Quality Aspects of Commercial Frozen Minced Fish Blocks

J. J. LICCIARDELLO*, E. M. RAVESI, and M. G. ALLSUP

United States Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service, Northeast Fisheries Center
Gloucester Laboratory, Emerson Avenue
Gloucester, Massachusetts 01930

(Received for publication April 3, 1978)

ABSTRACT

Imported frozen minced Alaska pollock blocks were inferior in flavor and texture when compared to minced blocks prepared from certain species of North Atlantic fish. Organoleptic scores were strongly influenced by the cooking method, that is, baked versus fried. Quality attributes assessed by objective tests (thiobarbituric acid, trimethylamine, dimethylamine, aerobic plate count) generally did not show strong correlation with sensory scores.

Practically all frozen minced fish blocks used by commercial fish processors in this country are imported. There is very little, if any, production within the continental United States (21). By the time these blocks are converted into consumer products such as breaded sticks and portions, a great deal of the frozen shelf life of the blocks may have been expended as a result of the total elapsed time in storage contributed by the primary manufacturer before releasing for sale, transit time during shipment, and by the secondary processor before conversion into finished products. Several researchers have shown that minced fish has a shorter frozen storage life than intact fillets (4,19). This is primarily due to the disintegration of the cellular integrity which enhances denaturation of proteins and loss of texture. In addition, development of oxidative rancidity is intensified, thus creating a problem with certain species of fatty fish. Protein denaturation not only affects the textural quality of breaded sticks or portions made from the affected blocks, but also causes a loss in functional property (binding) which is an important characteristic for preparing heat-gelled products (20). Although these storage changes in frozen minced fish can be suppressed considerably at low, subfreezing temperature (3, 18, 26), in commercial practice it is currently not feasible to maintain the low holding temperature usually required \[\text{[°F]} = \text{[°C]} - 29\].

During the early 1970s, some seafood processing companies suffered financial losses through marketing frozen minced seafood products which rapidly deteriorated in quality in retail distribution channels with subsequent consumer rejection. Use of marginal quality blocks (Alaska pollock) may also have contributed to this situation in some instances (23).

Dyer (17) proposed that standards of quality for minced fish blocks be directed to inform the secondary processor of the inherent stability of the particular frozen mince so that suitable finished products with a reasonable shelf life could be manufactured.

In a previous paper, results of a survey of the microbiological quality of commercial frozen, minced fish blocks were reported (20). This communication reports the quality of those blocks as measured by organoleptic and chemical tests.

MATERIALS AND METHODS

A total of 208 frozen minced fish blocks weighing either 16.5 or 18.5 lb. (7.5 or 8.4 kg) were analyzed in this survey. The source of these blocks and the species of fish involved were described in a previous publication (20).

Flavor and texture evaluations were conducted with a 12-member, experienced panel using a 9-point scale with descriptive terms ranging from "excellent" to "inedible" and in which a score of 5 represents a judgement of "borderline." USDC inspectors occasionally participated on the panel. Samples were prepared for tasting by wrapping small portions \(2.5 \times 2.5 \times 5 \text{ cm}\) of the frozen block in foil and baking in an oven at 350°F (176.7°C) for 20 min. Some of the samples were also tasted as precooked breaded sticks after heating in an oven from the frozen state.

Trimethylamine (TMA) and dimethylamine (DMA) were estimated by the method of Castell et al. (72). This particular procedure was selected because of the convenience in simultaneously assaying both amines; however, it is acknowledged that the dithiocarbamate method for measuring DMA is probably more accurate. Results were expressed as mg of TMA or DMA nitrogen/100 g of flesh.

The method of Yu and Sinnhuber (25,30) for determining thiobarbituric acid (TBA) number was modified by adding EDTA and propyl gallate during extraction (8).

Each block was sampled in duplicate while frozen using an electric drill with a 1-1/4-inch (32 mm) high-speed bit. Analyses made on both samples were averaged, and that figure was reported as the value for the block.

The procedure for aerobic plate count (APC) was described in a previous paper (20).
Linear regression analyses were done on the data using a Wang® 600 Series Advance Programming Calculator.

RESULTS AND DISCUSSION

The percent frequencies of flavor and texture scores of the various minced blocks prepared by baking are in Tables 1 and 2. In accordance with the organoleptic scoring system employed, a numerical rating of just less than 5 would be indicative of unacceptability. Thus, from the data it can be estimated that 92% of the Alaska pollock, 29% of the cod, 33% of the cod frame, 21% of the pollock (N. Atlantic), and none of the haddock blocks were unacceptable because of undesirable flavor; whereas, 100%, 40%, 21%, 19% and 44% of the same respective species were unacceptable because of poor texture. Textural degradation was manifested principally as toughness or rubberiness, whereas flavor change was usually characterized as soapy, bitter or fishy.

TABLE 1. Percent frequency of flavor scores for various frozen minced fish blocks.

<table>
<thead>
<tr>
<th>Flavor score</th>
<th>Alaska pollock</th>
<th>Cod</th>
<th>Cod frame</th>
<th>Pollock</th>
<th>Haddock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - 1.9</td>
<td>1.5</td>
<td>74</td>
<td>65</td>
<td>35</td>
<td>24</td>
</tr>
<tr>
<td>2.0 - 2.9</td>
<td>35.4</td>
<td>64</td>
<td>66</td>
<td>35</td>
<td>27</td>
</tr>
<tr>
<td>3.0 - 3.9</td>
<td>47.7</td>
<td>3.4</td>
<td>3.3</td>
<td>7.0</td>
<td>7.9</td>
</tr>
<tr>
<td>4.0 - 4.9</td>
<td>7.7</td>
<td>27</td>
<td>27.2</td>
<td>30.8</td>
<td>28.0</td>
</tr>
<tr>
<td>5.0 - 5.9</td>
<td>4.6</td>
<td>3.4</td>
<td>11.4</td>
<td>6.6</td>
<td>6.7</td>
</tr>
<tr>
<td>6.0 - 6.9</td>
<td>3.1</td>
<td>21.4</td>
<td>33.3</td>
<td>12.5</td>
<td>33.3</td>
</tr>
<tr>
<td>7.0 - 7.9</td>
<td>8.6</td>
<td>24</td>
<td>24.0</td>
<td>24.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>

No. blocks: 65 70 24 26 9

The rationale for tasting the samples baked was that this is the culinary method employed by the U. S. Department of Commerce inspectors in grading fish blocks; also, it had been demonstrated that this particular cooking method allowed for better discrimination among samples of frozen fish which had undergone storage deterioration (16). However, it was realized that frying usually masks or subdues off-flavors (7); since the consumer would ultimately taste the finished product made from these blocks as a fried batter-breaded item, a number of the blocks, just for comparison, were also tasted in this manner in addition to the baked form. Linear regression analysis done on the data plotted as baked flavor score (Y) as a function of fried flavor score (X) yielded a regression line of: Y = 1.04 X – 1.23, with a correlation coefficient of 0.87. Similarly, the relationship for baked texture score as a function of fried texture score was: Y = 0.94 X – 0.49, with a correlation coefficient of 0.89. In both instances the average fried flavor or texture score was about one scale unit higher than the corresponding baked score. The average flavor and texture scores and standard deviations (σ) are compared in Table 3 for the various minced blocks tasted as baked and fried fish. The higher rating of fried samples is readily apparent. From a consumer product standpoint, a greater percentage of blocks would have been considered acceptable after frying than was estimated from baked scores. To exemplify this point, whereas 40%, 21% and 44% of the cod, pollock and haddock blocks were judged unacceptable in the baked form due to either poor flavor or texture, 8% of the cod blocks, but none of the pollock or haddock blocks, were regarded as unacceptable when tasted as fried (breaded) products. This discrepancy in quality grading due to the method of culinary preparation is a controversial issue with some seafood processors.

In addition to assessing the quality of frozen minced fish by sensory methods, another objective of this study was to determine whether or not this parameter could be measured by certain chemical indices of spoilage. The average TBA number, TMA and DMA contents and standard deviations for the various minced blocks are in Table 4. The TMA value has been employed as a chemical index of the quality of the fish before freezing (14). In the present investigation, cod frame mince had the highest average level of TMA. This is not surprising in view of the additional handling that is involved with frames, and that unwashed mince from frames usually contains a large amount of blood pigments which reduce the naturally occurring precursor, TMA oxide, to TMA (9). Mince from pollock, a species with much dark muscle, was next highest in average TMA content.

TABLE 3. Comparison of baked and fried average flavor and texture scores of various minced fish blocks.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. blocks</th>
<th>Avg. flavor score</th>
<th>Avg. texture score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baked</td>
<td>Fried</td>
<td>Fried</td>
</tr>
<tr>
<td>Cod</td>
<td>45</td>
<td>5.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Pollock</td>
<td>26</td>
<td>5.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Haddock</td>
<td>9</td>
<td>5.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Cod frame</td>
<td>6</td>
<td>5.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Alaska pollock</td>
<td>5</td>
<td>2.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Hake</td>
<td>4</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Ocean catfish</td>
<td>3</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Ling cod</td>
<td>3</td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>

3Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.
that the TMA test would be a reliable indicator of the quality of frozen minced fish. In certain species of North Atlantic fish, other reactions may occur and contribute to the overall toughening process during frozen storage.

In general, this limited survey indicated imported frozen commercial minced Alaska pollock blocks to be of inferior quality compared to minced blocks made from certain species of North Atlantic fish with the possible exception of hake. The principal cause of quality failure was textural change which was described as rubbery, spongy, or fibrous. Although some blocks received low flavor scores, this defect could be obviated to some extent through addition of flavoring or seasoning agents in the finished product as occurred when the mince was tasted as fried breaded fish sticks. A defect in texture would preclude use of the afflicted blocks for production of breaded sticks or portions; however, these blocks could still be used to produce fish cakes or other “hash” type products which contain other texture modifying ingredients.

The minced Alaska pollock blocks examined in this survey are called “surimi” in Japan, and this product is tailored specifically as a frozen raw material for kamaboko (22). A desirable characteristic of kamaboko is a chewy or resilient texture (2) which might be undesirable in a fish stick or portion to an American consumer. Bond (6) does not recommend frozen surimi as a raw material for breaded sticks or portions. However, this product was the only Alaska pollock mince that was available during the survey period to U.S. seafood processors who were not fully cognizant of its storage characteristics and who were principally attracted to it because of its low cost and abundance.

It was surprising to find a rather low level of DMA in cod frame mince since this material may contain blood

Based on organoleptic evaluation, Dyer and Dyer (15) found a TMA value above 15 to be indicative of spoiled or spoiling fish. Twenty-five percent of the pollock or cod frame blocks exceeded this value. However, it cannot be stated unequivocally that these blocks were produced from poor raw material since it was previously indicated that heme pigments in pollock or cod frame mince catalyze formation of TMA; also, it has been demonstrated that the process of mincing caused an immediate increase in TMA value (5). Results of chemical tests for quality should be interpreted cautiously with minced fish because if the mince has been washed, there can be a drastic reduction in TMA content (13) and in volatile acids and volatile bases (27).

It is believed by some researchers that the “fishy” odor of stale or spoiling fish is due to the presence of TMA. In this study, there was some correlation between flavor score and TMA content for cod frame blocks (r = 0.68) and pollock blocks (r = 0.63), but not much (< 0.5) for cod or Alaska pollock blocks. Thus, it is not considered that the TMA test would be a reliable indicator of the quality of frozen minced fish blocks. No significant correlation was found between flavor score and APC at 21 C for blocks from any of the different species.

Sinnhuber and Yu (25) found poor quality frozen fish to have TBA numbers of 4 or greater. Since none of the blocks examined in this study exceeded a TBA number of 3.5, it is concluded that oxidative rancidity as measured by this parameter was not a major source of the off-flavors in those blocks that were rated low. Miyaochi et al. (23) reported minced Alaska pollock to have relatively good stability against development of rancid flavors during frozen storage; yet, in their storage studies with this species, flavor deterioration still occurred.

It has been suggested that the concentration of DMA in certain species of frozen fish could be used as a measure of frozen storage deterioration since it was found to correlate with the development of toughness (10,29). This compound has been detected in frozen Alaska pollock (28) and in other gadoid species (11) with the order of increasing activity being haddock, cod, pollock, cusk and hake. Dimethylamine and formaldehyde are both formed in equimolar amounts from the enzymatic degradation of TMA-oxide, but it is actually the formaldehyde that induces textural toughening through denaturation of myofibrillar proteins (7). In this survey the Alaska pollock blocks were relatively high in average DMA content; this seems to reflect the low texture scores afforded these particular blocks. Arithmetic means for DMA content of the North Atlantic species were low with the exception of hake which ranged in content from 23 to 36 mg/100 g for four blocks. To the authors’ knowledge, there are no published data relating concentration of DMA with textural quality of frozen fish. Linear regression analysis was done on the data (baked texture scores as a function of DMA content) to ascertain the degree of correlation and the value of DMA corresponding to borderline texture. Although some correlation was found (r ranged from -0.41 to -0.58), it was not considered sufficiently significant to validate the application of this test for grading texture of frozen minced blocks of unknown history. Sikorski et al. (24) have reviewed the mechanisms of protein denaturation in fish. Although formation of formaldehyde (and DMA) may be of some significance in the textural degradation of frozen gadoid fish, other reactions may also occur and contribute to the overall toughening process during frozen storage.

TABLE 4. Means and standard deviation of TBA number, TMA, and DMA content of various frozen minced fish blocks.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. blocks</th>
<th>Avg. TBA number</th>
<th>o TBA</th>
<th>Avg. TMA content</th>
<th>o TMA</th>
<th>Avg. DMA content</th>
<th>o DMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska pollock</td>
<td>85</td>
<td>1.3</td>
<td>0.48</td>
<td>3.6</td>
<td>3.3</td>
<td>18.4</td>
<td>13.1</td>
</tr>
<tr>
<td>Cod</td>
<td>70</td>
<td>1.2</td>
<td>0.51</td>
<td>3.0</td>
<td>3.5</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Cod frames</td>
<td>24</td>
<td>1.6</td>
<td>0.52</td>
<td>10.0</td>
<td>8.7</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Pollock</td>
<td>26</td>
<td>1.2</td>
<td>0.21</td>
<td>8.3</td>
<td>8.4</td>
<td>2.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Haddock</td>
<td>9</td>
<td>1.3</td>
<td>0.43</td>
<td>1.1</td>
<td>0.7</td>
<td>1.1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Downloaded from http://meridian.allenpress.com/jfp/article-pdf/42/1/23/1649374/0362-028x-42_1_23.pdf by guest on 28 February 2020
and kidney tissue which are known to accelerate DMA formation. Perhaps, the known susceptibility of this product to storage deterioration promotes expeditious usage so that the blocks we examined were relatively young. Nevertheless, since frozen minced fish is more prone to quality loss than intact fillets, it would behoove the fish processor to consider the age of the block and also the fish species in his decision on the final end product to be manufactured, as suggested by Dyer (17), and also to aim for a rapid turnover of the product in retail trade.

ACKNOWLEDGMENT

The authors acknowledge the technical assistance of M. E. Haskins and W. S. Hill.

REFERENCES