pérez-Alvárez, & Fernández-López, 2010), and the use of fat replacers, such as guar gum, carrageenan, xanthan gum, and inulin (Akesowan, 2008; Andres, Zaritzky, & Califano, 2006).

Skinless poultry meat contains more protein, less fat, and less cholesterol than red meat (Hu, 2005; Ressurreccion, 2004). Its protein is of excellent nutritional quality, and it contains all of the essential amino acids for human consumption (Varnam & Sutherland, 1995). Furthermore, the manufacture of poultry meat products usually costs less than that of similar beef and pork products (Guerrero-Legarreta & Hui, 2010). An added benefit is that poultry meat is not restricted by most cultural and religious laws, and it is consumed by both Jews and Muslims (Deumier & Collignan, 2003).

Dry-fermented sausages contain 45–50% fat (Bloukas, Paneras, & Fournitzis, 1997). A reduction in their fat content may lead to hard and adhesive meat products with greater weight loss that are unacceptable in appearance due to their rough texture, darker coloration, and shorter shelf-life (Colmenero, 2000; Muguerza, Fista, Ansorena, Astiasarán, & Bloukas, 2002).

The substitution of animal fat with vegetable oils has been suggested to improve the fatty acid profile and to decrease the cholesterol levels of meat products (Özvural & Vural, 2008). Several vegetable oils have already been used as fat substitutes, such as olive, flaxseed, corn, soybean, and canola oil (Fernández-Ginés, Fernández-López, Sayas-Barbera, & Pérez-Alvarez, 2005; Ospina-E et al., 2010). However, the simple replacement of animal fat with vegetable oil does not alter the lipid content or caloric value of the products (Muguerza, Gimeno, Ansorena, & Astiasarán, 2004). Thus, reducing the amount of added oil, combined with the use of non-lipid fat substitutes, could be an option in the production of dry-fermented sausages with low fat content and acceptable physicochemical and sensory characteristics (Muguerza et al., 2004).

Inulin is a soluble plant fiber that consists of a mixture of oligo- and polysaccharides (Selgas, Cáceres, & Garcia, 2005). Inulin can be used as a fat replacement in food products due to its ability to form a gel when mixed with water. The resulting gel has a fine, creamy texture that mimics the oral tactile sensation of fat in products with low fat content (Janvary, 2008). At the same time, inulin contributes few calories to food products, approximately 1 to 1.5 kcal/g (Coussement & Franck, 2001).

In meat products, inulin has been evaluated as a fat substitute in pâtés (Florowski, Adamczak, Fuertez-Hernández, Moreno-Franco, & Tyburcy, 2008), pork meatballs (Flaczyk, Gorecka, Kobus, & Szymandera-Buszka, 2009), and cooked sausages (Garcia, Cáceres, & Selgas, 2006; Nowak, Von Mueffling, Grotheer, Klein, & Watkinson, 2007; Selgas et al., 2005). Few studies have evaluated the effect of inulin as a fat substitute in dry-fermented meat sausage (Dragan, Ilija, & Snezana, 2011; Mendoza,

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Garcia, Casas, & Selgas, 2001), and none of these studies used poultry meat as a raw material. Therefore, this study aimed to evaluate the effects of reducing the oil content and adding inulin as a partial oil substitute on the physicochemical, microbiological, and textural characteristics and on acceptability during the storage of fermented chicken sausages produced with corn oil.

2. Material and methods

2.1. Materials

Commercial chicken breast fillets, corn oil (Xodómilho®), soy protein isolate (Frimesa®), BHA (Nutricom®), non-edible collagen wrap (R2LD75, Viscofan®, 6.8 cm in diameter), and inulin (Raftiline HP-Gel, Orafti®) were used in this experiment. A starter culture (Bactoferm T-SPX, Chr. Hansen®) consisting of *Staphylococcus xylosus* DD-34 and *Pediococcus pentosaceus* PC-1, and the probiotic culture *Lactobacillus paracasei* ssp. *paracasei* (*Lactobacillus casei* LC-01 Chr. Hansen®) were used in the fermentation of the chicken meat.

2.2. Methods

2.2.1. Formulations

Three formulations of fermented chicken sausages were prepared: F1 (with standard oil content [17% corn oil]), F2 (with reduced oil content [9% corn oil]), and F3 (with reduced oil content and added inulin [9% corn oil and 7% inulin]). The experimental design and the amounts of the relevant ingredients used are shown in Table 1. The following ingredients, common to all formulations, were also added (per kg of meat mixture): 4.4 g sucrose, 26.4 g sodium chloride, 0.1 g BHA, 0.15 g sodium nitrite, 0.3 g sodium nitrate, 0.05 g garlic, 2.49 g white pepper, 0.01 g probiotic culture, and 0.265 g starter culture.

2.2.2. Sausage preparation

The oil pre-emulsion was prepared using water and soy protein isolate to improve the stabilization of corn oil in the meat mixture to be fermented. Eight parts of hot water (50 °C) were mixed with one part soy protein isolate using a blender (Walita®) at medium speed, until all protein isolate was dispersed (about 2 min). For the pre-emulsion, ten parts corn oil was added dropwise to the mixture obtained, while mixing at ambient temperature using a blend at medium speed for about 3 min (Bloukas et al., 1997; Muguerza et al., 2002).

After grinding the refrigerated meat in a processor (Walita® master) equipped with 14 cm blade for 10 min at the highest speed, the following ingredients were added and mixed: salt, pepper, curing ingredients, BHA, and the probiotic and starter cultures (previously diluted in 4.5 mL sterile water for better homogenization). Then, the pre-emulsified oil and inulin were added. The meat mixture was stuffed in a collagen wrapper and fermented for 60 h at 18 °C in a climatic chamber. The product was then cured for 10 h in a sawdust (cedar and cedrela) smoker at room temperature and stored in a climatic chamber for 30 days at 15 °C to complete the aging process.

During aging, when the product reached a water activity of 0.89 ± 0.01, it was washed to remove external fungi, dried under air flow for approximately 2 h, and vacuum packed in biaxially oriented polypropylene (BOPP) film. The BOPP film had 58 μm thickness, water vapor transmission rate of 4.6 to 6.2 g of water/m^2 and oxygen transmission rate in the range of 1800 to 3120 cm^3/m^2; at 38 °C and 90% relative humidity (Teixeira Neto & Vitali, 1996). The product was then returned to the climatic chamber, under the same conditions, to complete the aging process.

The dry-fermented sausages were stored at 4 °C for 45 days. Physicochemical, texture, microbiological and acceptability analyses were performed every 15 days. The chemical composition was determined only in newly dry-fermented sausages (time 0).

Table 1
Experimental design and ingredients used.

Ingredient	Formulations (g/kg of product)[a]		
	F1	F2	F3
Chicken breast	705	791	791
Corn oil	176.2	90	90
Inulin	–	–	68.13
Soy protein isolate	17.2	9	9
Water	140.96	72	72

[a] Formulations: F1 (17% corn oil), F2 (9% corn oil) and F3 (9% corn oil and 7% inulin).

2.2.3. Physicochemical analysis

The moisture, protein, lipid, carbohydrate, and ash analyses were performed according to AOAC standards (1995). To measure pH, a 5 g sample was homogenized in 50 mL distilled neutralized water, and the pH was measured using a digital pH meter (Hanna® HI8314) that had been calibrated with buffer solutions at pH 4 and 7. The water activity was determined using Aqua Lab CX-2 (Decagon Devices®) as recommended by the manufacturer. Lipid oxidation was evaluated by the determination of TBARS (thiobarbituric acid reactive substance) values (Talardgis, Watts, Younathan, & Dougan, 1960).

To measure color, 8 mm-thick cross-sectional slices were cut from the products by using a cutter slicer (Yanes®). Digital images of slices from the product surface were obtained using a scanner (Genius®, ColorPage-vivid3). The images were converted to average RGB values using the "average RGB color converter to BMP images" function in a pixel-by-pixel reader application (Sachs, Portugal, Prudencio-Ferreira, & Felinto, 2001). Subsequently, the data were converted to CIELAB values in Munsell Conversion 4.01 software (Colorpro, 2001) to obtain the values of L* (luminosity), a* (red–green component), and b* (yellow–blue component). The parameter redness index (a*/b*) (Candogan & Kolsarici, 2003) was also calculated.

2.2.4. Microbiological analysis

A 25 g sample from each formulation was homogenized in 225 mL sterile 2% buffered peptone water (BPW, Oxoid®). Serial dilutions were performed, and the total lactic acid bacteria count was conducted in MRS agar plates (Himedia®). The plates were incubated anaerobically at 37 °C for 72 h (Pidcock, Heard, & Henriksson, 2002). Total coliforms, coagulase positive staphylococci, *Salmonella*, and sulfite-reducing *Clostridium* counts were determined as described by Brasil (1992).

2.2.5. Texture analysis

To analyze texture, 8 mm-thick cross-sectional slices were cut from the products, and a 3 cm diameter core was taken from the center of each slice using a tube. A fraction of the outer edge of the slice was also separated to measure hardness. The textural tests were performed in a TA-XT2i (Stable Micro Systems®) texturometer. The edge of the product was measured for hardness (N), and Texture Profile Analysis (TPA) was performed on the fraction that represents the center of the sample to determine hardness (N), cohesiveness (dimensionless), adhesiveness (Ns), springiness (dimensionless), and chewiness (N). The samples from the center of the slice were compressed (double compression) at 40% of the initial height with a P35 cylindrical acrylic sensor, 0.2 N force, and 5 mm/s speed. Only one compression cycle was used to measure the hardness of the edge.

2.2.6. Sensory evaluation

Acceptance testing using a hedonic scale of 9 points was conducted with a panel of 30 untrained assessors (Stone & Sidel, 1993). In each analysis session, the coded formulations were evaluated at room temperature, one at a time, in a randomized order. The test was conducted in individual booths with fluorescent lamps (daylight). Potable water at room temperature was used to rinse the mouth prior to and between