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Effect of preformed konjac gels, with and without olive oil, on the technological attributes and storage stability of merguez sausage

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ABSTRACT

In order to improve the fat content of fresh sausages (merguez), the effects of both reducing beef fat level (by konjac gel-KG) and incorporing olive oil (in a konjac matrix-OKM) on nutritional, quality characteristic and refrigerated storage stability were studied. Fat reductions in merguez sausages of between 53 and 76% were achieved when beef fat was replaced with KG; the proportion reached 34–49% using OKM as a beef fat replacer, where 23 to 36% of total fat in the merguez was from olive oil. The merguez contained substantial amounts of some minerals (Mg and Fe). Sensory analysis revealed no significant differences between the control and the reformulated products, which had relatively low levels of lipid oxidation. Shelf life and biogenic amines of merguez sausage were not affected by formulation during refrigerated storage. Therefore, the use of konjac materials as fat replacers could reduce total caloric energy by replacing/reducing beef fat and improving sausage formulation to achieve healthier merguez products.

1. Introduction

Merguez is a fresh sausage originating from North Africa that is widely consumed in different countries of the world including Europe and Asia. It is generally made of lean and fat beef (also with lamb or mutton) mixed with condiments stuffed into a lamb intestine. It is heavily spiced with chilli pepper or harissa, which gives it its characteristic hot and red color, as well as other spices such as fennel and mint. Merguez has a short shelf life even when stored at refrigerated temperature (Benkerroum, Daoudi, & Kamal, 2003). This raw strongly-spiced meat product is usually eaten grilled or with couscous; dried merguez is used to add flavor to typical Arabian and African dishes.

Fresh sausages of this kind usually present some negative health concerns related to their high fat (over 20%), energy (around 280–300 kcal/100 g) and salt (3.6%) contents, as well as the fatty acid profiles of the animal fat (ANSES, 2008). Like other meat products, merguez can be reformulated to achieve healthier lipid compositions. There is no doubt that dietary fat is needed as a metabolic energy source and a supplier of essential nutrients, but it must be consumed in moderation for reasons of human health. There is growing evidence associating dietary fat (quantity and type of fat) with chronic disorders such as ischaemic heart disease, some types of cancer, and obesity (WHO, 2003). Improving the fat content of foods has generally been seen as an important strategy to produce healthier products. This aspect is especially relevant to the processed meat industry because of the relatively high fat content in processed meats, including fresh and cooked sausages. Globally, meat accounts for about 8% of total energy availability, 18% of dietary protein, and 23% of dietary fat. Meat consumption is considerably higher in high-income countries—10% of total energy intake compared with 7% in low-income countries—(WCRF, 2007), although the amount of meat consumed in developing countries is increasing rapidly (Delgado, 2003). Therefore, healthier-lipid meat product formulations are important in all societies.

In order to improve fat content in meats, two different aspects must be considered: the reformulation of products containing less fat and a better fatty acid profile, by replacing the animal fat normally present with other fats more in line with health recommendations from plant or marine sources. Fat reduction in meat products is usually based on two main criteria: use of leaner meat raw materials and reduction of fat density (dilution) by adding water and other ingredients (Jiménez-Colmenero, 2007). These ingredients should assure a low calorie content and give the product the desired characteristics. One such ingredient is konjac (glucomannan)-based fat analogues, which open up interesting possibilities. Konjac is a neutral polysaccharide produced by *Amorphophallus konjac*, a plant native to East Asia, where it has been used since ancient times. The interest of this ingredient lies in its important technological properties (water retention capacity, gelling and thickening agent) and potential health implications (e.g. reducing cholesterol, insulin and glucose levels or its satiating and laxative effect) which offer great potential for application in food technology (Tye, 1991). Its use as a food additive is authorized in Europe (E-425), and it is classified as GRAS by the FDA. Konjac, added in different ways and concentrations, has been used to reduce fat in products such as frankfurters (Jiménez-Colmenero et al., 2010; Osburn & Keeton, 2004), bologna (Chin, Keeton, Miller, Longnecker, & Lamkey, 2000),

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fresh sausages (Osburn & Keeton, 1994), pork nuggets (Berry & Bigner, 1996) or pâtés (Delgado-Pando, Cofrades, Rodriguez-Salas, & Jiménez-Colmenero, 2011).

In order to improve fatty acid profiles, a variety of non-meat fats of plant and marine origin have been added to meat products as partial substitutes for meat fats, mainly pork or beef (Jiménez-Colmenero, 2007). Of vegetable oils, olive is the one that has received most attention, chiefly as a source of monounsaturated fatty acids (MUFAs). It has a high biological value attributed to a favorable mix of MUFAs and naturally-occurring antioxidants (vitamin E, vitamin K, carotenoids and various polyphenols: hydroxytyrosol, tyrosol, and oleuropein). Partial substitution of pork backfat by olive oil and high-oleic acid sunflower oil has been tried in meat products such as fresh, cooked and fermented sausages, beef patties, etc. (Jiménez-Colmenero, 2007; Koutsopoulos, Koutsimanis, & Bloukas, 2008; López-López, Cofrades, Yakan, Solas, & Jiménez-Colmenero, 2010). No studies have been conducted to combine 1) reduction of fat content and 2) alteration of fatty acid profile using konjac gels in fresh beef sausage (merguez).

One essential aspect of a strategy for achieving healthier lipid composition is the procedure used to incorporate the plant and marine oils in meat products. To that end, various technological options have been used, ranging from direct addition as liquid oils or as solids (including interesterified oils) to incorporation in encapsulated or pre-emulsified form or as part of plant ingredients (Jiménez-Colmenero, 2007). One such technological procedure that has yet to be explored is the incorporation of healthier oil into a konjac matrix and the use of this new ingredient as an animal fat replacer in meat products at the same time stabilizing the olive oil in the konjac gel matrix during formulation, processing and storage. Compared to other technological options, this approach to oil stabilization offers additional health benefits associated with the presence of konjac.

Therefore, the objective of this research was to evaluate the nutritional consequences, quality characteristics and storage stability (shelf life) of merguez (fresh beef sausage) produced by a reformulation process designed to improve fat content, by both reducing fat content (replacing the beef fat with konjac gel) and incorporating olive oil (replacing the beef fat with olive oil stabilized in a konjac matrix).

2. Materials and methods

2.1. Materials and konjac gel preparation

Fresh post-rigor beef (20.6%, 6.1%, 71.7% protein, fat and moisture contents respectively) and beef fat (10.0%, 46.1% and 37.3% protein, fat, and moisture contents respectively) were obtained from a local market, minced (15 mm diam. hole mincer plate) (Vam.Dall. Srl. Modelo FTSIII, Treviglio, Italy), and frozen at −20 °C. Frozen storage did not exceed 14 days.

The following ingredients were used: konjac flour (glucomannan 83%, 120 mesh) from Trades S.A. (Barcelona, Spain), pre-gelled cornstarch (Amigel, Julio Criado, S.L. Madrid. Spain). i-carrageenan (Hispanagar S.A, Burgos, Spain) and Ca(OH)2 (Panreac Química S.A., Barcelona, Spain). Other ingredients and additives used were olive oil (Carbonell Virgen Extra, SOS Cuétara SA, Madrid, Spain), sodium chloride (Panreac Química, S.A. Barcelona, Spain) and various condiments and spices including coriander (Naturel, Conditionnement de produits agricoles, El Sahlin, Tunisia), fennel (Kamy S.A. (Nabeul) Tunisia), paprika and hot pepper (Jose Mª Fuster Hernandez S.A., Murcia, Spain), mint (DUCROS, Mac Cormick S.A., Spain) and a commercial preparation of Harissa (Ferrero, TUCAL S.A., Manouba, Tunisia). Harissa is one of the ingredients most commonly used in the Maghreb countries (especially Tunisia) to prepare certain foods, particularly meat products. Ingredients commonly include red hot pepper, garlic, coriander, caraway and salt.

Two types of konjac materials (fat analogues) were prepared: one a konjac gel (KG) and another with olive oil added to the konjac matrix (oil-in-konjac matrix/OKM). KG was prepared as described by Osburn and Keeton (2004) with modifications (Jiménez-Colmenero et al., 2010). Briefly, konjac flour (5.0%) was homogenized (Stephan Universal Machine UM5, Stephan Machinery GmbH and Co., Hameln, Germany) with 64.8% of the water for 3 min, left to rest for 5 min then homogenized for a further 3 min. The i-carrageenan (1.0%) was then added and the mixture homogenized again for 3 min. The pre-gelled cornstarch powder (3.0%) was dispersed in 16.2% of the water and homogenized with the mixture of konjac flour and i-carrageenan, left to rest for 5 min then homogenized for a further 3 min. The mixture was cooled to 10 °C, then 10% of a Ca(OH)2 solution (1%) was added with gentle stirring at room temperature.

Oil-in-konjac matrix (OKM) was prepared in the same way as KG, except that 20% w/w of olive oil was added just after addition of i-carrageenan and the mixture was homogenized for 3 min. In both types of konjac materials (KG, OKM) the formulation maintained the same proportions of the components used to prepare them with respect to the water base (hence not including the added oil). The preparation conditions and the technological viability of adding these proportions of oils to konjac materials (OKM) were established earlier. KG and OKM were placed in suitable containers, covered, manually overpressured to eliminate air and stored at 2 ± 2 °C until used (within 24 h of preparation). Both ingredients were prepared in duplicate.

2.2. Experimental design and merguez sausage manufacture

Merguez sausages were designed and formulated to improve fat content, using similar amounts of lean meat since fat was reduced by replacing the beef fat with the same proportion of two fat analogues (konjac materials). Five treatment formulations were evaluated (Table 1): a control formulation (C) prepared with 20% fat content, two formulations in which 75 and 100% of the beef fat was replaced by the same portion of KG (fat analogue). Thus, both reformulated products contained less fat than the control, but in these three formulations (C, 75/KG and 100/KG) all the fat was animal fat (from beef). Finally another two formulations (75/OKM and 100/OKM) were prepared in which 75% and 100% of the beef fat was replaced respectively by the same proportion of OKM (fat analogue); in this case the reformulated sausages contained higher fat levels than 75KG and 100KG due to the olive oil present in the OKM. This means that the animal fat was partially replaced by olive oil. According to the experimental design, the resulting products would have different fat levels.

The meat and fat were thawed before use (18 h at 2 ± 2 °C). The sausages were made as follows. Firstly meat, fat and konjac materials were minced together to a 15 mm particle size (Vam.Dall. Srl. Modelo FTSIII, Treviglio, Italy) and placed in a mixer (MAINCA, Granollers, Barcelona, Spain). Half of the water and additives (Table 1) were added and sample mixed for 1 min. The other half of the additives

Table 1
Formulation (%) of merguez sausages.

	Beef meat	Beef fat	KG	OKM
C	55.00	29.00	–	–
75/KG	55.00	7.25	21.75	
75/OKM	55.00	7.25	–	21.75
100/KG	55.00	–	29.00	
100/OKM	55.00	–	–	29.00

Sample denomination: C—control sample (all beef fat) prepared with normal fat content; 75/KG and 100/KG—sausages prepared replacing 75% and 100% respectively of beef fat with the same proportion of KG (konjac gel); 75/OKM and 100/OKM—sausage prepared replacing 75% and 100% of beef fat respectively with the same proportion of OKM (oil-in-konjac matrix, as konjac material containing 20% of olive oil).
All samples also contain: 10.7% of water, 1.4% NaCl, 0.5 coriander, 0.8% fennel, 0.2% hot pepper, 0.2% paprika, 0.2% mint and 2.0% harissa.