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Konjac-based oil bulking system for development of improved-lipid pork patties: Technological, microbiological and sensory assessment

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ABSTRACT

Improved-lipid pork patties were manufactured following two different reformulation strategies: fat reduction by replacement of pork backfat with konjac gel (KG), and fat reduction/lipid improvement by replacement of pork backfat with an improved oil combination (olive, linseed and fish oils) bulking system based on konjac gel (O-KG). Technological, microbiological and sensory properties were analyzed as affected by the type of formulation and by chilled storage (9 days, 2 °C). Fat was reduced by between 30 and 86%. In the cases where O-KG was incorporated, 12 and 41% of total fat in patties came from the oil combination. There was no observable effect on color parameters in samples with O-K. Higher KG levels produced harder cooked patties. Animal fat replacement in patties promoted an increase in lipid oxidation, which was more pronounced in samples with an oil combination. In general, during chilled storage no major changes were observed in the studied properties as a result of the different treatments.

1. Introduction

Meat and meat products are some of the most important sources of dietary fat; however, their lipid composition diverges (quantitatively and qualitatively) from nutritional goals. This has prompted an interest in manipulating their composition by modifying the fat content and/or fatty acid profile to make healthier products. This approach is of particular interest in the case of products like burgers or patties, since they are widely accepted in certain population groups, and changes of composition can readily be induced to improve their nutritional value and their health-beneficial properties (Rodríguez-Carpena, Morcuende & Estévez, 2012).

As a strategy to achieve a healthier lipid composition in meat products, reformulation offers a possible means to improve the nutritional value of the fat by altering its composition in the product. There are two aspects to be considered in this connection: reduction of fat content and improvement of the fatty acid profile. Fat reduction in meat products is usually achieved by adding water and other ingredients to lower the fat density (dilution). These ingredients are selected for their low calorie content and their ability to impart desired characteristics to the product (Keeton, 1994). One such ingredient is konjac (glucomannan)-based fat analogs. These form gels which, when combined with other ingredients (starch, carrageenates, gellan gum), can be used as "fat analogs" in the formulation of reduced/low-fat meat products (Osburn & Keeton, 2004). As regards the improvement of fatty acid profiles, addition of individual lipids (of plant or marine origin) improves the fatty acid profile of meat products; however, a better result from a health standpoint can be achieved using healthier oil combinations as animal fat replacers.

In previous papers, our research group assessed the suitability of a healthier oil combination formed by olive, linseed and fish oils in suitable proportions to provide a fatty acid profile better adjusted to healthier intake goals. This combination was designed to produce a lipid material with a small proportion of saturated fatty acids (SFAs), large proportions of monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) and balanced n–6/n–3 PUFA and PUFA/SFA ratios (Delgado-Pando, Cofrades, Ruiz-Capillas, Solas & Jimenez-Colmenero, 2010a). The improvement of several CVD risk markers like total and LDL cholesterol has been reported in volunteers at risk of CVD through the consumption of meat products formulated with this oil combination (Delgado-Pando, Celada, Sánchez-Muniz, Jiménez-Colmenero & Olmedilla-Alonso, 2014). However, some recent studies conclude that there is no evidence that high levels of saturated fat in the diet are epidemiologically associated with either heart disease or cardiovascular problems (Malhotra, 2013; Siri-Tarino, Sun, Hu & Krauss, 2010). In contrast, according to the European Food Safety Authority (EFSA), the evidence provided by consensus opinions/reports from authoritative bodies and reviews shows that there is good consensus that a mixture of SFAs increases blood total and LDL-cholesterol concentrations (EFSA Panel on Dietetic Products, 2010).

Incorporation of oils in a gel-like matrix to form an oil bulking system (in which this new ingredient acts as an animal fat replacer) could offer new possibilities for improving the fat content of meat products. In this regard, oils in a konjac matrix have been used to improve fat content in dry fermented sausage (Jiménez-Colmenero, Triki, Herrero, Rodríguez-Salas & Ruiz-Capillas, 2013), fresh merguez sausages (Triki,

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Herrero, Jimenez-Colmenero & Ruiz-Capillas, 2013a) and frankfurters (Salcedo-Sandoval, Cofrades, Ruiz-Capillas Pérez, Solas & Jiménez-Colmenero, 2013). As far as the authors are aware, the use of an oil combination stabilized in a konjac matrix as a functional ingredient and animal fat replacer in the development of low-fat and PUFA enriched patties has not been explored.

Therefore, the purpose of this study was to evaluate technological, microbiological and sensory characteristics of improved-lipid pork patties, which were reformulated following two different approaches: 1) reduction of fat content by replacement of animal fat with konjac gel; and 2) reduction of fat/improvement of fatty acid profile through the replacement of animal fat by a healthier lipid combination made with olive, linseed and fish oils stabilized in a konjac gel matrix (oil bulking system). The influence of chilled storage (9 days at 2 ± 2 °C) on pork patty characteristics as affected by formulation was also considered.

2. Materials and methods

2.1. Meat raw material, ingredients and additives

Sufficient fresh post-rigor pork meat from different animals (mixture of *bíceps femoris*, *semimembranosus*, *semitendinosus*, *gracilis* and *adductor* muscles) and pork backfat were obtained from a local supermarket. Pork meat was trimmed of visible fat and connective tissue and cut in squares of approximately 5 × 5 cm. Backfat was passed through a grinder with a 6 mm plate (Mainca, Granollers, Spain). Both were vacuum packed in lots of approximately 500 g. All the materials were frozen and stored at −20 °C until use (less than 1 week).

Konjac materials used to replace pork backfat were made with 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). Olive oil (Carbonell Virgen Extra, Cuétara SA, Madrid, Spain), linseed oil (Natursoy S.L., Castellterçol, Spain) and fish oil (Omevital 18/12 TG Gold, Cognis GmbH, Illertissen, Germany) containing 160 mg eicosapentaenoic acid (EPA)/g and 115 mg docosahexaenoic acid (DHA)/g according to the producer, were used to prepare the healthier oil combination for incorporation in the konjac matrix. This oil combination was prepared with 44.39% olive oil, 37.87% linseed oil and 17.74% fish oil (Delgado-Pando, Cofrades, Ruiz-Capillas, Solas & Jimenez-Colmenero, 2010a).

2.2. Preparation of konjac materials

Two types of konjac materials were manufactured: a konjac gel (KG) and another material with 20% of a healthier oil mixture stabilized in a konjac gel matrix (oil bulking system based on konjac gel, O-KG), both prepared as described by Salcedo-Sandoval, Cofrades, Ruiz-Capillas Pérez, Solas and Jiménez-Colmenero (2013). Briefly, KG was prepared with konjac flour (5.0%) homogenized (Stephan Universal Machine UM5, Stephan Machinery GmbH and Co., Hameln, Germany) with 64.8% of the water and i-carrageenan (1.0%). The mixtures were then homogenized with pre-gelled corn starch powder (3.0%) previously dispersed in 16.2% of water. The mixture was cooled to 10 °C and 10% of a $Ca(OH)_2$ solution (1%) was added with gentle stirring. Samples were then placed in suitable containers, covered, manually overpressured to eliminate air and stored at 2 ± 2 °C until use (within 24 h of preparation). O-KG was prepared in the same way as KG, except that 20% of water was replaced by the same proportion of the healthier oil combination, which was added just after the i-carrageenan.

2.3. Design and production of pork patties

Modified pork patties were formulated in such a way that pork backfat was replaced with KG (to reduce fat content) or O-KG (to reduce fat content and improve the lipid profile). Six different formulations were prepared (Table 1). A pork patty made with normal fat content (100% pork backfat) as control (CFP); three reduced-fat samples: medium, low and very low fat pork patties (MFP, LFP and VLFP) in which pork backfat was replaced with the same proportion of KG (38%, 78% and 100% respectively); and two reduced-fat/improved lipid profile samples: improved medium and improved low fat pork patties (IMFP and ILFP) in which pork backfat was replaced with O-KG (49% and 100% respectively). Formulations with the same fat levels (medium and low fat samples) were designed to possess similar fat content but different lipid material. Thus, in MFP and LFP samples all the fat came from animal sources, whereas in IMFP and ILFP samples, the fat source was also provided in different proportions by the healthier oil combination. All samples contained a similar amount of lean meat (and therefore basically of muscle protein).

Before preparing formulations (7 kg each one), pork meat and pork backfat packages were thawed for 18 h at 2 ± 2 °C. Pork meat, backfat and KG and O-KG were passed through a grinder with a 4.5 mm plate (Vam. Dall. Srl. Modelo FTSIII, Treviglio, Italy). Meat and half of the ingredients (pork backfat, KG or O-KG, water and NaCl) were placed in a mixer (Hobart mixer N-506, Hobart MFG. Co., Troy, USA) for 1 min. After this, the other half of the ingredients was added and the whole mixed again for 1 min. Then, round patties (103 g, 12 mm thick, 115 mm diameter) were prepared using an automatic burger former (Formatic standard model, Deighton Engineering, Bradford, UK). Patties were weighed (initial weight) and placed in aerobic conditions in plastic bags (Cryovac® BB3050) and stored at 2 ± 2 °C for 9 days. The various analyses were performed at days 1, 3, 6 and 9 of chilled storage. Eight patties were randomly taken for the analyses on the abovementioned days: four for raw sample evaluation and four for cooked sample evaluation. The entire patty processing procedure was replicated twice on two different days.

2.4. Proximate analysis

Moisture and ash contents were determined on raw patties following the AOAC (2005). Protein content was measured with a LECO FP-2000 Nitrogen Determinator (Leco Corporation, St. Joseph, MI, USA) and fat content was evaluated according to Bligh and Dyer (1959). All analyses were done in triplicate. The energy content was calculated based on 9.1 kcal/g for fat and 4.1 kcal/g for protein and carbohydrates.

2.5. Purge loss, cooking loss and pH determination

The purge loss (PL) of pork patties was evaluated during chilled storage as follows: eight patties from each formulation were tempered for 10 min (at room temperature) and then removed from the bag, and their surfaces were wiped with a paper towel to eliminate surface

Table 1
Formulation (%) of pork patties.

Samples	Meat	Backfat	KG	O-KG
CFP	80.06	13.44	0.00	0.00
MFP	80.06	8.26	5.18	0.00
LFP	80.06	2.97	10.47	0.00
VLFP	80.06	0.00	13.44	0.00
IMFP	80.06	6.82	0.00	6.62
ILFP	80.06	0.00	0.00	13.44

Sample denomination: CFP, control pork patty prepared with normal fat content (all pork fat); MFP and LFP, medium and low fat pork patties prepared by partial replacement of pork backfat (38% and 78% respectively) with KG; VLFP, very low fat pork patty prepared by total replacement of pork backfat (100%) with KG; IMFP and ILFP, improved medium and improved low fat pork patties prepared by partial or total replacement of pork backfat (49% and 100% respectively) with O-KG. All samples also contained 5% added water and 1.5% NaCl.
KG: Konjac gel; O-KG: oil bulking agent based on konjac gel, as konjac material containing 20% of healthier oil combination (olive, linseed and fish oils).