Microbial Growth in Surimi and Mince made from Atlantic Pollock

STEVEN C. INGHAM and NORMAN N. POTTER*

Department of Food Science, Cornell University, Ithaca, New York 14853

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ABSTRACT

Surimi preparation from minced Atlantic pollock decreased protein, fat, and NaCl levels and increased moisture and carbohydrate levels of the mince. Aerobic plate counts and psychrotrophic counts of samples from three trials stored at 5 and 13°C were initially similar, but reached higher levels in surimi with time. The pH of surimi tended to decrease relative to that of mince during storage at both temperatures. Careful handling and storage are equally important for both products if microbiological quality is to be maintained.

Surimi is a food processing intermediate material made from minced fish flesh which has been heavily washed and to which cryoprotectants such as sucrose and sorbitol have been added. Surimi is made into a variety of traditional Japanese foods such as kamaboko, tempura, and chikuwa; it is also used in the manufacture of imitation crab, shrimp, lobster, and scallop. Surimi has two properties which are useful in food processing. The first is the gel-forming capacity of the fish myofibrillar proteins, which can be used to create many different textures in finished products. The myofibrillar proteins are concentrated during the washing step in the surimi-making process, which also removes fat and water-soluble pigments, proteins, vitamins, and odoriferous compounds. The second important property of surimi is that the cryoprotectants allow the surimi to be frozen for long periods without substantial freeze-denaturation. Freeze-denaturation causes reduction of functionality of the myofibrillar proteins (12, 17).

Most surimi in the United States is imported from Japan in the form of imitation seafoods. Imports of imitation seafoods from Japan have risen from 2600 metric tons in 1981 to over 26,000 metric tons in 1984 (17). In addition, surimi manufacturing and processing plants in the United States are expected to increase in number (1, 2, 19).

The microbial properties of minced fish have been reported on the microbiology of surimi. Because washing and addition of cryoprotectants alter minced fish composition, this study was undertaken to determine if Atlantic pollock mince and surimi prepared from it differ significantly in microbiological properties.

MATERIALS AND METHODS

Sample preparation

Iced gutted Atlantic pollock (Pollachius virens) (Trials 1 and 3) and iced Atlantic pollock fillets (Trial 2) were obtained from a major market and a local supermarket, respectively. The gutted fish were promptly filleted, skinned, and iced before further processing. Fillets were minced 15 s at high speed in a Cuisinart food processor. One half of the resulting mince from each trial was packed in 2-oz plastic jars and the remaining mince was made into surimi. The initial step in making surimi was washing the mince in chilled (1°C) deionized water. The amount of wash water was 2.4-5.0 x the weight of the mince, varying with the trial (see Table 1). The washed mince was next wrapped in cheesecloth and manually squeezed until water was no longer easily expressible. Sucrose, sorbitol, and sodium tripolyphosphate were then added in amounts of 4.0, 4.0, and 0.2% of the unwashed mince weight, respectively. The resulting surimi was packed in 2-oz plastic jars. Surimi and mince samples were stored at various temperatures depending on how they were to be tested. Samples for protein, fat, and NaCl analyses were frozen at -40°C for later use. Samples for moisture, pH, and initial microbial counts were refrigerated at 5°C and tested within 1.5 h. Samples for microbiological storage tests were held at abusive (13°C) and refrigerator (5°C) temperatures.

Proximate analysis

Percent moisture was determined by AOAC method 24.003 (4) with 5-g samples heated 24 h at 110°C. The pH was determined on 10 g of sample ground in 10 ml of deionized water by mortar and pestle. Percent NaCl was measured by AOAC method 18.034 (4) using 10-g samples. The method of Bligh and Dyer (5) was used for total lipid content of 25-g samples. The Kjeldahl method (6) was used to determine percent crude protein (% N x 6.25).
TABLE 1. Amount of wash water, aerobic plate count (APC), and psychrotrophic count (PC) per gram of surimi and mince made from Atlantic pollock.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Starting material</th>
<th>Mince</th>
<th>Surimi wash water</th>
<th>Surimi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>log APC</td>
<td>log PC</td>
<td>log APC</td>
</tr>
<tr>
<td>1</td>
<td>Gutted fish</td>
<td>&lt;5.00</td>
<td>&lt;5.00</td>
<td>3.00</td>
</tr>
<tr>
<td>2</td>
<td>Fillets</td>
<td>5.67</td>
<td>5.82</td>
<td>2.40</td>
</tr>
<tr>
<td>3</td>
<td>Gutted fish</td>
<td>4.89</td>
<td>4.94</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Microbiological tests

Plates for aerobic plate counts (APC) were incubated 48 h at 20-25°C, and for psychrotrophic counts 10 days at 5°C (18). In each test, three plates were poured for each sample dilution. All media contained 0.5% (w/v) NaCl. For storage studies, samples held at 5°C were plated daily for 5 d, and samples held at 13°C were plated every 12 h for 60 h. For Trial 3, pH was measured during storage.

Statistical analysis

One way analysis of variance (16) was used to determine if differences between means for proximate analyses were statistically significant (p<0.05).

RESULTS AND DISCUSSION

The proximate compositions (means of Trials 1-3) of surimi and mince are given in Table 2. Surimi contained significantly (p<0.05) less protein, fat, and NaCl, and significantly more water than the mince. The remaining major component of the surimi was carbohydrate from the added sucrose and sorbitol and averaged 5.7% (by difference) of the finished weight of the surimi. Surimi thus contained two main types of organic compounds, protein and carbohydrate, to support microbial growth while mince contained almost exclusively protein.

During storage at both 5 and 13°C the pH of the surimi decreased while that of the mince increased slightly and remained higher than for the surimi (Fig. 1). While the magnitude of the pH decrease of surimi was not large, it occurred consistently in Trial 3 and in two tests done on previously frozen samples from Trial 2 (data not shown). Bacteria that metabolize carbohydrates frequently produce acidic products such as lactic acid. The decrease in surimi pH may have been due to native microflora adapting from protein to carbohydrate degradation. Bacteria from the genera Pseudomonas, Achromobacter, Vibrio, Aeromonas, Bacillus, Micrococcus, Moraxella, and Flavobacterium have been reported to be present on fish flesh (7, 8, 10, 11, 15). Of these genera, all but Moraxella and Flavobacterium contain species which produce acid from carbohydrate. The decrease in pH of surimi only occurred when the APC was near 10^7 CFU/g, and thus might only serve as an indicator of severe spoilage. The slight increase in pH of the mince is probably the result of ammonia produced by bacterial degradation of protein.

TABLE 2. Proximate percentage composition of surimi and mince made from Atlantic pollock.a

<table>
<thead>
<tr>
<th>Component</th>
<th>Mince</th>
<th>Surimi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>80.18 ± 0.66</td>
<td>82.32 ± 1.12</td>
</tr>
<tr>
<td>Protein</td>
<td>18.91 ± 0.47</td>
<td>11.45 ± 0.60</td>
</tr>
<tr>
<td>Lipid</td>
<td>0.75 ± 0.31</td>
<td>0.50 ± 0.25</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.22 ± 0.08</td>
<td>0.08 ± 0.03</td>
</tr>
</tbody>
</table>

a Values are means ± standard deviation from Trials 1-3. Different superscripts in the same row indicate significantly (p<0.05) different means.

The washing step in surimi-making could be expected to reduce the initial bacterial load of the surimi relative to that of the mince. Raccach and Baker (14) found that washing of fish frames that were subsequently mechanically deboned resulted in APC values about one log lower than for mechanically deboned unwashed frames. Others have also reported that washing reduced the bacterial load of fish (9, 13) and surimi (3). In Trials 2 and 3, for which initial APC and psychrotrophic counts were obtained, the surimi in all instances had a slightly but...
not significantly lower initial bacterial load. It was observed that the initial APC and psychrotrophic counts for both surimi and mince were higher when the starting material was fillets than when it was gutted fish.

The APCs of surimi and mince held at 5 and 13°C in Trial 3 are shown in Fig. 2. Although not shown, similar results were obtained in Trial 1 for 13°C storage and for both storage temperatures in Trial 2. Insufficient data were collected in the Trial 1, 5°C test. These results show that the bacterial growth rates in mince and surimi were initially very similar but after prolonged storage the growth rates in surimi became greater than in mince. This increase in growth rate roughly coincides with the pH drop in surimi and may reflect the bacterial metabolic shift to carbohydrate degradation. The psychrotrophic counts of surimi and mince held at 5 and 13°C in Trial 2 are shown in Fig. 3. Again, similar results were obtained in Trials 1 and 3, but the data are not shown. Psychrotrophic counts in mince and surimi were similar until large populations were present, after which time counts in surimi were consistently higher than in mince. In all of the storage tests, the comparative values of APC and psychrotrophic counts over time were very similar. In addition, the colony morphologies observed for both were practically the same. Therefore it is likely that nearly all of the aerobic bacteria present in mince and surimi were psychrotrophic.

Results of this study show that in terms of microbial growth during storage at abusive and refrigerator temperatures, raw minced Atlantic pollock and raw surimi made from it behaved very similarly until large bacterial populations were present. Then populations in the surimi became greater than the mince and the pH of the surimi decreased relative to the mince. It can be concluded that careful handling and low-temperature storage are equally important for both raw minced Atlantic pollock and raw surimi made from it.

REFERENCES

Figure 2. Aerobic Plate Count of surimi and mince stored at 5 and 13°C. Symbols are (△) mince at 5°C, (△) surimi at 5°C, (■) mince at 13°C, (△) surimi at 13°C.

Figure 3. Psychrotrophic count of surimi and mince stored at 5 and 13°C. Symbols are (□) mince at 5°C, (△) surimi at 5°C, (■) mince at 13°C, (△) surimi at 13°C.


