Characterization of Acid-soluble Collagen from Pacific Whiting Surimi Processing Byproducts

J.-S. KIM AND J. W. PARK

ABSTRACT: Three different solid byproducts (skin, frame, and refiner discharge) from Pacific whiting surimi manufacturing are a good resource for collagen extraction according to their total protein concentrations and other biochemical properties. Denaturation temperature of acid-soluble collagens was 23.3 °C for refiner discharge, 21.7 °C for skin, and 20.6 °C for frame. Based on the functional properties, acid-soluble collagen from refiner discharge was the best and showed potential as an ingredient in processed food manufacturing.

Keywords: collagen, gelatin, surimi byproducts, refiner discharge

Introduction

Collagen, commonly manufactured from land animal by-products, is used in various food applications (clarification agent, emulsifier, or whipping agent). Its usage extends even further to other industrial (shampoo and lipstick) and pharmaceutical applications (film-forming agent, microencapsulation, or tablet coating) (Nagai and Suzuki 2000). Today’s health-conscious consumers, however, are reluctant to try collagen extracted from land animals because of the recent outbreaks of bovine spongiform encephalopathy or foot-and-mouth disease. Therefore, raw materials from fishery products receive new attention as a consumer-friendly collagen resource.

Surimi byproducts are generated in a large quantity (approximately 65% based on whole fish) during surimi manufacturing (Wendel 1999). However, the use of surimi solid byproducts as a human food has not been widely studied yet. Most surimi solid byproducts are conventionally used to produce fish meal and fertilizer or are directly discharged into estuaries, resulting in environmental pollution (Ciarlo and others 1997). New challenges must be attempted to find a way to upgrade the processing of waste to food-grade ingredients such as collagen.

Fish collagens are of interest in the food-processing industry for their use in the production of gelatin from the extracted collagen. Fish collagen, however, differs from animal collagen because of a lower content of the imino acids (proline and hydroxyproline) (Park 2000). To use collagen from fishery products in various foods or other industrial or pharmaceutical applications, functional properties (water, oil absorption, and emulsion ability and stability) as well as physicochemical properties must be optimized.

Some efforts have been made toward the preparation of collagens from fishery products, such as fish skin (Montero and others 1990; Ciarlo and others 1997) and fish bone (Nagai and Suzuki 2000). However, these studies were limited to fillet byproducts as a collagen resource and did not measure the functional properties of collagen for effective utilization.

Our objective was to examine various byproducts (skin, frame, and refiner discharge) from Pacific whiting surimi processing as a collagen resource by characterizing biochemical and functional properties of collagen.

Materials and Methods

Fish and surimi solid byproducts

Pacific whiting (Merluccius productus), 42 to 48 cm long, was caught off the coast of Oregon by trawl. Pacific whiting and its surimi solid byproducts were obtained from a commercial surimi processing plant (Warrenton, Ore., U.S.A.) in July 2002.

Skin and frame from Pacific whiting were generated from deboning and mincing steps, whereas refiner discharge was separated from the refining step immediately before screw-press dewatering. The samples (fresh whole fish and solid byproducts of Pacific whiting surimi) were transferred on ice to the Oregon State Univ. Seafood Laboratory within 30 min and kept frozen at −30 °C until used for collagen extraction.

Proximate composition, volatile basic nitrogen, and heavy metal

According to AOAC methods (AOAC 1990), moisture content was quantified by oven drying at 105 °C, total protein by the Kjeldahl procedure, and crude ash by incineration in a muffle furnace at 550 °C. In addition, total lipid was extracted into a methanol-chloroform mixture and quantified according to the method of Bligh and Dyer (1959). The concentration of volatile basic nitrogen (VBN) was determined using the method of Conway (1950). The mercury content was determined by the combustion gold amalgamation method (KFDA 1999) using a mercury analyzer (Model SP-3A, Nippon Instrument Co., Tokyo, Japan). Other heavy metals, such as Pb, Cd, and Cr were determined by the wet ash method (Tsutagawa and others 1994), using an inductively coupled plasma spectrophotometer (ICP, Atomscan 25, Thermo Electron Co., Waltham, Mass., U.S.A.).

Preparation of collagen fractions

All analyses were performed in a cold room (5 °C). Native collagen was prepared as described by Sato and others (1986) and Nagai and Suzuki (2000). Pacific whiting whole muscle and its suri-
mi solid byproducts were 1st cut into small pieces before homoge-
nizing with 5 volumes (v/w) of cold distilled water. The homogenate was then centrifuged at 10000 × g for 20 min. To the residues, 20 volumes (v/w) of 0.1 N NaOH was added to remove noncollagenous protein. The homogenate was stirred overnight before centrifuging at 10000 × g for 20 min. Alkali-extractions were repeated 3 addition-
tal times. Final precipitate was washed thoroughly with cold distilled water. For the frame sample, which contains a significant amount of ash (Table 1), alkali-insoluble residue was decalcified using 0.5 M ethylenediaminetetraacetic acid (EDTA-4Na, pH 7.4) for 5 d by changing the solution once a day and washing the residue thor-
oughly with cold distilled water.

To all the residues, 10 volumes (v/w) of 0.5 M acetic acid was added. Suspensions were stirred for 3 d and then centrifuged at 10000 × g for 20 min. This acid extraction process was repeated once more. The precipitates were then washed with cold distilled water at 1:2 (w/v) ratio. The supernatant from acid extraction and the filtrate from rinsing were combined and subjected to salting out by adding NaCl to 2.0 M before centrifuging at 20000 × g for 20 min. The precipitate was redissolved in 0.5 M acetic acid and then dia-
lized (molecular weight cut-off 10000) against cold distilled water to remove salt. Salting out and dialysis were repeated twice more for further purification of collagen. The final dialyzed solution was used as acid-soluble collagen fraction.

Separately from preparation of acid-soluble collagen, centrifuge residues obtained after acid extraction were heated with 5 volumes (v/w) of distilled water in an autoclave at 120 °C for 1 h and then centrifuged at 10000 × g for 20 min. The precipitates were rinsed using hot distilled water at a 1:2 (w/v) ratio. The supernatant from centrifugation and the filtrate from rinsing were combined and used as acid-insoluble collagen fraction. The acid-insoluble frac-
tion was used for calculation total Collagen N concentration.

Acid-soluble fraction was lyophilized and used for further analy-
zes of collagen characteristics. Concentration and solubility of collagen were calculated, respectively, as (total collagen-N concentra-
tion, %/total-N concentration, %) × 100 and (acid-soluble col-
lagen-N concentration, %/total collagen-N concentration, %) × 100.

Sodium dodecyl sulfate-polyacrylamide gel electrophoresis

Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was performed by the method of Laemmli (1970) using 7.5% gel containing 0.1% SDS at pH 8.8. SDS-PAGE was per-
formed using a slab gel electrophoresis system (FB-VE 16-1, 16 × 14 cm, Fisher Scientific, Pittsburgh, Pa., U.S.A.). Protein samples and protein marker (M 4038; Sigma Chemical Co., St. Louis., Mo., U.S.A.) were heated at 100 °C for 3 min in 10 mM tris-HCl buffer (pH 6.8) containing 2% SDS, 1% 2-mercaptoethanol, 25% glycerol, and 0.1% bromophenol blue. The gels were stained for protein with 0.1% Coomassie brilliant blue R-250 and destained in 10% methanol and 10% acetic acid.

Amino acid composition

Amino acid composition was determined using an amino acid analyzer (Biochrom 20, Pharmacia Biotech, Cambridge, Sweden) according to the method of Kimura (1988). Samples were hydro-
lyzed in 6 N HCl in evacuated/sealed tubes at 110 °C for 16 h. The hydrolysates were evaporated to dryness in a vacuum evaporator at 40 °C and then diluted with Li-buffer for analyses of amino acids containing hydroxyproline and hydroxylysine.

Hydroxylation (%) of proline (Pro) and lysine (Lys) was calculated on the basis of the amino acid composition according to the following equations:

\[ \text{Hydroxylation of Pro} = \frac{(\text{Hyp} \times 100)}{(\text{Pro} + \text{Hyp})} \]

\[ \text{Hydroxylation of Lys} = \frac{(\text{Hyl} \times 100)}{(\text{Pro} + \text{Hyl})} \]

\[ \text{HyP} = \text{hydroxyproline}, \text{Hyl} = \text{hydroxylysine} \]

Denaturation temperature

Thermal denaturation temperature was measured using 5 mL of collagen solution (30 mg collagen dissolved in 100 mL acetic solution, 0.1 M) according to the method of Zhu and Kimura (1991). The control sample was 0.1 M acetic acid. All sample solutions were kept in water bath (8 °C) before measuring specific viscosity using an Ostwald viscometer. Specific viscosity was measured at 8 °C, 15 °C to 31 °C at every 2 °C, and at 45 °C. We assumed that collagen heli-
conformation was undenatured at 8 °C, whereas breakdown was completed at 45 °C.

Denaturation temperature of collagen solution was defined as the temperature at which the change in viscosity reached by 50%. Fraction change was calculated as follows:

\[ \text{Fraction change} = \frac{[\text{e}_3/C] - [\text{e}_1/C]}{[\text{e}_1/C] - [\text{e}_3/C]} \]

\[ C = \text{collagen concentration (mg/mL)}; \text{e}_1 = \text{specific viscosity at 8 °C}; \text{e}_3 = \text{specific viscosity at measured temperature (°C)}; \text{e}_3 = \text{specific viscosity at 45 °C}. \]

Functional properties

Water and oil absorption capacities were determined by the method of Beuchat (1981). Freeze-dried collagen (0.3 g) was mixed with 10 mL distilled water for water absorption measurement and with 10 mL vegetable oil for oil absorption measurement. Mixing was done at fast speed using a vortex mixer for 30 s. Samples were then allowed to stand at room temperature (22 °C) for 30 min before centrifuging at 5000 × g for 30 min. The volume of supernatant was measured in a graduated cylinder (10 mL), and the value was expressed on a dry weight basis.

Emulsifying activity and cooking stability were determined by the method of Wang and Kinsella (1976). Freeze-dried collagen (0.2 g) and Tween-80 (0.2 g, Fisher Scientific, Pittsburg, Pa., U.S.A.) were added to 20 mL of 0.1 N acetic acid, respectively, and the mixture was set at room temperature for 2 min using a PT 10/35 polytron homogenizer at setting 3 (Kinematica, Luzern, Switzerland). Twenty milliliters of vegetable oil (Mazola corn oil, CPC Intl. Inc., Engle-
wood Cliffs, N.J., U.S.A.) were added before mixing for 3 min using a PT 10/35 polytron homogenizer at high speed (setting 5). The
Cooking stability was measured using the following equation:

\[
\text{Cooking stability} = \frac{\text{Height of emulsified layer}}{\text{Height of total contents in the tube}} \times 100\%.
\]

Cooking stability was determined similarly to the emulsifying activity except that the emulsion in the centrifuge tube (height × inner dia, 11.5 × 3.0 cm) was initially heated in a water bath (80 °C) for 30 min and subsequently cooled to 15 °C before centrifugation. Cooking stability was measured using the following equation:

\[
\text{Cooking stability} = \frac{\text{Height of emulsified layer after centrifugation}}{\text{Height of total contents in the tube}} \times 100\%.
\]

Statistical analysis

Statistical analysis was done using the ANOVA (analysis of variance) test. Significant differences between means were performed using Systat Version 7.5K (SPSS, Inc. Richmond, Va., U.S.A.) at \( P < 0.05 \) (Steel and Torrie 1980).

Results and Discussion

Proximate composition

A significant difference \( (P < 0.05) \) was found for all parameters between samples except between whole muscle and refiner discharge for ash content (Table 1). Moisture of refiner discharge (81.4%) was similar to that of whole muscle (80.5%) but much higher than that of other samples. The highest total protein content was obtained from skin sample, followed by whole muscle, refiner discharge, and frame. The highest lipid was also found in skin samples probably. The highest ash content was 17.4% for frame, probably because of the calcium content derived from the bone (Kim and others 2002). The trend of proximate composition on the dried weight basis among samples was similar to that based on the wet weight. For effective utilization of the solid byproducts for collagen, foreign components, such as lipid and ash, should be removed from the solid byproducts. Therefore, frame did not appear to be a good raw material for collagen extraction because of its high ash content.

Volatile basic nitrogen (VBN) and heavy metal contents

Volatile basic nitrogen contents in solid byproducts were 3.9 mg/100 g in skin and frame and 2.1 mg/100 g in refiner discharge (Table 2). The concentrations of VBN were much lower than 20 mg/100 g, which are believed to be an acceptable limit for marine products (Kim and others 2002). Mercury was not detected in all solid byproducts. Lead was also not detected in skin and refiner discharge except for frame (0.020 mg/kg). Cadmium and chromium ranged from 0 to 0.019 mg/kg and 0.002 to 0.010 mg/kg in all solid byproducts, respectively. According to Codex Code (2004), the heavy metal safety values were 0.2 to 1.0 mg/kg for cadmium, 0.2 to 0.4 mg/kg for lead, and zero for mercury and cadmium. Because the concentrations of VBN and heavy metals in solid byproducts were below these reported safety limits, all solid byproduct samples appeared safe as a raw material for collagen.

Collagen content

Collagen contents of solid byproducts of Pacific whiting surimi were in the descending order of skin (65.6%), refiner discharge (55.3%), and frame (30.2%) (Figure 1). Whole muscle showed a significantly low concentration (2.4%). A significant difference in collagen content between 2 samples (whole muscle and refiner discharge) containing similar moisture content was probably because the refining process is primarily to separate connective tissues from washed mince. The collagen content of fish frame (bone) was quite low compared with fish skin and refiner discharge, probably because of its high ash content (17.4%). To use the frame as a collagen source, the excessive ash, foreign material of collagen, should be removed before collagen extraction (Nagai and Suzuki 2000). Therefore, the frame did not appear to be a good raw material for collagen extraction because of economic values and complicated processing. These results suggested that skin and refiner discharge could be used for collagen extraction based on the concentration of collagen.

Collagen solubility

The protein solubility of collagen was 77.4% for skin, 66.9% for refiner discharge, 66.4% for whole muscle, and 24.5% for frame (Figure 2). There was, however, no difference \( (P > 0.05) \) in solubility between refiner discharge and whole muscle, probably because refiner discharge was primarily generated from washed mince. Low solubility of frame collagen compared with the others might be because of a different structure by covalent cross-link in collagen, especially telopeptide region (Takahashi and others 1989). Montoro and others (1990) and Yamaguchi and others (1976) reported that collagen solubility of hake (Merluccius merluccius L.) was higher in

![Figure 1 — Collagen contents of various solid byproducts and whole muscle. Different letters on the bars indicate a significant difference at \( P < 0.05 \).](image-url)

<table>
<thead>
<tr>
<th>Components</th>
<th>Skin</th>
<th>Frame</th>
<th>Refiner discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBN (mg/100 g)</td>
<td>3.9 ± 0.0</td>
<td>3.9 ± 0.0</td>
<td>2.1 ± 0.0</td>
</tr>
<tr>
<td>Heavy metal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td>0.002 ± 0.002</td>
<td>0.019 ± 0.004</td>
<td>ND</td>
</tr>
<tr>
<td>Cr</td>
<td>0.002 ± 0.001</td>
<td>0.010 ± 0.000</td>
<td>0.002 ± 0.002</td>
</tr>
</tbody>
</table>

Cd = cadmium; Cr = chromium; Hg = mercury; Pb = lead; ND = not detected.
Collagen from surimi processing . . .

skin collagen (93.1% and 65.2%, respectively) than in muscle collagen (74.4% and 60.0%, respectively). A difference in solubility between our results and reported values was believed to be due to a difference in age of fish, fish species, and/or different methodology (Sikorski and Borderias 1994).

Amino acid composition

Glycine was the most abundant amino acid present in all collagen samples (Table 3). Alanine and proline compositions were also rich in all collagen samples. However, cysteine, methionine, isoleucine, tyrosine, phenylalanine, hydroxylysine, and histidine showed a significantly low concentration. Similar patterns of amino acid composition of collagen samples were also found in skin and muscle of various species, such as squid mantle (Ando and others 2001), hake (M. merluccius L.), and trout (Montero and others 1990), carp, eel, common mackerel, saury and chum salmon (Kimura and others 1988), and filefish (Kim and Cho 1996).

Hydroxylation ratio of proline and lysine

The hydroxylation ratio of proline in collagens from solid byproducts were quite high, with a descending order of refiner discharge (39.4%), skin (36.9%), and frame (32.8%) (Figure 3). There was, however, no significant difference (P > 0.05) in the hydroxylation ratio of lysine among collagens from solid byproducts and whole muscle. Ando and others (2001) and Montero and others (1990) reported that hydroxyproline plays a role in stabilizing the triple helix, whereas hydroxylysine contributes to the formation and stabilization of cross-links of nonhydrolyzable bonds. Kimura and others (1988) and Zhu and Kimura (1991) also reported that the hydroxylation ratio of proline was higher in muscle collagen than in skin collagen. Based on our results and the literature, the thermal stability of collagens from solid byproducts is likely to be in the descending order of refiner discharge, skin, and frame. The hydroxylation ratio of proline in collagen from refiner discharge was 39.4% and was similar to that of collagens from muscle of common horse mackerel (38%), yellow sea bream (40%), and tiger puffer (39%) (Yata and others 2001). However, it was much lower than that from shark and carp (Yata and others 2001) and land animals and other higher vertebrates (Park and others 1995).

SDS-PAGE pattern

According to SDS-PAGE pattern (Figure 4), 3 distinctive chains, 2 α bands (α1, upper; α2, lower) with their molecular weight at about 100 kDa and their β-crooss-linked components, with a molecular weight of 200 kDa, were clearly detected in all solid byproducts. As a whole, our electrophoretic patterns of collagens from byproducts were almost identical to those of the corresponding calf skin type I collagen in mobility of chains (data not shown) and similar to those obtained with collagens from the skin and muscle of other species (hake [Merluccius hubbsi, Ciarlo and others 1997; M. merluccius L., Montero and others 1990], trout [Montero and others 1990], and Alaska pollock [Kimura and Ohno 1987]). There was no difference in the relative mobility of α1 and α2 chains among acid-soluble collagens from all solid byproducts. Based on our results and the literature, the collagens obtained in this experiment were found to be free of noncollagenous proteins.

High molecular weight cross-links (> 205 kDa) were formed and shown on the top of each lane with more evidence in whole muscle and frame than refiner discharge or skin. These large molecules are yet to be identified.

Thermal denaturation

Thermal denaturation temperature of collagens from solid byproducts was 23.3 °C for refiner discharge, 21.7 °C for skin, and
Collagen from surimi processing . . .

Table 3—Amino acid composition of collagen from various solid byproducts and whole muscle

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>Cod skin gelatin(^a)</th>
<th>Whole muscle</th>
<th>Solid byproducts (residues/1000 residues)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skin</td>
<td>Frame</td>
<td>Refiner discharge</td>
</tr>
<tr>
<td>Asp 51</td>
<td>32.5 ± 0.7a</td>
<td>34.4 ± 0.7ab</td>
<td>36.9 ± 1.2b</td>
</tr>
<tr>
<td>Hyp 53</td>
<td>68.7 ± 0.4c</td>
<td>60.6 ± 0.3b</td>
<td>50.6 ± 1.1a</td>
</tr>
<tr>
<td>Thr 25</td>
<td>28.8 ± 0.5a</td>
<td>28.8 ± 0.5a</td>
<td>33.0 ± 1.0b</td>
</tr>
<tr>
<td>Ser 69</td>
<td>41.0 ± 0.5a</td>
<td>40.9 ± 0.5a</td>
<td>43.1 ± 0.5a</td>
</tr>
<tr>
<td>Glu 75</td>
<td>76.7 ± 0.5a</td>
<td>79.9 ± 1.7a</td>
<td>85.2 ± 0.5b</td>
</tr>
<tr>
<td>Pro 102</td>
<td>104.8 ± 1.5a</td>
<td>103.7 ± 1.7a</td>
<td>103.9 ± 1.8a</td>
</tr>
<tr>
<td>Gly 345</td>
<td>350.3 ± 1.3b</td>
<td>349.6 ± 4.1b</td>
<td>322.0 ± 3.2a</td>
</tr>
<tr>
<td>Ala 107</td>
<td>130.2 ± 1.1a</td>
<td>128.1 ± 3.5a</td>
<td>124.6 ± 1.2a</td>
</tr>
<tr>
<td>Cys &lt;1</td>
<td>ND(^c)</td>
<td>ND(^c)</td>
<td>ND(^c)</td>
</tr>
<tr>
<td>Val 19</td>
<td>19.1 ± 0.1a</td>
<td>20.6 ± 1.1a</td>
<td>24.7 ± 1.2b</td>
</tr>
<tr>
<td>Met 13</td>
<td>14.5 ± 0.3a</td>
<td>15.2 ± 0.6a</td>
<td>17.1 ± 0.5b</td>
</tr>
<tr>
<td>Ile 11</td>
<td>11.2 ± 0.3a</td>
<td>12.3 ± 0.3a</td>
<td>16.5 ± 0.4b</td>
</tr>
<tr>
<td>Leu 23</td>
<td>20.0 ± 0.7a</td>
<td>21.4 ± 0.8a</td>
<td>30.1 ± 0.5b</td>
</tr>
<tr>
<td>Tyr 4</td>
<td>1.7 ± 0.0a</td>
<td>2.1 ± 0.2a</td>
<td>3.2 ± 0.2b</td>
</tr>
<tr>
<td>Phe 13</td>
<td>14.7 ± 0.3a</td>
<td>13.5 ± 1.3a</td>
<td>16.3 ± 0.5a</td>
</tr>
<tr>
<td>Hyl 6</td>
<td>6.9 ± 0.2a</td>
<td>7.1 ± 0.4a</td>
<td>7.0 ± 0.3a</td>
</tr>
<tr>
<td>Lys 25</td>
<td>26.4 ± 0.4a</td>
<td>26.9 ± 1.3a</td>
<td>30.9 ± 1.3a</td>
</tr>
<tr>
<td>His 8</td>
<td>6.8 ± 0.3a</td>
<td>7.8 ± 0.6ab</td>
<td>8.6 ± 0.3b</td>
</tr>
<tr>
<td>Arg 51</td>
<td>45.8 ± 0.6a</td>
<td>47.1 ± 0.6a</td>
<td>48.3 ± 0.5a</td>
</tr>
<tr>
<td>Total 1000</td>
<td>1000.0</td>
<td>1000.0</td>
<td>1000.0</td>
</tr>
</tbody>
</table>

\(^a\)Different letters in the same row indicate a significant difference at \(P < 0.05\).
\(^b\)Voigt and Botta (1990).
\(^c\)ND = not detected.

20.6 °C for frame (Figure 5). These results might be due to the difference of the hydroxylation ratio of proline, which is highly correlated to thermal stability (Ando and others 2001). Thermal denaturation temperature of collagen from refiner discharge was similar to that of collagen from whole muscle; 23.5 °C. However, the thermal denaturation temperature of collagens from refiner discharge was much lower than collagens obtained from shark (Hamada 1990), carp (Miyauchi and Kimura 1990), and land animal byproducts (Voigt and Botta 1989). This result suggested that the thermal stability of collagens from surimi byproducts must be improved to be more effectively used as a food or industrial ingredient.

Water and oil absorption capacities

Water absorption capacity of acid-soluble collagens from refiner discharge was 15.92 (mL/g), followed by 9.83 mL/g for frame and 8.58 mL/g for skin (Figure 6). There was, however, no significant difference \((P > 0.05)\) in water absorption capacity between collagens from refiner discharge and whole muscle (16.12 mL/g). Water absorption capacity of acid-soluble collagens from refiner discharge was also higher than those of the other protein from vegetables, such as soy protein isolate (3 to 8 mL/g, Yim and Lee 2000), alfalfa leaf protein (1.85 to 3.58 mL/g, Wang and Kinsella 1976), and bean protein (1.67 to 5.93 g/g, Sathe and Salunkhe 1981). This difference may be due to the high swelling ability of collagen (Sadowska and Rudzki 1987) along with the differences of size, shape, hydrophilic-hydrophobic balance of amino acids in the protein molecule and the physicochemical environment such as pH, ionic strength, and temperature (Sathe and Salunkhe 1981).

Oil absorption capacity of acid-soluble collagens from refiner discharge was 26.10 mL/g, followed by 12.93 mL/g for skin and 11.82 mL/g for frame (Figure 6). There was no difference \((P > 0.05)\) in oil absorption capacity for collagens from refiner discharge and whole

Figure 5—Effects of incubation temperature on fractional change of acid-soluble collagen from various solid byproducts and whole muscle

Figure 6—Water absorption capacity (WAC) and oil absorption capacity (OAC) of acid-soluble collagen from various solid byproducts and whole muscle. Different letters on the bars within the same properties indicate a significant difference at \(P < 0.05\).
Collagen from surimi processing . . .

Figure 7—Emulsion activity and cooking stability of acid-soluble collagen from various solid byproducts and whole muscle. Different letters on the bars within the same properties indicate a significant difference at $P < 0.05$.

Emulsion activity and cooking stability

Acid-soluble collagen from refiner discharge had the highest emulsifying activity (51.9%) among acid-soluble collagens from solid byproducts (Figure 7). This value was also superior to a commercial emulsifier, Tween-80 (45.9%) (PB192; Sigma Chem., St. Louis, Mo., U.S.A.). However, there was no significant difference ($P > 0.05$) in emulsion activity of collagens from refiner discharge and whole muscle. The emulsion activity of collagen from byproducts is primarily determined by the orientation at the interface between the 2 phases where a monomolecular film is formed around the colloidal particles (Yang 1997).

Acid-soluble collagen from refiner discharge also had the highest cooking stability (45.4%) among acid-soluble collagens from solid byproducts (Figure 7). This value was superior to a commercial emulsifier, Tween-80 (45.9%). However, there was no significant difference ($P > 0.05$) in cooking stability between collagens from refiner discharge and whole muscle. Kim and others (1996) reported that emulsifying properties of gelatin from cod bone were similar to those of a commercial emulsifier, such as Tween-60 and Tween-80.

References


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Conclusions

Acid-soluble collagens from refiner discharge of surimi manu- facturing demonstrated the highest functional properties compared with the other byproducts, such as skin and frame, and could be used as a functional ingredient for food and industrial ap- plications. In addition, if the thermal stability of the acid-soluble collagens is improved, collagens from surimi byproducts could be more effectively used.