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Influence of carrageenan addition on turkey meat sausages properties

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ABSTRACT

Influence of carrageenan addition on the properties of turkey meat sausages was studied. The results obtained show that carrageenan causes a decrease in emulsion stability, and an increase in water holding capacity, hardness and cohesiveness of the formulated sausage samples. Carrageenan addition at low levels (0.2% and 0.5%) increases gel elasticity. However, a higher carrageenan concentration causes a reduction in sausages elasticity. Microstructure observation shows that increasing carrageenan levels in sausage formulation leads to a progressive appearance of an additional carrageenan gel network. Sensorial analysis shows that carrageenan presence has no significant effect on sausages taste. However, it improves sausage appearance and texture.

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1. Introduction

Protein–polysaccharide interactions play a significant role in the structure and stability of various processed foods. Functional properties of food proteins, such as solubility, gel forming and emulsifying capacity are affected by their interaction with polysaccharides. In the case of formulated and cooked meat products myofibrillar proteins play a key role during processing because of their ability to produce three-dimensional gels upon heating and subsequent cooling, which has a significant influence on sensorial and textural properties of the processed products (Smith, 1988; Vega-Warner et al., 1999). In the literature polysaccharide–protein interaction are well documented for non-meat proteins (eggs, milk...). However, more studies are required to understand the interaction of meat proteins with hydrocolloids in order to achieve desirable characteristics in the formulated meat products. Several functional ingredients capable of improving water binding properties and modifying texture, are of interest to meat processors. Hydrocolloids with their unique characteristics are of great interest in processed meat due to their ability to bind water and form gels (Candogan and Kolsarici, 2003a,b). One of the most interesting hydrocolloids gums, which could be used in meat industries, is carrageenan. This hydrocolloid is a linear sulphated polysaccharide, extracted from red algae. It is widely used in the food industry for a broad range of applications because of its water binding, thickening and gelling properties. In the meat industry, carrageenan is used as a gelling agent in canned meats and petfoods and it allows reduction in fat content in comminuted meat products like frankfurters (Candogan and Kolsarici, 2003a,b). In cooked sliced meat products carrageenan is used to improve moisture retention, cooking yields, slicing properties, mouth-feel and juiciness (Imeson, 2000).

The effect of carrageenan addition on the functional properties of formulated meat products has been the subject of numerous studies. Bater et al. (1992) found that carrageenan caused an increase in yield, sliceability and rigidity and a decrease in expressible juice in roasted turkey breasts. In breakfast sausages, carrageenan was also found to increase the hardness of meat batters when replacing fat by water–gum solution, whereas carrageenan importantly improved the water holding ability (Barbut and Mittal, 1992). DeFreitas et al. (1997) reported increased gel strength and water retention when adding carrageenan to salt–soluble meat protein gels. Xiong et al. (1999) reported that carrageenan increased the cooking yield, hardness and bind strength of low-fat sausages. Pietrasik (2003) studied the binding and textural properties of beef gels processed with carrageenan, egg albumin and microbial transglutaminase. Hsu and Chung (2001) observed an increase in cooking yield, hardness, and other textural profile analysis parameters by adding up to 2% carrageenan to low-fat emulsified meatballs.

In spite of these published studies, meat processors, especially turkey meat processors, need more scientific data to deliver formulated products which are able to meet special requirements of consumers. Examples of such requirements may be an improvement in moisture retention, cooking yields, slicing properties, mouth-feel and juiciness of final products.

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In this paper, attention is drawn to the influence of carrageen addition and storage time on meat emulsion stability, water holding capacity, textural properties, microstructure and sensorial properties of formulated and cooked turkey meat product.

2. Materials and methods

2.1. Materials

Turkey sausage products were formulated using mechanically separated turkey (MST) meat obtained from local processors (Chahia, Sfax Tunisie). MST meat was produced from turkey after meat cutting. Approximate chemical composition of MST was 65% water, 14% proteins, 20% fat and 1% ash. Analytical grade NaCl, $NaNO_2$, ascorbic acid and sodium tripolyphosphate (TPP) were used. Iota Carrageen samples were purchased from CEAMSA Company (CEAMSA, CEAMGEL 9623, Spain). Cold distilled water was used in all formulations (4 °C).

2.2. Sausage preparation

MST meat was ground in a commercial food processor (Universo, Rowenta, Germany), equipped with a 14 cm blade, for 2 min at the highest speed. Dry ingredients (salt, carrageen, modified starch, etc) were slowly added to the ground MST as powders while processing. Afterwards, cold water was incorporated. The addition of ingredients took less than 5 min and final temperature of batters varied between 10 and 12 °C. The batters were manually stuffed in collagen reconstituted casing (27 mm diameter) and hand-linked to form approximately 8 cm long links. The sausages were then heat-processed in a temperature-controlled water-bath (Haake L, Haake Buchler Instruments, Karlsruhe, Germany) maintained at 90 °C until a final internal temperature of 74 °C was reached. Temperature was measure using a type-T (copper–constantan) thermocouple inserted into the centre of a link, and the time/temperature data were recorded. Then, samples were cooled immediately in an ice-water-bath and stored at 4 °C for 40 days.

Different carrageenan levels were studied by adding 0.2%, 0.5%, 0.8% and 1.5% of carrageenan powder, in addition to studying a sample which did not contain carrageenan. All formulations were prepared with the same common ingredients: 60% MST, 29% water (ice- and cold-water), 8% modified starch (E1422, Sigma Chemical CO., St Louis, MO), 2% NaCl, 0.5% TPP, 0.8% $NaNO_2$ and 0.045% ascorbic acid. The process was replicated twice.

2.3. Influence of carrageenan addition on meat batter emulsion

Influences of carrageenan addition on meat emulsions stabilities before cooking were analysed. The size distribution of the oil droplets was observed using an optical microscope (Olumpus U-CMAD-2, Japan) employing a 100× objective lens. For each samples, 100 emulsion particles, selected at random, were measured. These data were processed to obtain the particle size histogram (distribution).

The stability of emulsion (ES) was determined by a centrifugation of the samples at 11,000g for 30 min at 4 °C. Emulsion stability (ES) was calculated as (Huang et al., 2001):

$$\mathrm{ES}\,(\%) = \frac{W_{ac}}{W_{bc}} \times 100 \tag{1}$$

where W_{ac} is the weight of meat emulsion after centrifugation and W_{bc} is the weight prior to centrifugation.

2.4. Influence of carrageenan addition on sausages properties

2.4.1. Sausages water holding capacity

About 10 g of each sausage sample was centrifuged at 12,000g for 30 min at 4 °C. The water holding capacity (WHC) was calculated as a percentage of bound water, using the following equation (Verbeken et al., 2005):

$$\mathrm{WHC}\,(\%) = \frac{W_{ac}}{W_{bc}} \times 100 \tag{2}$$

where W_{ac} is the weight of sausage sample after centrifugation and W_{bc} is the weight prior to centrifugation.

To measure the stability of formulated sausages during storage, the water holding capacity was measured after 1, 20 and 40 storage days at 4 °C.

2.4.2. Texture measurement

All instrumental texture analyses were done on cooked samples and samples stored at least for 24 h at 4 °C. For every formulation two repeated measurements were taken for each replicate and mean values are reported. Texture profile analysis (TPA) of sausage samples was performed. A cylindrical samples, 2 cm in diameter and 2 cm long, were cut from the centre of the links and compressed twice to 50% of their original height between flat plates and a cylindrical probe (1 cm^2 in diameter) using a texturometer (Texture Analyser, TA Plus, LLOYD instruments, England). In these experiments hardness, cohesiveness, elasticity and chewiness were determined.

To measure the stability of formulated sausages during storage, textural parameters were measured after 1, 20 and 40 days of storage at 4 °C.

2.4.3. Microstructure observations

Small sausage samples (1 cm long and 1 cm in diameter) were cut from the centre of the links and used to perform microscopic observation. Meat gel microstructure was examined by environmental scanning electron microscopy (ESEM) (Philips XL 30 ESEM, Japan). ESEM allows the observation of samples in their natural state, under controlled conditions of temperature and pressure. The environmental mode does not require any preliminary preparation; in addition, this mode removes completely the electronic load effects on the surface and thus preserves the native structure and content of the sample. In this study, microscopic observation was carried under vacuum (pressure = 0.1 kPa). Sausage sample was fixed to the support using double side adhesive tape. A large number of micrographs were taken in order to select the most representative ones.

2.4.4. Sensorial analysis

Sensory analysis was conducted by 15 panellists, who were experienced in sensory evaluation of foods, but received no specific training relevant to this product. Panellists were asked to indicate how much they liked or disliked each product on a 5-point hedonic scale (4 = like extremely; 0 = dislike extremely) according to taste, appearance and texture characteristics. 2 cm long pieces were distributed in white polystyrene plates and presented to the panellists with three-digit codes and in random order for evaluation. Experiments were conducted in an appropriately designed and lighted room and a mean score was estimated for each product.

2.5. Statistical analysis

Analysis and samples treatment were repeated at least three times. Means and standard deviations were calculated with Microsoft Windows Excel 2003. SPSS (version 13.0, USA) for Windows

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