Meat Science 96 (2014) 762–768

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Development of reduced fat minced meats using inulin and bovine plasma proteins as fat replacers

Laura T. Rodriguez Furlán, Antonio Pérez Padilla, Mercedes E. Campderrós *

Instituto de Investigaciones en Tecnología Química (INTEQUI-CONICET-CCT San Luis) Facultad de Química, Bioquímica y Farmacia, Universidad Nacional de San Luis, Ej. de los Andes 950-5700 San Luis, Argentina

ARTICLE INFO

Article history:
Received 9 April 2013
Received in revised form 16 September 2013
Accepted 19 September 2013

Keywords:
Minced meat
Fat replacers
Bovine plasma proteins
Inulin
Texture profile analysis

ABSTRACT

This work deals with the effect of the addition of inulin and bovine plasma proteins as fat replacers, on the quality of minced meat. The proteins are obtained by ultrafiltration and freeze-drying. The following determinations were carried out: chemical composition, sensorial analysis (color, flavor, taste and consistency), emulsion stability and instrumental texture analysis of samples. The resulting formulations were compared with full-fat minced meat, as control. The results showed an increase of protein contents after fat replacement, while a fat reduction of 20–35% produced light products enriched with proteins and inulin as the functional ingredient. No change was observed in color, flavor, or taste among the samples. However, the sensory analysis showed that the combination of plasma protein (2.5%w/w) and inulin (2%w/w) had the best acceptability with respect to consistency, and had a lower fat drain from the emulsion. Texture profile analysis revealed that this formulation assimilated the control texture properties, being that this result is required for adequate consumer acceptance.

1. Introduction

Meat and meat products are important sources of proteins, fats, essential amino acids, minerals, vitamins and other nutrients. However, the high saturated fat content of such products results in a restriction of consumption for those who are prone to cardiovascular diseases and/or suffer from overweight (Weiss, Gibis, Schuh, & Salminen, 2010). Yet, fat is an important constituent of human nutrition and contribute to the flavor, tenderness, juiciness, appearance, texture and shelf life of meat products. Thus, the challenge for meat industry is to develop low-fat meat products without compromising sensory and texture characteristics (Mun, Kim, & Kang, 2009; Zhang, Xiao, Samaraweera, Lee, & Ahn, 2010). In this regard, a number of hydrocolloid systems have been examined due to their ability to replace fat (Weiss et al., 2010). Polymers, such as proteins and polysaccharides, are often incorporated into fat-reduced products to provide some of the lost functional properties. Furthermore, proteins are a source of amino acids, providing foods with a higher nutritional value (Viana, Silva, Delvivo, Bizzotto, & Silvestre, 2005; Zhang et al., 2010). Proteins act as emulsifiers decreasing the surface tension and thus, the free energy of the system imparting, therefore, the desired kinetic stability to dispersions (emulsion or foam) (Rodríguez Patino, Carrera Sánchez, & Rodríguez Niño, 2008). The stability and formation of emulsions, the water holding capacity, and the oil binding capacity depend, among others, on the type of protein used and the presence of other components in a mixture (Borcherding, Lorenzen, Hoffmann, & Schrader, 2008; Glaser, Paulson, Speers, Yada, & Rousseau, 2007; Nikovska, 2010). With respect to polysaccharide, inulin is frequently used in meat formulations. In this respect, Cardoso, Mendes, and Nunes (2008) reported that the addition of dietary fiber obtained from inner chicory root improved gel strength and hardness of low-fat fish sausages, reducing fat and energy intake. Álvarez and Barbut (2013) studied the effect of inulin on emulsion stability, color and textural parameters of cooked meat batters, and reported that the addition of inulin resulted in a creamy and softer product. Beriain, Gómez, Petri, Insausti, and Sarriés (2011) found that the addition of inulin to low-fat sausages (20% less fat than traditional sausage) retained sensory notes similar to those of the traditional chorizo, and achieved a good acceptability rating. Inulin is a fructooligosaccharide consisting of fructose molecules linked by β(2–1) glycosidic bonds, which are responsible for its nutritional characteristics. It may contain either a terminal β-D-fructose or a α-D-glucose molecule (Zimeri & Kokini, 2003). The incorporation of inulin, in foods is known to reduce the risk of colon cancer, diabetes, obesity, and cardiovascular diseases in human beings. It is considered a prebiotic (Mendoza, García, Casas, & Selgas, 2001; Zhang et al., 2010). The functionality of the carbohydrate-based fat substitutes is established in relation to their ability to increase viscosity, form gels, provide mouthfeel and texture, and to increase water-holding capacity. The ability to form a gel is critical for its use as fat substitute in spread products (Hennelly, Dunne, O´Sullivan, & O'Riordan, 2006; Kip, Meyer, & Jellema, 2006; Rodriguez Furlán, Pérez Padilla, & Campderrós, 2011).

As previously discussed, the combined use of proteins and inulin as functional ingredients improves the nutritional and technological properties of foods. Therefore, the objective of this work was to study

* Corresponding author. Tel./fax: +54 266 4426711.
E-mail address: mcamp@unsl.edu.ar (M.E. Campderrós).

0309-1740/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.meatsci.2013.09.015

the incorporation of bovine plasma proteins and the polysaccharide inulin as fat substitutes in minced meats.

2. Materials and methods

2.1. Raw materials

Spray dried bovine blood plasma has been provided by a local supplier (Yerubá S.A., Esperanza, Argentina). The molecular weights of proteins were in the range of 15,000 to 80,000 Da. The proximate composition provided by the manufacturer was: 76 ± 5% proteins, 0.1% fat, 10% ash, 4% water, and 1% low molecular weight compounds.

Inulin obtained from chicory was provided by Orafti Chile S. A. The commercial inulin employed was mainly constituted by linear chains of fructose molecules with a terminal glucose unit. It has a molecular weight of 2400 g/mol and a polymerization grade (PG) of 12.

Inulin, bovine plasma protein and their mixtures in different proportions were evaluated to establish the effect of these components as fat replacers. Selection of the amounts was based on preliminary studies of their functional properties.

The additives used in the formulations were: sodium diphosphate, sodium triphosphate, sodium nitrite, citric acid, sodium citrate, and ascorbic acid. The ingredients employed to prepare the minced meat formulations, such as meat courts, beef fat, starch, sucrose, salt, and seasonings were purchased from a local grocery store.

2.2. Ultrafiltration and freeze drying of bovine plasma proteins

The feed solution was the bovine plasma which was dissolved in deionized water to a concentration of 3% w/v using a mixer at low speed to avoid the formation of vortex and to minimize the appearance of foam. The obtained solution was passed through a porous support (Viledon FO 2431D, Germany) to remove macroscopic aggregates. The feed (3 L) was thermostated in a water bath and impelled with a centrifugal pump, first through a frontal flow stainless steel filter, with a pore size of 60 μm (Gora, Argentina). This procedure of microfiltration (MF) reduces the amount of bacteria and spores and acts as cold pasteurization, moreover this stage protects the ultrafiltration (UF) membrane from fouling. The UF was performed using Pellicon cassette module (Millipore, Bedford, MA, USA), containing modified polyethersulfone membranes with a molecular weight cutoff (MWCO) of 10 kDa, with a membrane area of 0.5 m^2. The concentration of proteins by UF was carried out by continuously removing the permeate stream until the desired concentration of 4% (w/v), was achieved. The operating conditions were the following: transmembrane pressure (ΔP) of 1.5 bars, flow rate of (2.9 ± 0.05) L/min and a temperature of 10 °C. A discontinuous diafiltration (DD) process was applied to removal salts and other contaminant of low molecular weight. For this operation the starting material was the UF concentrate, which was diluted to the initial volume (3 L) with deionized water in a single state and ultrafiltrated to the desired concentration range. The cleaning of the fouled membrane was performed by applying a "Cleaning in Place" (CIP) procedure according to the manufacturer's instructions. At the end of each run, a cycle of water/alkali (NaOH, pH = 12.5 ± 0.5)/water wash was applied to the membrane at (40 ± 2) °C and at a transmembrane pressure of 1×10^5 Pa. Furthermore, a cleaning step using 300 ppm NaClO (commercial grade) was carried out at the same temperature and pressure to ensure sanitation and cleaning. Measurements of normalized water permeability were performed in order to verify the recovery of flow through the membrane and the optimal performance during the separation process. The obtained bovine plasma protein concentrate was then mixed with inulin in order to use as a protective agent, placed on stainless steel trays, frozen at −40 °C and freeze-dried in a lyophilizer (Rificor, Model L-A-B4, Buenos Aires, Argentina) during 48 h at 1 bar. The composition of the fat substitute dried concentrate was 27.80 ± 0.4% w/w proteins, <0.1% w/w fat, 2.80 ± 0.13% w/w ash and 64 ± 1 °Brix carbohydrate content. In previous papers, it was demonstrated that the procedure described reduced the protein denaturation, improving the functional function of plasma proteins (Rodriguez Furlán, Lecot, Pérez Padilla, Campderrós, & Zaritzky, 2012; Rodriguez Furlán, Pérez Padilla, & Campderrós, 2010).

2.3. Inulin characterization

Functional inulin characterization was carried out in order to determine the adequate polysaccharide content and predict its behavior in the formulation. The following tests were performed:

- Water holding capacity (WHC) was measured weighing 1 g of inulin (w_0) and mixed with 10 mL of deionized water for 5 min. After 30 min, the samples were centrifuged at 20,000 rpm at 5 °C for 30 min (Beckmann J2-HS, California, USA, ultracentrifuge). The supernatant was decanted and the sediment was weighted (w_2) and dried in a stove for 30 min (w_1). Water holding capacity was calculated as follows: $WHC = (w_2 - w_1)/(w_0)$.
- Oil binding capacity (OBC) was determined using the method of Chakraborty (1986). One gram of inulin (w_0) was thoroughly mixed with 10 mL of vegetable oil (V_1). After 30 min the samples were centrifuged at 20,000 rpm at 5 °C for 30 min. Then, the supernatant volume was recorded (V_2). The OBC was calculated as $OBC = (V_1 - V_2)/w_0$.
- The emulsifying capacity (EC) determination was performed as described by Rodriguez Furlán et al. (2010). One gram of inulin was mixed with 200 mL of deionized water for 2 min before addition of 500 mL of vegetable oil under continuous mixing. Blending was stopped every 2 min to check for emulsion breakage. When a clear emulsion breakage was observed, the total volume of oil added was recorded and used to calculate EC as volume (mL) of oil emulsified per gram of inulin.

2.4. Preparation of minced meats

The minced meats were elaborated using a 2 kg batch per treatment, according to legal regulations: moisture <68% and meat content >30% in the final product (Argentinean Alimentary Code (AAC), 2012). The formulations were: i) a control sample (C) containing a regular amount of fat (18% w/w), full fat minced meat and, ii) reduced fat samples (13% w/w) where bovine plasma proteins, inulin and their mixtures were used as fat replacers, in different proportions according to the experimental design. Each formulation was replicated three times including the control (36 batches), and all the analyses were carried out in independent form. Each set of formulations was made in the same day. The control sample containing a regular amount of fat (18%) without adding inulin and proteins was prepared to evaluate the effect of fat reduction on technological properties of minced meats. The ingredients used for preparing minced meat per kg of meat were: bovine fat: 135 g for control sample and 99 g for reduced fat samples; broth 680 g; bovine plasma protein (P) and inulin (I) were added in reduced fat samples according to the experimental design (Table 1), cornstarch 4 g, wheat flour 1 g, sodium diphosphate 3.75 g, sodium triphosphate 3.75 g, salt 22.5 g, sucrose 1.75 g, nitrite 17.5 mg, ascorbic acid 0.5 g, citric acid 1.5 g, sodium citrate 1.5 g, onion 3 g, garlic 1 g, pepper 2 g, paprika 2 g, parsley 1.5 g, oregano 1 g, and beet (betaine coloring) 1 g.

Table 1
Applied factor and level ranges of processed plasma protein (P) and inulin (I) in the minced meat formulation design used to study the influence of composition on the their properties.

Factor	Low level (−1)	Center point (0)	High level (+1)
P — Protein concentration (%, w/w)	2.5	2.7	3
I — Inulin concentration (%, w/w)	0	1	2