UTILIZATION OF MINCED SUCKER FLESH

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ABSTRACT

Freshwater suckers (Catostomidae family) were obtained from Lake Huron to study the possibility of developing new products utilizing its flesh and the influences of additives on the functionality of sucker muscle proteins. Results showed that sodium chloride increased protein solubility, but also decreased swelling, gel forming and pH. In comparison, sodium tripolyphosphate increased protein solubility, pH, swelling and gel formation. Fish sausages and canned products showed low binding characteristics. However, adding corn meal and soy protein in combination with sodium chloride and sodium tripolyphosphate improved their water holding capacity, texture and cook yield. It was concluded that sodium tripolyphosphate, corn meal and fat should be used in manufacturing minced sucker products.

INTRODUCTION

Baker (1878) stated that about 80-90% of the fish resources from the great Lakes are wasted. So called “trash” fish considered pollutants, are routinely thrown back by fishermen. Those species can be used as raw materials for new fish products.

The role of muscle proteins in functional performance can be specified more precisely by dividing those into three major classes on the basis of their solubility to myofibrillar, sarcoplasmic and stroma proteins (Goll et al. 1974). Myofibrillar proteins are essential for water binding, gel formation and emulsification characteristics in comminuted sausages (Briskey and Fukazawa, 1971; Goll et al. 1974). Water
soluble proteins have relatively minor effect on water binding, gel forming ability and emulsifying capacity compared to myofibrillar proteins (Hamm, 1960; Schut and Brouwer, 1974). Stroma proteins have poor water and fat binding ability. However, they are useful in reduction of the cost of finished products (Kramlich, 1971; Saffle, 1968). The role of fish proteins has been described as being similar to that of red meat proteins (Learson et al, 1971).

Protein extractability and solubility are useful parameters for determining the quantity of proteins available for binding and emulsification (Saffle, 1968). Ionic strength, pH and freezing influence the extractability of muscle proteins. Solubility of fish muscle protein is reported to be minimal in the pH range 5.5-6.0 but increases on both the acidic and basic sides of this range. Frozen meat has been shown to be less stable than fresh meat in sausage-type emulsions (Morrison et al, 1971). Poulter and Lawrie (1977) found that protein solubility decreased more rapidly during storage at −8°C than during storage at −30°C. About 70-80% of myosin from cod flesh became nonextractable at a rate similar to the extractability of myofibrillar protein during storage of this species at −14°C (Connell, 1962). Observations in this laboratory indicate that minced muscle tissue from the sucker species was extremely susceptible to freeze damage which was associated with a soft texture in cooked product.

Rigor mortis involves a type of aggregation of muscle protein in situ, characterized by the disorganization of tissue and loss of ATP from myofibrils. These changes may prevent the distribution of proteins into solution when salt solutions are used (Dixon and Webb, 1961). According to Asghar and Yeates (1974), the effect of rigor mortis on protein solubility apparently disappeared with the addition of phosphate and appropriate conditions of ionic strength, pH and temperature during muscle protein extraction.

Swelling and gel-forming measurements were negatively correlated with water loss (Hermansson and Akesson, 1975a). According to Hermansson (1972), swelling is strongly dependent on pH and ionic strength. Nakayama and Sato (1971b) found that myosin fractions have major effects on gel formation. Tong et al. (1975) reported that alkaline extractions (pH 11) of squid protein concentrations were more effective than protein extracted by 4% salt in forming gels.

Sherman (1961) reported that pH, time, temperature, additive concentration and the ability of alkaline phosphates to split the bond between myosin and actin are factors influencing water binding capacity. Hamm (1975) indicated that water holding capacity (WHC) and swelling (SW), myosin and actin interaction changes, and solubilization of myofibrillar proteins are the main factors affecting rheo-
logical properties of minced meat.

Lee and Toledo (1976) indicated that amount of time spent in commi-
ination, addition of NaCl or NaCl and tripolyphosphates, effect of
mechanical deboning, cooking temperature and type of heating
medium used are the factors affecting texture characteristics of fish
sausages.

Soy protein isolate is a widely used additive in sausage batters and it
has properties similar to those of meat proteins (Brown, 1972). The
addition of SPI to a variety of foods supplies desirable functional
properties, such as emulsifiability, ability to absorb fat, moisture re-
tention and thickening and foaming ability (Wolf, 1970).

The aim of this study was to investigate the effect of added salt,
sodium tripolyphosphate and soy protein isolate at various levels on
the functional properties of frozen minced sucker and to study the
possibility of developing new products utilizing its flesh.

MATERIALS AND METHODS

Fish

Freshwater sucker from Lake Huron (Saginaw Bay) were obtained
for study in July of 1978. The fish were a mix of redhorse (Moxostoma
ansiunum) and white (Catostomus commersoni) suckers. They were
transported in ice to the Meat Laboratory at Michigan State Uni-
versity where they were processed. Fish were headed, gutted, rinsed under
running cold water, split lengthwise, and passed through a Bibun
mechanical deboning machine (Type SDX 13, Bibun Co., Fukeyama
Hiroshima, Japan) equipped with a 5 mm hole size drum.

The sucker flesh was then vacuum packaged in 2.3 and 9 kg lots in
Cryovac (polyvinylidene chloride) bags which were blast frozen and
stored at -29°C. The frozen fish was thawed in a 3°C cooler as needed.

Processing Procedures

Smoked fish sausages. All ingredients presented in Table 1 except
hydrogenated vegetable oil were mixed at medium speed for 8 mins. in
a Kitchen Aid Food preparer (Model A-200, Hobart Mfg. Co., Troy, OH)
with a paddle attachment. Hydroganted vegetable oil (Mazola, corn
oil) was added and the mixture blended at low speed for 7 minutes
more. The fish pastes was stuffed into collagen casings (Brechteen,
Box 711, Mt. Clemens, MI) 35mm in diameter which were then linked.

Sausages were cooked in an Elek-Trol Laboratory Smokehouse
Table 1. Design and formulation of smoked fish sausage treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Treatment and Formulations (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>97% Mechanically deboned frozen fish (MDFF), 2% sodium chloride (NaCl), 3% hydrogenated vegetable oil (HVO)</td>
</tr>
<tr>
<td>B</td>
<td>88% MDFF, 3% NaCl and 8% HVO</td>
</tr>
<tr>
<td>C</td>
<td>84% MDFF, 3% NaCl, 4% soy protein isolate (SPI) and 9% HVO</td>
</tr>
<tr>
<td>D</td>
<td>84% MDFF, 3% NaCl, 4% white corn meal and 8% HVO</td>
</tr>
<tr>
<td>E</td>
<td>80% MDFF, 3% NaCl, 4% SPI, 4% white corn meal and 8% HVO</td>
</tr>
</tbody>
</table>

\(^1\) In all formulations (A, B, C, D, E) the following additives and spices are present: 0.43% sodium tripolyphosphate, 0.1% monosodium glutamate, 0.5% sodium acetate, 0.5% condiment smoke, and the spices.

(Drying Systems Inc., Chicago, IL) until the internal temperature reached 82°C, using a 6-1/2 hr. stepwise cooking cycle (40°C-88°C and 22-40% RH).

Canned minced fish. The following ingredients were mixed in the same manner described earlier for sausages (Table 2). The fish paste was then placed into size 211 x 304, C-enamel coated cans (American Can Company, Greenwich, CT). The filled cans were baked in a dry air oven for 30 mins. at 167°F (75°C) then cans were closed using an automatic closing machine (Canning Devices Inc., Manitowoc, WI). The sealed cans were processed in a still retort (Food Machinery Corp., Sprague-Sells Division, Hoopston, IL) at 250°F (121°C) for 75 minutes. The processed cans were immediately cooled in water until the

Table 2. Design and formulation of canned minced fish treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Treatment and Formulations (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86.5% mechanically deboned frozen fish (MDFF)</td>
</tr>
<tr>
<td>B</td>
<td>82.5% MDFF, 4% soy protein isolate (SPI)</td>
</tr>
<tr>
<td>C</td>
<td>82.5% MDFF, 4% white corn meal</td>
</tr>
<tr>
<td>D</td>
<td>78.5% MDFF, 4% SPI, 4% white corn meal</td>
</tr>
</tbody>
</table>

\(^1\) In all formulations (A, B, C, D) the following additives and spices are present: 4% beef tripe, 8% hydrogenated vegetable oil, 1% sodium chloride, 0.4% sodium tripolyphosphate, 0.30% white pepper powder, 0.15% anise powder, 0.15% garlic powder, 0.30% paprika pepper powder and 0.05% ground ginger.
temperature at the center of the cans was reduced to approximately 100°F.

**Chemical and Physical Measurements**

Total extractable protein, salt-soluble proteins, and water-soluble proteins as well as non-protein nitrogen were extracted by a modification of the method described by Trautman (1964). All total soluble protein fractions were compared using a modification of the sodium dodecylsulphate (SDS) polyacrylamide gel electrophoresis technique described by Weber and Osborne (1967). Gel formation was determined using the least concentration endpoint (LCE) method reported by Trautman (1966b). Percent swelling was determined according to the method reported by Wiericki et al. (1963).

The pH of total extracted proteins was measured with a pH meter (Beckman, Model 35600 Digital pH meter), using a glass electrode. The difference in weight of the stuffed product before and after smokehouse cooking was calculated as percent cooking loss. Baking loss was calculated by the weight difference of filled cans before and after baking. Results are presented as percent baking loss. Water holding capacity of the cooked fish flesh was determined using the centrifuge technique of Bremner (1974). The water holding capacity calculated according to the following formula:

\[
\text{Water holding capacity} = \frac{100 \times \text{weight of meat residue}}{10 \ g \ of \ sample}
\]

The texture of both products, measured as shear force, was determined on the Instron Universal Testing Machine (Model TTB, Instron Corp., Canton, MA). The edible casing and firm surface layer were removed in order that only the resistance to shear of the internal mass was measured. The products were sheared using a compression load cell of the 1 to 50 kg range. A shear cell was attached to the upper moving fixture. Drive speed and chart speed adjusted at 20 cm/minute and 5 cm/minute, respectively. The resistance force met by the cell was expressed as kg-f per cm length of fish product of a standard diameter (see below).

**RESULTS AND DISCUSSION**

**Effects of Additives on Solubility**

The value of measurements of protein solubility in various salt solutions lies in the functional role of proteins in processing high
quality products. The data (Table 3) indicated that total extracted protein increased significantly when NaCl was added. The largest average value was noted when 3.0% NaCl was used in the extraction, and the minimum protein solubility of minced frozen fish was noted at 0% NaCl. Salt soluble protein (SSP) extracted from frozen minced fish also increased as NaCl concentration increased, with the largest

Table 3. Effects of adding sodium chloride and sodium tripolyphosphate on the amount of total extracted protein from frozen mechanically deboned fish (% total extracted protein = mg extracted protein/100 mg total protein)

<table>
<thead>
<tr>
<th>Sodium tripolyphosphate %</th>
<th>% Sodium Chloride</th>
<th>% Total Extracted Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.0</td>
<td>13.47*</td>
</tr>
<tr>
<td>0.225</td>
<td>3.0</td>
<td>67.40</td>
</tr>
<tr>
<td>0.450</td>
<td>3.6</td>
<td>62.17</td>
</tr>
<tr>
<td>Mean*</td>
<td>0.6</td>
<td>47.63</td>
</tr>
</tbody>
</table>

*Standard error for each cell mean (N = 12) is 0.07

<table>
<thead>
<tr>
<th>Sodium tripolyphosphate %</th>
<th>% Sodium Chloride</th>
<th>% Salt Soluble Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.0</td>
<td>51.47</td>
</tr>
<tr>
<td>0.225</td>
<td>3.0</td>
<td>47.65</td>
</tr>
<tr>
<td>0.450</td>
<td>3.6</td>
<td>54.84</td>
</tr>
<tr>
<td>Mean*</td>
<td>0.6</td>
<td>53.30</td>
</tr>
</tbody>
</table>

*Standard error for each row or column mean (N = 36) is 0.04

increase obtained between 0.0% and 3.0% NaCl (Table 4). Adding NaCl decreased the percent of extracted water soluble protein (WSP) in the total extracted protein (Figure 1). This effect was expected, since SSP content increased as NaCl concentration increased (Table 4).
Utilization of minced sucker flesh

FIG. 1. EFFECT OF SODIUM CHLORIDE IN VARYING CONCENTRATIONS ON THE RATIO BETWEEN THE AMOUNTS OF SALT SOLUBLE PROTEIN AND WATER SOLUBLE PROTEIN EXTRACTED FROM FROZEN MINCED FISH

0.0 Total Extracted protein, • • • salt soluble protein and X • X water soluble protein

average percentages of nonprotein nitrogen (NPN) decreased slightly as NaCl concentration increased (Table 5), the larger effect occurring in the absence of phosphate.

Protein solubility was low in low ionic strength solutions. The lower extractability of protein at lower ionic strengths was attributed to the presence of strong associations between myofibrillar proteins. Sodium tripolyphosphate (STP) concentration of 0.225% and 0.45% were not strong enough to spread protein filaments apart at low ionic strength. However, 0.45% STP raised the pH to 7.8, which was more favorable for extraction of fish muscle proteins as indicated by the sharp increase in the percent extractability of fish protein (Figure 2). In samples without NaCl, no SSP was extracted unless STP was present. The data suggest
Table 8. Effects of adding sodium chloride and sodium tripolyphosphate on the soluble nonprotein nitrogen of frozen mechanically deboned fish (\( \frac{mg \text{ nonprotein nitrogen}}{100 \text{ mg total protein}} \times 6.26 \))

<table>
<thead>
<tr>
<th>Sodium tripolyphosphate %</th>
<th>0.0</th>
<th>3.0</th>
<th>3.6</th>
<th>Mean *</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Sodium Chloride</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.000</td>
<td>7.77</td>
<td>6.11</td>
<td>5.15</td>
<td>6.34</td>
</tr>
<tr>
<td>0.223</td>
<td>8.07</td>
<td>6.07</td>
<td>6.06</td>
<td>6.07</td>
</tr>
<tr>
<td>0.450</td>
<td>3.75</td>
<td>5.30</td>
<td>5.61</td>
<td>5.65</td>
</tr>
<tr>
<td>Mean *</td>
<td>8.53</td>
<td>5.33</td>
<td>5.61</td>
<td></td>
</tr>
</tbody>
</table>

*Standard error for each cell mean (N = 12) is 0.01

*Standard error for each row or column mean (N = 36) is 0.005

![Graph](image-url)
that adding STP sharply increased the extractability of SSP in the absence of NaCl (Figure 2). However, the addition of STP in the presence of 3.0% NaCl had slight adverse effect on the extractability of SSP.

WSP was lowest at the 0.45% level of STP (Table 6). Once again, this effect was expected, since the amount of SSP increased as STP increased.

<table>
<thead>
<tr>
<th>Sodium tripolyphosphate (%)</th>
<th>0.00</th>
<th>3.00</th>
<th>3.60</th>
<th>Mean*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>99.21</td>
<td>36.68</td>
<td>35.13</td>
<td>57.00</td>
</tr>
<tr>
<td>0.225</td>
<td>88.91</td>
<td>46.11</td>
<td>50.51</td>
<td>61.84</td>
</tr>
<tr>
<td>0.450</td>
<td>44.26</td>
<td>37.41</td>
<td>43.78</td>
<td>41.82</td>
</tr>
<tr>
<td>Mean</td>
<td>77.46</td>
<td>40.07</td>
<td>43.14</td>
<td></td>
</tr>
</tbody>
</table>

Standard error for each cell mean (N = 6) is 0.08
Standard error for each row or column mean (N = 18) is 0.04

Myosin heavy chain (MHC) did not solubilize in samples containing only 0.225% STP and in the absence of NaCl or STP (Table 7). These data indicated that MHC is not soluble at low ionic strength. However, 0.45% STP solubilized myosin. The effect of the latter concentration of STP may be due to the high pH (7.8) of the extraction solution. As NaCl increased, MHC total area increased in samples containing no STP. In general, adding either NaCl or STP increased the solubility of MHC.

### Effects of Additive on pH, Swelling and Gel Formations

It is interesting to note changes in pH caused by adding NaCl and STP, since protein solubility, swelling, gel formation and WHC in fish muscle are affected by pH (Table 8). As NaCl was increased, the pH of frozen deboned fish decreased. As STP increased, pH also increased. Adding STP to meat increased its pH, which in turn increased the negative charge on myofibrillar proteins. There were no remarkable changes in pH caused by adding soy protein isolate to frozen minced fish.
Table 7. Effects of adding sodium chloride and sodium tripolyphosphate of Myosin Heavy Chain of frozen mechanically deboned fish

<table>
<thead>
<tr>
<th>% Sodium Tripolyphosphate</th>
<th>% Sodium Chloride</th>
<th>3.0</th>
<th>3.6</th>
<th>Mean^*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.000</td>
<td>0.74</td>
<td>1.00</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>0.225</td>
<td>2.14</td>
<td>1.14</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>0.450</td>
<td>1.85</td>
<td>1.45</td>
<td>1.96</td>
</tr>
<tr>
<td>Mean^†</td>
<td>0.86</td>
<td>1.57</td>
<td>1.19</td>
<td></td>
</tr>
</tbody>
</table>

^* Standard error for each cell mean (N = 9) is 0.29 millivolts

^ Standard error for each row or column mean (N = 27) is 0.55

Table 8. Effects of adding sodium chloride and sodium tripolyphosphate on pH of frozen mechanically deboned fish

<table>
<thead>
<tr>
<th>% Sodium Tripolyphosphate</th>
<th>% Sodium Chloride</th>
<th>pH Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.000</td>
<td>6.86a</td>
</tr>
<tr>
<td></td>
<td>0.225</td>
<td>7.27</td>
</tr>
<tr>
<td></td>
<td>0.450</td>
<td>7.80</td>
</tr>
<tr>
<td>Mean^†</td>
<td>0.31</td>
<td>6.43</td>
</tr>
</tbody>
</table>

^* Standard error for each cell mean (N = 6) is 0.002

^ Standard error for each row or column mean (N = 18) is 0.007

The data on swelling (Table 9) shows as NaCl increased, swelling decreased. Schults et al. reported similar results, stating that meat swelling decreased with the addition of 3.5% NaCl. The decrease in swelling was attributed to the exchange of Mg^2+ and K^+ by Na^+. As amounts of STP blended with frozen minced fish increased, swelling also increased. Swelling is due to the ability of inorganic phosphate to split actomyosin into its component proteins actin and myosin, resulting in the uptake of water. Swelling of fish muscle increased as SPI increased due to the tendency of this protein to absorb H_2O.

Gel forming ability has been measured at Least Concentration Endpoint (LCE). LCE is the minimum protein concentration required to form a gel. The LCE of total extracted protein for gelation increased as the concentration of NaCl increased (Table 10). These poor gelation
Table 9. Effects of adding soy protein isolate on percent swelling of frozen mechanically deboned fish

<table>
<thead>
<tr>
<th>% Soy Protein Isolate</th>
<th>% Sodium Chloride</th>
<th>% Swelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>72.19</td>
<td>49.65</td>
</tr>
<tr>
<td>2.0</td>
<td>73.48</td>
<td>54.42</td>
</tr>
<tr>
<td>4.0</td>
<td>88.67</td>
<td>70.62</td>
</tr>
</tbody>
</table>

Mean: 54.78

Standard error for each cell mean (N = 12) is 1.10
Standard error for each row or column mean (N = 36) is 0.63

Table 10. Effects of adding sodium chloride and sodium tripolyphosphate on the least concentration endpoint of frozen mechanically deboned fish extracted protein

<table>
<thead>
<tr>
<th>% Sodium Chloride</th>
<th>% Sodium Tripolyphosphate</th>
<th>Least Concentration Endpoint for Stable Gel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.41</td>
<td>4.36</td>
</tr>
<tr>
<td>2.25</td>
<td>1.40</td>
<td>5.53</td>
</tr>
<tr>
<td>4.50</td>
<td>1.22</td>
<td>7.75</td>
</tr>
<tr>
<td>Mean</td>
<td>1.34</td>
<td>5.89</td>
</tr>
</tbody>
</table>

Mean: 3.40

Standard error for each cell mean (N = 12) is 0.11
Standard error for each row or column mean (N = 36) is 0.44

Properties in samples containing NaCl were probably related to high ionic strength and possibly lower pH in these samples. The LCE was decreased by adding 0.45% STP only in samples containing no NaCl. Soy protein isolate slightly improved formation of gel in samples of frozen minced fish.

Further Processing of Minced Frozen Fish

From this basic knowledge of the functionality of sucker proteins, it was decided to utilize the frozen minced sucker in two different products: (1) sausage type and (2) canned minced products. The addition of 3.0% NaCl, 0.45% STP and 4% SPI were adequate for the sausage formulation. However, samples containing 0.45% STP without NaCl had 50% of its total protein content solubilized and the highest solubility of MHC occurred with that treatment. Those samples also had the
highest pH and swelling and the best gel forming ability. Therefore, it was decided to use the same blend of minced fish in a canned product with the addition of 1.0% NaCl to improve product taste. Since 4% SPI did not improve the functional properties of fish products imparted a soy flavor to the finished product, 4% corn meal was substituted in product formulations.

The addition of fat was needed since sucker flesh contained only about 2% fat, and fat is needed to improve succulence and acceptability of products.

Fish sausages showed low binding characteristics. Sausages in treatment A shrank more when heated to 82°C internal temperature for 30 min. than any of the other sausages and shriveled or had poor physical structure and shape, whereas the others appeared normal. The data (Table 11) indicated that adding corn meal, SPI and hydrogenated vegetable oil (HVO) with NaCl and STP improved the WHC, texture and cook yield of the sausages.

Canned minced frozen sucker also showed low binding characteristics. Again the treatment A group shrank more than the other treatments. When the finished products had been processed at 121°C for 75 min...all but those subject to treatment A showed relatively firm structure with few air pockets.

Treatment A showed approximately 80% WHC. Further improvement in WHC was obtained by adding SPI and/or corn meal (treatment A vs B, C and D) (Table 12). The greatest WHC (98.79%) was obtained by using 4% SPI and 4% cornmeal in combination with the other ingredients. The canned fish product made according to treatment A was soft and mushy and difficult to slice. Firmness with the addition of 4% SPI (treatment B), 4% cornmeal (treatment C) and a combination of the two (treatment D).

In conclusion, results showed that sodium chloride increased protein solubility, but also decreased swelling, gel forming and pH. In comparison, sodium tripolyphosphate increased protein solubility, pH, swelling and gel formation. Fish sausages and canned products showed low binding characteristics. However, adding cornmeal and soy protein in combination with sodium chloride and sodium tripolyphosphate improved their water holding capacity, texture and cook yield. It was concluded that sodium tripolyphosphate, cornmeal and fat should be used in manufacturing minced sucker products.
Table 11. Average percentages* and standard deviations of cooking loss, water holding capacity and shear force (kg f/3.0 cm sectional 0) of smoked fish sausages

<table>
<thead>
<tr>
<th>Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking loss %</td>
<td>34.65 ± 0.49</td>
<td>23.20 ± 0.14</td>
<td>21.15 ± 1.77</td>
<td>22.43 ± 1.34</td>
<td>18.83 ± 1.64</td>
</tr>
<tr>
<td>(N = 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water holding</td>
<td>83.10 ± 1.62</td>
<td>90.20 ± 1.47</td>
<td>93.09 ± 1.20</td>
<td>98.94 ± 0.95</td>
<td>99.53 ± 0.17</td>
</tr>
<tr>
<td>capacity %</td>
<td>(N = 8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear force</td>
<td>0.94 ± 0.06</td>
<td>0.80 ± 0.09</td>
<td>1.03 ± 0.06</td>
<td>1.04 ± 0.05</td>
<td>1.52 ± 0.10</td>
</tr>
<tr>
<td>(N = 12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Average percentages in the same row not followed by the same superscript are significantly different (P < 0.05).

A = 2% NaCl
B = NaCl, 8% HVO, 4% corn meal
C = NaCl, 8% HVO, 4% SPI
D = NaCl, 8% HVO, 4% corn meal
E = NaCl, 8% HVO, 4% SPI, 4% corn meal

All sausages (A, B, C, D and E) the following additives and spices are present: 0.25% sodium tripolyphosphate, 0.05% sodium chloride, 0.05% monosodium glutamate, 0.05% sodium ascorbate, 1.5% salt, 1% dry smoke, and mixed spices.

Utilization of Minced Sticker Fish. Therefore, fish in a canned product.

Further improvements were made with the addition of SPI and HVO. The SPI and HVO significantly improved the WHC of the fish products. Since 4% SPI and HVO improved the WHC, the fish products imparted a more fishy flavor. The fish products imparted a fishy flavor and acceptable shelf life.
Table 12. Average percentages* and standard deviations of baking loss, water holding capacity and shear force of canned minced fish.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baking loss % (N = 2)</td>
<td>0.73 ± 0.05</td>
<td>0.69 ± 0.01</td>
<td>0.41d ± 0.00</td>
<td>0.33d ± 0.09</td>
</tr>
<tr>
<td>Water holding capacity % (N = 8)</td>
<td>79.24d ± 1.27</td>
<td>92.24d ± 1.60</td>
<td>95.33c ± 0.73</td>
<td>98.79c ± 0.21</td>
</tr>
<tr>
<td>Shear force (N = 12)</td>
<td>0.18a ± 0.12</td>
<td>0.29a ± 0.01</td>
<td>0.31a ± 0.02</td>
<td>0.41d ± 0.02</td>
</tr>
</tbody>
</table>

Kg-f/1.8 cm cross section

*Average percentage in the same row not followed by the same superscript are significantly different (P < 0.05)

A = 88.5% mechanically deboned frozen fish (MDPF)
B = 82.5% MDFF, 4% soy protein isolate
C = 82.5% MDFF, 4% corn meal
D = 78.5% MDFF, 4% soy protein isolate, 4% corn meal

In all treatments (A, B, C, D) the following additives and spices are present: 4% beet tripe, 8% hydrogenated vegetable oil, 1% sodium chloride, 0.45% sodium tripolyphosphate, 0.30 white pepper powder, 0.15% onion powder, 0.15% garlic powder, 0.10% paprika, pepper powder and 0.05% ground ginger.
REFERENCES


to rheological properties of heated minced meat gel. J. Texture Studies 2:75.

Nutritional consequences of the changes occurring during frozen storage. J.


SCHULTS, G. W., D. R. RUSSELL and E. WIERBICKI. 1972. Effect of
condensed phosphate on pH, swelling, and water holding capacity of beef.
J. Food Sci. 37:360.

SCHUT, J. and BROUWER, F. 1974. The influence of the presence of fat on
water binding properties of meat proteins. Proc. of the 20th European Meat

SHERMAN, P. 1961. The water binding capacity of fresh pork. 1. The influence
of sodium chloride, pyrophosphate, and polyphosphate on water
absorption. Food Technol. 15:79.

TONG, S., J. M. FLINK and S. A. GOLDBLITH. 1975. Squid protein con-
8:70.

TRAUTMAN, J. C. 1964. Fat emulsifying properties of prerigor and postrigo-
pork proteins. Food Technol. 18:1065.

TRAUTMAN, J. C. 1966. Effect of temperature and pH on the soluble proteins
of ham. J. Food Sci. 31:409.

WEBER, K. and M. OSBORN. 1969. The reliability of molecular weight deter-
iminations by Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis. J. Bio.
Chem. 244(16):4406.

WIERBICKI, E., M. G. TIEDE and R. C. BURRELL. 1963. Determination of
meat swelling as a method of investigating the water binding capacity of
muscle protein with low water holding forces. 2. Application of the swelling

WOLF, W. J. 1970. Soybean proteins: their functional, chemical, and physical

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