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Effects of high pressure processing on the physical properties of fish ham prepared with farmed meagre (*Argyrosomus regius*) with reduced use of microbial transglutaminase

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ABSTRACT

Marketing issues of small-sized meagre can be overcome with the development of fish hams. This study aimed to test high pressure processing (HPP) to promote gelation of meagre hams, as an alternative to the heat processing. It was also aimed to reduce microbial transglutaminase (MTGase) from the formulation of HPP hams.

Meagre hams were subjected to HPP varying different pressure parameters. The water holding capacity (WHC) and folding properties of hams were not affected by HPP, compared with heat processed hams. Whiteness was lower in HPP hams, and values increased with pressure level. The best results were obtained at 350 and 500 MPa at 30 °C, which also enhanced the textural properties of hams.

Meagre hams prepared with different contents of MTGase (0–5.0 g/kg) were subjected to HPP. This enzyme did not affect the WHC and the folding properties of hams within each condition tested. HPP hams can be prepared with lower levels of MTGase (2.5 g/kg), without compromising the textural properties of hams.

The results showed that it is possible to produce meagre hams with good textural properties and to reduce the MTGase content using HPP, validating the use of this technology as an alternative to the heat-induced gelation.

1. Introduction

Meagre (*Argyrosomus regius*) is a marine fish species common in the Mediterranean area where farming has gained economic importance, especially for specimens that attained at least 1 kg. According to Monfort (2010), portion-sized meagre are not considered suited for marketing as this size fish have a large head, large bones, little flesh, and are not very tasty, and thus few farmed fish are sold at a size below 1 kg. A solution to overcome the marketing problems of small-sized fish could be the development of innovative functional foods. The potential of small-sized meagre for the preparation of heat-induced gels with dietary fibers (Cardoso, Ribeiro, & Mendes, 2014, 2015) and fish sausages (Ribeiro et al., 2013) has been demonstrated. Within the variety of traditional meat products in marketplaces, cooked ham is particularly appropriated, on account of its broad public acceptance supported by suitable organoleptic and technological characteristics, for essaying meagre as a novel raw material. Apart from the fish hams developed by Cardoso, Mendes, and Nunes (2013) with hake or gilthead sea bream and incorporation of dietary fibers, which evidenced the potential of this new product as a healthier alternative to the traditional pork ham, the preparation of fish hams with meagre incorporating dietary fibers would be a novelty since no other similar product is known. Among dietary fibers, chicory root fiber, inner pea fiber, and carrageenan have been identified as promising ingredients for the formulation of restructured fish products (Nunes, Batista, Raymundo, Alves, & Sousa, 2003; Ortiz & Aguilera, 2004; Tolstoguzov, 1991). Chicory root fiber is a low caloric ingredient and can be used as a fat mimetic additive, as in fish sausages, ensuring smoothness, creaminess, and an oily mouth feel (Cardoso, Mendes, & Nunes, 2008; Ribeiro et al., 2013). Inner pea fiber can be used to increase gel strength and hardness, as in Cape hake gel

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products (Cardoso et al., 2008). Carrageenan also has gelling ability and its incorporation can increase hardness, springiness, and water holding capacity (WHC), as in sea bass gel products (Cardoso, Mendes, Vaz-Pires, & Nunes, 2011). It is also known that the effects caused by the incorporation of fibers can differ between fish species (Cardoso et al., 2008, 2009).

Quality and texture of gelified products are affected by thermal treatment usually applied to promote gelation, due to protein degradation and lipid oxidation (Cardoso, Mendes, Saraiva, Vaz-Pires, & Nunes, 2010). Therefore, alternative gelation techniques to the traditional thermal treatments are being investigated. Among gelation promoting additives, microbial transglutaminase (MTGase) has been widely used in the food industry for cross-linking of proteins (Téllez-Luis, Uresti, Ramírez, & Vázquez, 2002). Previous studies on cold gelation showed that MTGase was able to generate gels, prepared with trout and hake mince, with good properties (Moreno, Javier Borderías, & Baron, 2010).

The procedure for preparation of cooked fish ham is partially based on the process typically used in the production of pork hams in Southern Europe (Barat, Grau, Ibáñez, & Fito, 2005) and involves a cooking step. Nevertheless the thermal processing used to promote gelation induces a certain degree of protein degradation and, particularly, myosin, the myofibrillar protein responsible for functional and mechanical properties, is subjected to proteolytic degradation leading to the loss of textural quality (Ramírez, García-Carreño, Morales, & Sánchez, 2002), thus warranting the need for an alternative processing technology.

High pressure processing (HPP) is a technology of growing research interest for the processing and preservation of food. This technology is well known for its potential to better retain the food's nutritional and organoleptic characteristics, and also for having the ability to inactivate spoilage and pathogenic microorganisms, thus extending food shelf life (Patterson, Linton, & Doona, 2007). Moreover, HPP can be used to create new product textures since it induces modifications on food functional properties (Chapleau & de Lamballerie-Anton, 2003).

Research on the use of HPP to induce gelation of fish products, as an alternative to thermal treatments, has recently increased (Cando et al., 2015, 2016; Ma, Yi, Yu, Li, & Chen, 2015; Moreno et al., 2015). Studies indicate that HPP promotes an aggregation characterized by side-to-side interactions of proteins with a low degree of denaturation, instead of aggregation of proteins with large changes in molecular conformation as occurs in thermal gelation (Uresti, Velazquez, Vázquez, Ramírez, & Torres, 2006). Also, HPP has the potential to produce fish gels with better textural properties than heat-induced gels (Cardoso et al., 2010; Ma et al., 2015).

To the best of authors' knowledge, the development of fish hams prepared with meagre and dietary fibers has not been studied. Moreover, the influence of other pressure parameters, besides pressure level, in the gelification of fish products has not been explored. The positive results obtained regarding the gelifying quality of meagre (Cardoso, Ribeiro, & Mendes, 2015), in contrast to other fish species, justify the processing of such raw material with HPP to develop gel products. In this context, the aims of this work were: to determine suitable HPP conditions (pressure level, pressurization time, and temperature) in the preparation of meagre hams as an alternative to the thermal treatment for the gelation process; to evaluate if the effects of HPP on the texture of fish hams can overcome the need for MTGase addition.

Texture is the main drawback in the mimicking of the traditional pork ham, justified by significant differences at the connective tissue level, and also in view of the detrimental effect of the traditional heat process on the fish ham textural parameters. Thus, a particular emphasis was given to the study of the physical properties of the new meagre ham in order to deliver to consumers a food with the expected textural characteristics.

2. Material and methods

2.1. Experimental treatments

In order to optimize the preparation of meagre hams two experiments were conducted. As starting point, three meagre hams were subjected to each experimental condition (thermal processing or HPP). Different pressure levels (200, 350, and 500 MPa), pressurization times (10 and 20 min), and temperatures (10 and 30 °C) were combined in a total of 12 HPP conditions according to a full factorial design experiment and tested to evaluate the effect of HPP on physical properties of fish hams, identifying the best HPP conditions to obtain a fish ham comparable to heat processed fish ham.

In a second experiment, fish hams were prepared with different amounts (0, 2.5, and 5.0 g/kg) of microbial transglutaminase (MTGase) in order to test if HPP could be used as an alternative to MTGase in its effects on physical properties. Three meagre hams were subjected to each experimental condition (thermal processing or HPP). Fish hams were subjected to those HPP conditions that provided the best results in the first experiment (350MPa/10min/30 °C, 350MPa/20min/30 °C, and 500MPa/10min/30 °C).

2.1.1. Raw material and ingredients

Farmed meagre (*Argyrosomus regius*) was captured from IPMA Aquaculture Research Station at Olhão, Portugal (EPPO) and slaughtered by immersion on an ice and sea water (1 kg:1 L) bath. The fish were kept in ice and transported to the laboratory within 24 h. The individual fish weight was 376 ± 111 g. Fish was processed (headed, tailed, gutted, and filleted) at low temperature (below 10 °C) and, after filleting, meagre was minced in a 694 BAADER meat deboner (BAADER, Lübeck, Germany) equipped with a 3 mm diameter hole rotating cylinder.

The remaining ingredients used for the preparation of fish hams were all of food grade materials manufactured by different companies, as specified in Table 1. Sodium triphosphate was of analytical grade from Merck (Darmstadt, Germany). Sodium triphosphate was used as fat/protein stabilizer acting on protein crosslinking, controls pH and removes traces of iron and reduces sensitization to discoloration. Sodium chloride was used to increase the solubility of the proteins and crosslinking. Sodium nitrite was used for color fixation, imparting flavor and characteristic aromas, reduces lipid oxidation and inhibits growth of *Clostridium botulinum*. Casings and packages used were of food grade.

2.1.2. Preparation of meagre hams

The preparation of meagre hams was done according to the procedure described by Cardoso et al. (2013), as shown in the flow sheet of Fig. 1. The ingredients amount of fish hams with 5.0 g/kg MTGase are presented in Table 1. Water was added in the form of ice to adjust the moisture content to 80 g/100 g in the final fish ham. The mixture of meagre mince and the remaining ingredients was done in a refrigerated vacuum homogenizer (UM12, Stephan and Söhne, Hameln, Germany), being the whole mixing process performed under vacuum at refrigerated temperatures (below 7 °C). In a first step, meagre mince was mixed (1420 rpm, 1 min) with sodium triphosphate, salt (NaCl), and nitrified salt. Then, ice (70 g/100 g of the total amount of added water, taking into account the final moisture level of 80 g/100 g), MTGase, and sucrose were added and the same mixing conditions were applied. Finally, the carrageenan, chicory fibre (previously hydrated with 30 g/100 g of the total amount of added water taking into account the final moisture level of 80 g/100 g), pea protein, and the ham flavour were added and mixed (2800 rpm, 2 min).

The final mixture was packed in 25 mm diameter cellulose casings with a hydraulic filler (EB-12, Mainca Equipamientos Carnicos, S.L., Granollers, Spain), followed by manual twisting and knotting. Fish hams were vacuum packed. The setting of fish hams was performed by