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Effect of adding insoluble solids from surimi wash water on the functional and mechanical properties of pacific whiting grade A surimi

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Abstract

Surimi processors are seeking means to improve the utilization of seafood resources to increase productivity and also in response to the strong public pressure on this industry to reduce the organic matter in processing water discharged into the environment. Insoluble solids (IS) can be recovered from surimi wash water (SWW) by centrifugation. The quality implications of adding 0 (control), 1%, 3% and 5% of solids (SWW-IS) into surimi paste and gels were evaluated by determining their mechanical properties, moisture retention and color. This study showed that adding 1% SWW-IS improved the mechanical properties of Pacific whiting surimi with a minimal effect on color. Higher additions resulted in quality deterioration in mechanical properties and color.

Keywords: Pacific whiting; Surimi wash water; Insoluble proteins; Mechanical properties; Color

1. Introduction

Seafood processing requires a large amount of freshwater which is often discharged from the plant carrying proteins and oils (Carawan et al., 1986). The processing of Pacific whiting, Alaska Pollock, and shrimp in Oregon, Alaska, and Washington generates 20 million ton/year of processing water (Park, 2000) which should be treated before discharging it to the environment. In the Pacific Northwest, the most utilized fish species for surimi production are Pacific whiting and Alaska Pollock. Surimi production requires cleaning, mincing and washing operations using typically about 5.7 L of water per kg of raw fish with approximately 35% of this freshwater used for cleaning and mincing, and the remaining 65% for mince washing operations (Huang et al., 1997). Washing eliminates sarcoplasmic proteins, blood, fat and nitrogenous compounds but also removes small minced fish particles (Park and Morrissey, 2000; Morrissey et al., 2000). Surimi wash water (SWW) contains about 0.5–2.3% total protein composed mostly of sarcoplasmic proteins with small amounts of the myofibrillar proteins myosin and actin (Lin and Park, 1996; Park and Morrissey, 2000; Morrissey et al., 2000; Savant and Torres, 2003). Recovering protein from SWW not only produces protein for food and feed but also generates treated water for potential reuse in the seafood processing plant.

US government offices responsible for ensuring compliance with the requirements of the Federal Water Pollution Control Act such as the Office of Wastewater Management (OWM) and the Environmental Protection Agency (EPA) have not developed policies to discourage the high

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consumption of freshwater by seafood processing plants. Also, local agencies providing utility services in coastal cities do not discourage the excessive use of this scarce resource, e.g., by charging higher fees for industrial customers consuming larger freshwater volumes (Terebus, 2002). However, surimi plants operating on-shore, are facing strong environmental pressures on their operations because several processing aspects have become a major public concern. They include the poor utilization of fish resources, the large use of freshwater that threatens the availability of this resource for other users, and the negative impact on the environment as a result of discharging processing water that has not been adequately treated (Carawan, 1991).

Many protein sources have been employed to improve the mechanical properties of surimi gels. The most frequently used are egg white and whey protein concentrates; other sources such as leguminous extracts and porcine plasma protein have been proposed. These proteins are added to inhibit the Modori phenomenon, i.e., the proteolytic degradation of fish myosin when gels are incubated at 60 °C, and to favor gel setting by the action of endogenous and added transglutaminase enzymes (An et al., 1996; García-Carreño, 1996; Sánchez et al., 1998; Benjakul et al., 2001). The objective of this work was to recover insoluble proteins from Pacific whiting SWW and assess the impact on mechanical properties, moisture retention and color when added to commercial Pacific whiting grade A surimi.

2. Methods

2.1. Dry insoluble SWW solids

SWW obtained from Pacific whiting (*Merluccius productus*) processing was collected from a commercial plant (Pacific Surimi Joint Venture L.L.C., Warrenton, OR) at the rotary stage used to remove solid fish waste from surimi processing water (Morrissey et al., 2000) and transported refrigerated to Corvallis, OR. The SWW collected in four trips to the processing plant, approximately 28 L each time, was centrifuged for 20 min at 3100 g (Model J-6B, Beckman Coulter, Inc., Fullerton, CA) at 4 °C to recover insoluble solids (SWW-IS) which were immediately frozen. Sorbitol (1%) was added as a cryoprotectant to prevent low-temperature damage to SWW proteins. The lots of recovered SWW-IS were frozen at −30 °C and then freeze-dried using a −60 °C condensing plate and no sample heating to minimize damage to the functional properties of proteins. The dehydrated SWW-IS was combined into a single sample and analyzed for moisture, protein, fat and carbohydrate content, according to official methods (AOAC, 1980). Composition data was previously reported by Wibowo et al. (2005). Dried SWW-IS was then stored under refrigeration (4 °C) until use in this study. The same material was used for a feed study previously reported (Wibowo et al., 2005).

2.2. Solubilized fish pastes and gels

Commercial grade A frozen Pacific whiting surimi partially thawed (4 °C) overnight was cut into small pieces to facilitate mixing with SWW-IS. The moisture content removed by freeze-drying from SWW-IS was restored by adding distilled water (11.7 g water/g solids). Surimi paste samples (500 g) were prepared in a 5.5 L capacity Hobart cutter (Model 84145, Troy, OH) by mixing for 4 min commercial surimi with rehydrated SWW-IS at 0 (control), 1%, 3% and 5%. The final chopping temperature was maintained below 15 °C and 2% salt was added to help solubilize myofibrillar proteins. The paste was stuffed into stainless steel tubes (internal diameter = 20.8 mm; length = 175 mm) previously sprayed with commercial vegetable oil to prevent sticking. The tubes were capped before immersion for 15 min in a water bath at 90 °C and then immediately placed for 30 min in a 4–5 °C water bath. Prior to testing, fish gels were removed from the tubes and stored overnight at 4 °C in polyethylene bags.

2.3. Expressible water

The expressible water content (EW) for each treatment was measured using the procedures described by Uresti et al. (2003) and implemented as follows. Triplicate samples (3 ± 0.2 g) of solubilized fish paste or gel, placed between two layers of filter paper, were loaded at the bottom of 50 mL centrifuge tubes and centrifuged at 1000*g* for 15 min at 4 °C. Immediately after centrifugation, the solubilized fish paste or gel samples were weighted and the EW was calculated as follows:

$$\mathrm{EW} = \frac{W_\mathrm{i} - W_\mathrm{f}}{W_\mathrm{i}} \cdot 100$$

where W_i and W_f are the initial and final sample weight.

2.4. Color

Spectral reflectance of surimi paste and gels were determined following the procedures described by Uresti et al. (2003) using a HunterLab MiniScan XE Plus spectrocolorimeter (Model 45/0-L, Hunter Assoc., Reston, VA) calibrated against black and white tiles. L^*, a^*, and b^* values, chroma ($C^* = [a^{*2} + b^{*2}]^{1/2}$), and hue angle ($H^* = \arctan b^*/a^*$) were calculated based on illuminant C and the 2° standard observer. Six samples were evaluated at each SWW-IS concentration.

2.5. Back-extrusion of fish paste

A TA.XT2i Texture Analyzer (Stable Micro Systems, Vienna Court, UK) with a back extrusion rig (model A/BE, 40 mm inner diameter) was used to measure the force required for the product to be extruded around a 35 mm piston disc using the technique described by Uresti et al. (2003) and implemented as follows. Samples (30 g) stored