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Restructured products from tilapia industry byproducts: The effects of tapioca starch and washing cycles

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A B S T R A C T

The tilapia fileting industry generates large amounts of nutritionally significant waste material, and the recovery of this material is important. The manufacture of restructured products from mechanically recovered fish meat (MRFM) obtained from tilapia fileting allows the use of proteins of high biological value that would otherwise be discharged into the environment. The objective of this study was to evaluate the effect of washing cycles (either one cycle or five cycles) and of the addition of tapioca starch (20% vs. a no-starch control) on the characteristics of surimi obtained from MRFM produced by the tilapia industry and destined for use in restructured products. To evaluate the quality attributes of the product, the structure of a surimi protein matrix and its relationship to selected physicochemical parameters and morphological characteristics was assessed. Both the number of washing cycles and the starch addition were found to influence the moisture, protein and lipid content of the MRFM surimi. Higher whiteness was found after five washing cycles. Because the tapioca starch acted as a stabilizer, the fat globules were more stable and well distributed, and an emulsion with better properties resulted. A homogeneous network of fat globules linked to the protein matrix by a layer of tapioca starch was formed. Another advantage of this approach is that tapioca starch is gluten free. This property is important for specific groups in the population, e.g., celiac-intolerant consumers.
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1. Introduction

The commercial processing of foods of aquatic origin requires the removal of the bones, skin, head and viscera (byproducts), which represent approximately 60–70 g/100 g of the total weight of the fish (Taskaya and Jaczynski, 2009). The development of technology for protein recovery from the byproducts of fileting offers many benefits because this technology facilitates a more responsible use of the available resources for human food and reduces the environmental stresses associated with the disposal of the processing byproducts (Jaczynski, 2005).

Fileting byproducts can be transformed into high-value products through the use of restructuring technology. This technology can be applied to obtain novel products based on the use of an array of additives to improve the mechanical and functional properties of the material (Ramirez et al., 2011). Surimi consists of stabilized myofibrillar proteins obtained from mechanically deboned fish flesh that is washed with water and blended with cryoprotectants (Park and Lin, 2005). The methods used to concentrate myofibrillar proteins in surimi production can be adapted for use in restructured products. Note, however, that the loss of freshness sustained by fileting byproducts compromises the quality of the surimi produced from these byproducts.

Abbreviations: MDA, malondialdehyde; MRFM, mechanically recovered fish meat; TBARS, thiobarbituric acid-reactive substances; TCA, trichloroacetic acid.

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Washing the mechanically recovered meat is a critical step in the production of surimi. The amount of water required and the number of washing cycles are determined by the fish species, the condition of the fish and the product quality required (Lee, 1984). The washing procedure is the key to the quality of the surimi produced. Washing not only removes fat and undesirable materials but also, more importantly, increases the concentration of myofibrillar protein, thereby improving the gel-forming ability of the surimi (Nopianti et al., 2011). However, the repeated washes that are applied during surimi processing require increased amounts of freshwater and cause severe contamination of the wastewater (Park and Lin, 2005). In this context, the number of washing cycles is one of the most important steps in surimi production, especially if fileting byproducts are used.

Viscoelasticity is an important quality of surimi products. The ingredients used to prepare surimi significantly influence the rheological properties of the product (Sarker et al., 2012). Starch has been considered the most important ingredient in surimi seafood products due to its effects on the textural and physical characteristics of surimi fish protein gels (Burey et al., 2008; Hunt et al., 2009). Starches promote the formation of a continuous matrix by interacting with water and protein in the fish paste, and they play an important role in improving the mechanical and functional properties of surimi (Ramirez et al., 2011). Furthermore, starch is added to surimi because of its water-binding ability. The starch serves to maintain gel strength in the face of a decrease in the water content of the surimi. It also improves stability during refrigerated or frozen storage (Lee, 1984). The biological origin of the starch used in surimi and surimi products has an important influence on the resulting physico-chemical and functional properties of the material (Sarker et al., 2012).

Starch is commonly added to surimi at a level of 4–12%. The most frequently used starches include wheat, corn, potato, waxy maize and tapioca (Hunt et al., 2010).

Tapioca starch has been used in surimi products because it provides cohesive, elastic-matrix-consistent seafood (Mason, 2009). Tapioca starch is the highly concentrated (>80% starch) product obtained when water is used to extract the starch from cassava. The cassava plant originated in the Brazilian Amazon rainforest and has been adopted as a staple food in Africa and Asia. These continents are now the leading producers of this raw material (Maieves et al., 2011).

In Brazil, tapioca starch is widely used in the baking industry because of its special starch gelatinization properties and because of its added attractiveness as a gluten-free product. Tapioca starch is used in the meat industry because it produces a surface sheen and a smooth texture, has a neutral taste and is clear in solution (Zhang and Barbut, 2005).

Brazilian consumers habitually eat restructured products from the poultry industry, and we believe that restructured fish products can also be well accepted. The objective of this study was to evaluate the effect of wash cycles and of the addition of starch on the characteristics of the surimi obtained from MRFM produced by the tilapia industry. This evaluation addressed the potential use of the surimi in restructured products.

2. Materials and methods

2.1. Fish

The experiments reported here were performed at Universidade Estadual Paulista (UNESP), Brazil. The meat was removed from tilapia carcasses that were produced and slaughtered at the site and that belonged to the same production lot. The fish were deprived of food for 24 h and then killed by heat shock (using water and ice at a 1:1 ratio) before gutting and heading prior to filet removal. After filet removal, the fish carcasses were passed through a deboning machine (High Tech, HT 250, Chapecó, SC, Brazil) to remove the muscle attached to the bones. The resulting product constitutes the MRFM. The MRFM was packaged and frozen in a freezing tunnel at −25 °C, then stored in a freezer at −18 °C. The samples were transported in cold boxes to ensure that they would remain frozen. On arrival at the laboratory, they were held in a freezer (−18 °C).

2.2. Surimi preparation

Surimi was prepared using a manual process. The MRFM was kept under refrigeration at 5 °C for 24 h before handling. After thawing, it was subjected to wash steps (either one or five steps) with four volumes of cold distilled water (pH = 7). The water temperature during washing was maintained at approximately 5 °C with crushed ice. After each wash, the MRFM was manually pressed in cotton. The material from each washing treatment (one or five washing cycles) was then divided into two equal portions. Tapioca starch (20%, w/w) was added to one portion from each washing treatment. The 20% (w/w) tapioca starch addition was performed slowly while the MRFM was homogenized. At the end of processing, 1% (w/w) sucrose was added as a primary cryoprotectant, and 2% (w/w) of sodium chloride was used as a flavor enhancer to mask the sweetness.

The sucrose, sodium chloride and tapioca starch were mixed with the MRFM. An electric mixer (Arno, Planetária, São Paulo, Brazil) was used to combine these ingredients. According to the information furnished by the manufacturer, the chemical composition of tapioca starch is as follows: moisture, 12.6%; protein, 0.4%; carbohydrates, 86.8%; and dietary fiber, 0.2%.

The samples were stored at −18 °C until analysis.

2.3. Surimi gel preparation

The surimi samples were thawed and approximately 100 g of each treatment were placed in steel forms for baking and for the induction of surimi gelation. Each sample in triplicate was exposed to heat in a bath (NT 249, Novatecnica, Piracicaba, SP, Brazil) at 90 °C for 30 min. After cooking, the samples were cooled in crushed ice for 15 min to stop the process. The samples were then packaged and frozen until analysis.

2.4. Physical and chemical analyses

The moisture content of the product was measured by determining the difference between the initial weight (2.0 g) of a surimi sample before heating in an oven (Fanem, São Paulo, Brazil) and the weight of the sample after heating for 16 h at 105 °C (method 950.46) (AOAC, 2005). The total nitrogen content was determined by the Kjeldahl procedure (method 981.10), and the protein content was estimated using a conversion factor of 6.25 (AOAC, 2005). The lipid content was determined by extraction with chloroform and methanol according to the method of Folch et al. (1957). All wet surimi samples were stored at −18 °C and thawed at 5 °C for 24 h before analysis. Four surimi samples were taken for each treatment, and all analyses were performed in triplicate.

Lipid oxidation was evaluated from the formation of thiobarbituric acid reactive substances (TBARS) according to Vyncke (1970) for samples of 10 g of surimi. A 5-ml aliquot of the distillate was used for color development and was measured at 532 nm using a spectrophotometer (UVmini 1240, Shimadzu, Tokyo, Japan). The malondialdehyde (MDA) concentration was calculated based on the calibration curve obtained using 1,1,3,3-tetraethoxypropane, a precursor of MDA. The results were expressed as mg MDA per kg of surimi.

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