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Comparison of Atlantic menhaden gels from surimi processed by acid or alkaline solubilization

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Abstract

Heat-induced gelling abilities of surimis prepared by pH shifting (isoelectric precipitation following acid (AC) or alkaline (AL) solubilization) were compared to that of conventionally washed (CW) surimi. Greater endogenous transglutaminase activity (evidenced as enhanced strength of cooked gels subjected to 30–40 °C preincubation) was measured for CW and AL surimi than for AC surimi (all at pH 7). Upon addition of microbial transglutaminase (MTGase), increased crosslinking of myosin heavy chain and gel strengthening during 30–40 °C preincubation were apparent for all three types of surimi, most markedly in CW and AL surimi. Salt addition improved CW gels most, but seemed to adversely affect MTGase activity in AC and AL surimi. AC and AL surimi gels were of lower whiteness than were CW surimi gels.

Keywords: Transglutaminase; Surimi; Acid; Alkaline; Solubilization; Menhaden

1. Introduction

Despite a continuing strong market for surimi-based foods, there is increasing demand for fillets from whitefish species that have traditionally been used for surimi production. This portends a future time when surimi production may increasingly depend upon abundant pelagic species that are presently under-utilized or under-valued, such as mackerel or menhaden (Davis, 1988). Menhaden surimi has previously been shown to have excellent gelling properties (Boye & Lanier, 1988), but poor lipid stability in frozen storage.

Hultin and Kelleher (1999, 2000a) proposed a new process for surimi production based on solubilization at high or low pH, followed by isoelectric precipitation. Besides yielding a higher recovery of the proteins, this pH-shifting approach is particularly promising for dark-fleshed fish since centrifugation of solubilized proteins, during these processes, was found to facilitate removal of membranous material high in content of unstable phospholipids, leading to a more stable product in frozen storage (Hultin & Kelleher, 2000b, chapter 3). Recently, it has been found that the alkaline pH-shifting process further contributes to lipid stability by stabilizing residual heme groups (from myoglobin or hemoglobin), reducing its reactivity with lipids (Kristinsson & Hultin, 2004).

Conventionally-produced menhaden surimi will exhibit a strong "setting" ability induced by low temperature preincubation (optimum at 40 °C for menhaden) (Boye & Lanier, 1988). This setting phenomenon has been attributed to endogenous transglutaminase (TGase) activity that induces protein crosslinking and gel strengthening. Since sarcoplasmic proteins are retained in both the acid and alkaline pH-shifting processes, endogenous transglutaminase activity may be even greater in such surimi than in conventionally washed surimi if the extremes in pH do not inactivate the TGase. Conformational changes in the myofibrillar proteins during acid and alkaline processing may also expose more functional groups for TGase-induced

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crosslinking and other protein–protein interactions (Kristinsson & Hultin, 2003a, 2003b; Pérez-Mateos, Amato, & Lanier, 2004).

This work was conducted to compare the effects of the acid or alkaline pH-shifting methods of surimi preparation to that of the conventional washing process for surimi manufacture on the gel-forming properties of surimis made from Atlantic menhaden. A particular interest was to measure the endogenous setting ability (TGase activity induced by low temperature preincubation) of surimi prepared in these ways, as well as to determine their suitability as substrates for a microbially-derived TGase (MTGase) additive recently approved for food use (Ashie & Lanier, 2000, chapter 6; Motoki & Seguro, 1998).

2. Materials and methods

2.1. Stabilized mince preparation

Atlantic menhaden (*Brevoortia tyrannus*) was harvested off the North Carolina coast. Fresh, net-caught fish were headed, eviscerated, and thoroughly washed. Skinless, boneless mince was obtained by passing these through a Yanagiya mini belt deboner, having drum perforations of 5 mm diameter. As cryoprotectants, 10% sucrose and 0.3% sodium tripolyphosphate w/w were added. As antioxidants, 0.2% sodium ascorbate (w/w on total weight) and 0.02% propyl gallate based on an estimate of 10% total lipid were added, and all mixed for 2 min in a large dough mixer. The stabilized mince (MacDonald, Wilson, & Lanier, 1990) was portioned (1 kg) and vacuum-packed in oxygen-impermeable bags (Cryovac® CN-590 cook-in material bags; Cryovac Division of W.R. Grace and Co., Duncan, SC), then frozen and stored at −20 °C until needed (within 2 months).

2.2. Processing into surimi

Frozen stabilized mince (1200 g) was briefly tempered at room temperature before cubing with a knife while still frozen, then homogenized with eight parts deionized cold water (0–6 °C) for 1 min in a blender at maximum speed (Model CB-6/34BL22, Waring Products Division, Dynamics Corporation of America, New Hartford, CT). To solubilize proteins, the pH was adjusted from about 5.0 (native) to 2.5 using 1 N cold HCl for the acid-aided process (AC), or to pH 10 with 1 N cold NaOH for alkaline-aided surimi (AL). Homogenates were centrifuged at 4000*g* for 5 min at 4 °C. The top layer (containing neutral lipid) and bottom layer (containing insoluble lipid membranes and connective tissue) were discarded. The middle layer, containing dilute solubilized protein, of low viscosity, was filtered through four layers of cheesecloth, then adjusted to pH 5.5 using 1 N cold NaOH or 1 N cold HCl with slow stirring. The average time for pH adjustment was about 10 min per batch. The resulting precipitate (surimi) was collected by centrifugation at 4000*g* for 5 min at 4 °C and excess moisture was removed by squeezing manually between "chiffon" mesh fabrics. Conventionally water-leached (CW) surimi was also prepared as described by Pérez-Mateos et al. (2004) by three water washings.

Cryoprotectants, in proportions previously described, were added to all surimis before freezing. Antioxidants were added, based on an estimated 3% of remaining lipid content, in the same proportion as the stabilized mince. Samples were packed flat in sealed plastic bags and stored in a freezer (−20 °C) overnight. For AC and AL surimi, the pH during storage was 5.5, while the pH of CW during storage was near 7.

2.3. Gel preparation

Frozen surimi was briefly tempered at room temperature before cubing with a knife while still frozen. Sodium chloride (0% or 2% w/w), ice sufficient to achieve 78% (w/w) final moisture content, as well as 1 N cold NaOH or 1 N HCl (between 5 and 10 ml) for pH adjustment to 7.0 were added together and the mixture was chopped in a food processor (Model LPP; Cuisinart, East Windsor, NJ) to a final temperature of 5 °C (about 6 min). To some pastes 0.2% of a commercial preparation of microbial transglutaminase (MTGase) derived from *Streptoverticilium* (Activa™ TI, containing 100 U of MTGase/g dispersed in maltodextrin; Ajinomoto USA, Inc., Teaneck, NJ) was added, yielding 20 U of MTGase activity per 100 g surimi paste (Lee, Lanier, Hamann, & Knopp, 1997).

The pastes were extruded into open-ended (ends cut off) polypropylene centrifuge tubes (9 cm length, 1.4 cm i.d.), previously sprayed inside with a lecithin-based release agent to prevent gel adhesion. The tubes were capped at both ends with serum sleeve stoppers clamped with metal thumbscrew clamps. They were then heated by one of three water bath treatments: (1) 90 °C for 20 min; (2) 30 °C for 2 h, followed by 90 °C for 20 min; (3) 40 °C for 2 h, followed by 90 °C for 20 min. Immediately after heating, the tubes were cooled in ice water. Gels were then removed from the tubes and held at 4 °C overnight in sealed plastic bags.

2.4. Gel strength and deformability

Gel samples (1.4 cm long, 1.4 cm i.d.) were tested as described by Pérez-Mateos et al. (2004) by axial puncture with a 3.175 mm dia. ball in the centre of gels at a penetration speed of 1.1 mm/s. Breaking force (g) and deformation (penetration depth, mm) were determined on at least six specimens per treatment.

2.5. Gel whiteness

Colour was measured on six specimens per treatment with a Chroma Meter CR 300 (Minolta Camera Co., Ltd., Osaka, Japan), using the CIE Lab scale (D65/10°),