Gelation of Surimi by High Hydrostatic Pressure

Y.C. CHUNG, A. GEBREHIWOT, D.F. FARKAS, and M.T. MORRISSEY

ABSTRACT
The effects of high hydrostatic pressure (HP) on gel strength of Pacific whiting and Alaska pollock surimi were determined by torsion. Pacific whiting gels were made with and without 1% beef plasma protein (BPP) as protease inhibitor. HHP treated whiting (1% BPP added) and pollock gels showed greatly increased strain values at all pressure/temperature combinations compared with heat-set controls. Stress values for the same samples were variable depending on treatment and species. A three-fold increase in strain and sizer was found for HHP treated whiting gels made without inhibitor.

Key Words: hydrostatic pressure, surimi, pollock, whiting, gel strength

INTRODUCTION
Interest in use of high hydrostatic pressure (HHP) in the seafood industry is increasing. HHP has been shown to decrease microorganisms, affect enzymatic activity, and cause rheological changes in several foods (Farr, 1990; Okiyodo et al., 1990; Hoover, 1993). Researchers have shown that HHP could be used to induce gelation of surimi paste from several fish species. Pressure treated gels from frozen Alaska pollock (Theragra chalcogramma) have been produced at 0°C with treatment as low as 2.0 Kbar (Shoji et al., 1990). Gelation of pollock surimi by HHP was attributed to increased cross-linkage of the myosin heavy chain. Okazaki and Nakamura (1992) have shown that gelation of sarcoplasmic protein from different fish was related to fish species, pH, protein concentration and pressure treatment.

Surimi analogs are traditionally made from heat-set gels at temperatures approaching 90°C (Lee, 1984). Several fish species may undergo a weakening of gel structure during normal heating regimes because of endogenous proteases in the muscle tissue (Niwa, 1992). As temperature increases during cooking, leading to gelation, the product is subjected to a temperature range (50-60°C) where such proteases are most active. This potential weakening of the gel is circumvented by use of protease inhibitors (Matsutome and Noguchi, 1992). Good quality surimi gels from Pacific whiting (Merluccius productus) have been produced with addition of food grade protease inhibitors such as beef plasma protein and egg white (Morrissey et al., 1993). Our objective was to determine the effects of HHP treatments on gelation of Pacific whiting surimi (with and without protease inhibitors) and Alaska pollock.

MATERIALS & METHODS
Sample preparation
Commercially frozen Pacific whiting surimi and Alaska pollock surimi were obtained from American Seafoods Co. (Seattle, WA). Both types contained 4% sorbitol, 4% sucrose, 0.3% triphosphates, and 0.12% mono- and diglycerides. The commercial Pacific whiting surimi was made without protease inhibitors. Surimi blocks were stored at -20°C at the Oregon State University Seafood Laboratory (Asteria, OR). Three types of surimi paste were prepared for testing: Pacific whiting surimi, Pacific whiting surimi with 1% beef plasma protein (BPP), and Pacific whiting surimi with 1% BPP plus 0.5% threonine. The surimi paste was homogenized at 25°C and then quickly frozen by immersion in dry ice.

The HHP treatments were performed using a multi-use system at Oceanside Seafoods Co. (Asteria, OR). The surimi paste was placed in a high-pressure vessel (250 mL) and pressurized to 200 MPa. The vessel was then heated to 15°C and held at this temperature for 10 min. After cooling to 4°C, the gels were removed from the tubes, placed in plastic bags, and stored at 4°C for testing the following day.

Pressure treatments
Experimental samples were extruded into stainless steel tubes in the same manner as described. The tubes were placed in an isostatic press (Model I-P-2B-22, Autoclave Engineers Inc., Erie, PA) and subjected to treatments for 1 hr. The pressure/temperature settings used were: (1) 1.0 Kbar/28°C, (2) 1.7 Kbar/28°C, (3) 2.4 Kbar/28°C, (4) 4.0 Kbar/35°C, (5) 1.7 Kbar/35°C, (6) 2.4 Kbar/35°C, (7) 0.8 Kbar/50°C, and (9) 2.4 Kbar/50°C. The temperature was kept constant with a modular temperature controller (Autoclave Engineers Inc., Erie, PA). The pressure treated gels were removed from the tubes, stored in plastic bags at 4°C and analyzed the following day.

Torsion measurement
Gel texture properties were determined by torsion. Gels were placed at 25°C for 2 hr and cut into 2.8 cm lengths and turned into an hourglass shape with a 1 cm diameter on a latex-type apparatus (Gel Consistometer Inc., Raleigh, NC). Samples were subjected to torsional stress in a modified Brookfield viscometer (Gel Consistometer Inc., Raleigh, NC) connected to a strip chart recorder as described by Kim et al. (1986). Stress and shear strain at failure, were calculated using equations developed by Hamann (1983). Statistical analysis
A sub-set of six samples from each treatment was used for each analysis. Statistical analysis of data was carried out using one way analysis of variance. Differences among mean values were established using the Least Significant Difference (LSD) multiple range test (Snedecor and Turrisi, 1960). Values were considered significant when p<0.05.

Table 1—Torsion results for Pacific whiting surimi as related to pressure treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Shear stress (kPa)</th>
<th>Shear strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.4±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>2/18</td>
<td>3.4±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/28</td>
<td>2.9±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>2/28</td>
<td>4.4±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/28</td>
<td>3.4±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/728</td>
<td>2.8±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>2/728</td>
<td>4.1±0.1</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/160</td>
<td>0.00±0.0</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/160</td>
<td>0.00±0.0</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>1/750</td>
<td>0.00±0.0</td>
<td>0.00±0.0</td>
</tr>
<tr>
<td>2/4000</td>
<td>0.00±0.0</td>
<td>0.00±0.0</td>
</tr>
</tbody>
</table>

**Means within a column not followed by the same letter are significantly different at the 99% confidence level.

(HPP) (American Meat Corp., Ames, IA) is protease inhibitor, and Alaska pollock surimi. Fish paste was prepared as described in the surimi testing manual (NFPA, 1993). All samples were standardized at 2% NaCl and 78% moisture. Ingredients were blended in a Stephan mixer (Model UMS, Stephan Machinery Corporation, Columbus, OH) for 3-4 min. The mixed paste was transferred to a sausage stuffer (2.3 kg capacity, The Sausage Maker, Buffalo, NY) and extruded into stainless steel cooking tubes (17.8 x 2.2 cm i.d.) sprayed with the lithium-based release agent PAM (Boyle-Midway Household Products, New York, NY). Both ends of the tube were sealed and control samples were cooked in a water bath at 90°C (900 KPa) for 15 min. After cooking, the gels were transferred to an ice water bath for 15 min. The gels were removed from the tubes, placed in plastic bags and stored at 4°C for testing the following day.

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RESULTS & DISCUSSION

The shear stress and shear strain values of Pacific whiting surimi made without BPP increased significantly for all pressure treatments compared with heat-set control gels (Table 1). Shear stress is indicative of gel hardness while strain measures cohesiveness or elasticity of surimi gels (Hamann and Lanier, 1987). The strain for Pacific whiting surimi cooked at 90°C for 15 min was 1.0 and the shear stress value was 12.4 kPa. Strain and stress tripled in value under pressure treatment of 1.0 Kbar/28°C. There was a slight decrease in strain and stress when pressure was increased to 1.7 Kbar at the same temperature. Strain continued to decrease while stress increased to 44 kPa at the highest pressures at 28°C. Similar results were found for pressure treatments at 35°C. Strain decreased while stress increased slightly at 1.7 Kbar and then increased to 44 kPa at 2.5 Kbar. When pressure treatment was undertaken at 50°C, those gels made without BPP were too weak to measure. The protease enzyme in Pacific whiting surimi has a temperature optimum at 55°C (An et al., 1994). These results indicate that the enzyme was still very active during pressure treatments at that temperature.

The control sample of Pacific whiting surimi made with 1% BPP and heat-set at 90°C for 15 min showed a strain value of 2.14 and a stress of 45.7 kPa (Table 2). Strain values for all pressure treatments were significantly higher than the control. Stress values were lower than the control except for the 2.4 Kbar treatment at both 28 and 35°C. Within the same temperature range, strain decreased with increased pressure. The highest strain value occurred at 1.0 Kbar/28°C. Stress measurements showed a direct relationship with pressure, increasing in value with increasing pressure. The only deviation from this pattern was the pressure treatments at 50°C. The Pacific whiting gels made with 1% BPP at 50°C were high quality gels but were significantly lower in stress and strain than several of the pressure treated gels made at lower temperatures. Whether this decrease in gel strength was due to residual protease activity or pressure effects at that temperature, needs to be determined.

Pollock surimi showed significant increases in both strain and stress values for all treatments except those at 50°C (Table 3). The strain and stress values of 2.09 and 32.4 kPa, respectively, for the heat-set pollock gel indicated that the samples were made from a medium quality surimi. Strain increased to 2.74 with pressure treatment at 1 Kbar/28°C and stress increased in a similar manner to 48.6 kPa for the same treatment. No significant differences occurred between strain values for 1.0 and 1.7 Kbar at 28°C. Stress values increased with increased pressure at both 28 and 35°C. Only the 2.4 Kbar treatment showed higher stress than the control at 50°C test temperature.

HHP was very effective in forming good quality gels for Pacific whiting and Alaska pollock surimi. The pressure-treated gels had a translucent appearance compared to heat-set gels which were opaque. Similar results were shown by Shoji et al. (1990) for Alaska pollock. The effect of HHP on gel strength was also significant for Pacific whiting surimi. The stress and strain values were among the highest we have recorded for Pacific whiting surimi both with and without BPP. A direct relationship was found between pressure and stress values. Strain measurements were, for the most part, inversely related to pressure. However, the pollock and whiting samples treated at 1.7 Kbar/50°C were an exception. Probably an increase in protease activity caused that pressure/temperature treatment. The main protease in Pacific whiting surimi has been identified as cathepsin L, a lysosomal protease (Seymour et al., 1993). The pressures between 1 and 2 Kbars may have induced the rupture of lysosomal membranes, releasing enzymes and increasing proteolytic activity, even in the presence of BPP. Similar results have been shown in pressure treated beef (Oshnori et al., 1991). Pollock surimi has substantially less protease but would still be affected by the destruction of lysosomal membranes and release of endogenous proteases. The heat-activated proteases, once released, would react with some of the myofibrillar protein and result in weaker gels at that temperature.

The gelation of surimi paste at room temperature (~23°C) by HHP appeared to circumvent the gel-weakening effects of endogenous proteases in Pacific whiting. Surimi paste at atmospheric pressure also forms gels at room temperature through the “suwari” or setting phenomena (Matsumoto and Noguchi, 1992). However, Pacific whiting and pollock suwari gels are at room temperature without heating, are usually much weaker than traditional heat-set gels (Park, 1993). HHP represents a potential processing technology for high quality surimi-based seafood. Additional research is needed to determine effects of pressure on enzyme activity and microorganisms and for optimization of processing parameters.

REFERENCES


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Changes in textural characteristics occurred in different ways and at different rates among cheeses. Additional instrumental approaches would be required for textural properties throughout the chew sequence to be adequately accounted for in routine analyses.

REFERENCES


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cates (Table 1) and either a weighted least squares or log transformation analysis, the two assays were strongly correlated (correlation coefficient 0.999). A variance component analysis showed that the small statistical difference between the two assays was almost completely due to measurement error rather than differences among methods.

CONCLUSIONS

The copper chelation method of histamine determination is a simple and rapid alternative to the standard AOAC fluorometric histamine assay. It is sensitive enough to accurately determine levels of histamine which may be of regulatory action. It is also more convenient since it is quantitated with a simple spectrophotometer rather than a fluorometer or could be observed visually without instrumentation.

REFERENCES


We thank Dr. Margie Hall for encouragement and helpful comments on the manuscript. We also gratefully acknowledge the assistance of Drs. Diane Pardington and J. Johnson with the statistical analyses.

This work was supported in part by a grant from the National Marine Fisheries Service NA6600308R to CB and by a Patricia Roberts Harris Fellowship to JMM.

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the Surimi and Surimi Seafood Committee, T.C. Lanier, K. Hart, and B.E. Martin (Eds.), National Fisheries Institute, Washington, D.C., Univ. of North Carolina Sea Grant Program, Raleigh, NC.


*Research was supported with funds from the National Fisheries Institute in Arlington, VA and the U.S. Dept. of Agriculture under grant no. 83-3400-1-701.

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