IN VITRO LIPID OXIDATION OF SARCOPLASMIC RETICULUM
BY IN SITU CONCENTRATIONS OF Fe AND Cu

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INTRODUCTION

Lipid oxidation is a major pathway of chemical deterioration in frozen fish muscle which leads to decreased quality. An enzyme found in winter flounder (Pseudopleuronectes americanus) is an active catalyst of lipid oxidation at temperatures as low as -20°C (Apgar and Hultin, 1982). This enzymic system, which is located in the sarcoplasmic reticulum (Borhan et al., 1984), catalyzes lipid oxidation in the presence of iron and NADH and is stimulated by the presence of ADP (McDonald and Hultin, 1987). The ability of copper to interact with this enzyme system is not well understood.

Halliwell and Gutteridge (1986) have suggested that a low molecular weight pool of soluble iron chelates are capable of stimulating lipid oxidation in vivo. Thirty percent of the iron of winter flounder is found in the water-soluble (press juice) fraction (Kramer, 1987). Addition of the soluble metals with a molecular weight less than 10,000 daltons as the sole source of metal to a model system containing 0.1 mM ADP and 0.5 mg sarcoplasmic reticulur (SR) protein resulted in stimulation of lipid oxidation after 6 days (Kramer, 1987).

The purpose of this paper was to determine the soluble and low molecular weight (LMW) Fe and Cu concentrations of winter flounder and Atlantic mackerel (Scromber scrombrus) muscle and to determine if these concentrations of Fe and Cu could promote lipid oxidation. Varying concentrations of NADH and ADP were also tested to see their effects on SR-catalyzed lipid oxidation at in situ Fe and Cu concentrations.

MATERIALS AND METHODS

Winter flounder and Atlantic mackerel were obtained from fish processors in Gloucester, Massachusetts. The fish were immediately iced and used within 24 hr. Mackerel were frozen by placing whole in a -80°C freezer and thawed by placing under running tap water. Nicotinamide adenine dinucleotide, reduced (NADH) and adenosine-5'-diphosphate (ADP) were obtained from Boehringer Mannheim Biochemicals. Baker Instra-analyzed nitric acid and Gold-label magnesium nitrate used for metal determinations were purchased from J.T. Baker. All other
chemicals were reagent grade. All glassware used in metal determinations were acid washed.

Sarcoplasmic reticulum was isolated from flounder muscle using the method of Borhan et al. (1984) except that the minced tissue was homogenized three times at 30 s intervals, the resulting homogenate was adjusted to pH 7.3, the ratio of supernatant:45% sucrose:20% sucrose used for the discontinuous sucrose gradient was 50:9:3 and the gradient was centrifuged for 60 min. SR protein was determined using the Lowry procedure as modified by Markwell et al. (1978).

A "press juice" representing the soluble components of flounder muscle was prepared by centrifuging coarsely cut up tissue at 15,000 rpm in a type 19 rotor (22,000 x g) for 15 hr in a Beckman L5-65B preparative ultracentrifuge at 5°C. The LMW fraction of the press juice was isolated by ultrafiltration using an Amicon Stirred Cell Model 52. The filtrate was collected until the press juice volume was reduced by one half. YM series membranes with molecular weight cutoffs (MWCO) of 10,000, 5,000 and 1,000 were used to isolate the LMW fraction. The LMW fraction (10,000 MWCO) of aged flounder muscle was isolated after storing the fillets on ice for 6 days.

Iron and copper concentrations of the press juice and the LMW fractions were performed on a Perkin-Elmer 3030B Atomic Absorption Spectrophotometer with a HGA-400 Graphite Furnace accessory. Iron concentrations were determined at 248.3 nm with a slit width of 0.2 nm. Pretreatment temperature was 1400°C with a ramp time of 5 s and a hold time of 20 s. Atomization temperature was 2400°C for 4 s with the gas flow shut off. All samples for iron determination contained 0.5 mg% magnesium nitrate. Copper contents were analyzed at 324.8 nm with a slit width of 0.7 nm, a pretreatment temperature of 1200°C with a ramp time of 5 s, a hold time of 20 s and an atomization temperature of 2300°C for 4 s with stop flow. Both iron and copper samples contained 0.2% nitric acid.

SR-catalyzed lipid oxidation in a model system was measured by determining the production of thiobarbaric acid-reactive substances as described by McDonald and Hultin (1987). The model system contained 0.5 mg SR protein in 5 mM histidine, 0.12 M KCl buffer, pH 6.8 with varying concentrations of metals, ADP and NADH. All reactions were run for 20 h at 6°C in triplicate unless otherwise indicated.

RESULTS AND DISCUSSION

Iron concentrations of the press juice and LMW fractions from flounder and mackerel are listed in Table 1. Flounder and mackerel white muscle had very similar levels of iron in the press juice and the LMW fraction. Approximately 10% percent of this water-soluble iron was found to have a molecular weight of 1,000 daltons or less. Storing
flounder muscle on ice for 6 d did not cause any changes in the iron content of the press juice or the LMW fraction. Freezing the mackerel muscle resulted in an increase in the iron concentration of the press juice. Mackerel red muscle had approximately 6 times as much iron in the press juice and about 4 times as much iron in the LMW fraction as flounder and mackerel white muscle. The LMW iron of the red muscle also represented about 10% of the total soluble iron. Freezing had very little effect on the total soluble iron of the mackerel red muscle.

Table 1. Iron concentrations (ppb) of the water-soluble fractions of mackerel and flounder muscle.

<table>
<thead>
<tr>
<th>Muscle Fraction</th>
<th>Flounder Muscle</th>
<th>Mackerel White Muscle</th>
<th>Mackerel Red Muscle</th>
</tr>
</thead>
</table>
| Press Juice     | Fresh           | Aged 

<10,000 daltons  | 33               | 33                    | 49                  |
| <5,000 daltons  | 43               | --                    | 36                  |
| <1,000 daltons  | 48               | --                    | 36                  |

1Fillets stored on ice for 6 days.

Table 2 shows the copper concentration of press juice and the LMW fractions of flounder and mackerel muscle. The LMW copper in flounder muscle was found in 2 fractions. Approximately 60% of the copper was between 1,000 and 10,000 daltons and the remaining 40% was less than 1,000 daltons. These 2 fractions represented approximately 37% of the total soluble copper. Storing flounder fillets on ice for 6 d did not change the copper concentration in the press juice or the LMW fraction. The total soluble copper concentration of mackerel white muscle was very similar to flounder muscle. The LMW copper of mackerel white muscle had a molecular weight of less than 1,000 daltons and represented approximately 40% of the total soluble copper. Freezing the mackerel resulted in an increase in the copper concentration of the press juice. The soluble copper concentration of the mackerel red muscle was approximately 3 times as high as in flounder and mackerel white muscle. The concentration of LMW copper in red muscle was similar to the concentrations found in white muscle and flounder, but this only represented about 10% of the total soluble copper. Although copper tends to be found in lower concentrations than iron in fish.
muscle (Gordon and Martin, 1982) its concentration in the LMW fractions is similar to iron suggesting that it could play an important role in SR-catalyzed lipid oxidation.

Table 2. Copper concentrations (ppb) of the water-soluble fractions of mackerel and flounder muscle.

<table>
<thead>
<tr>
<th>Muscle Fraction</th>
<th>Flounder Muscle</th>
<th>Mackerel White Muscle</th>
<th>Mackerel Red Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press Juice</td>
<td>Fresh</td>
<td>Aged 1</td>
<td>Fresh Frozen (-80°C)</td>
</tr>
<tr>
<td></td>
<td>98</td>
<td>--</td>
<td>109</td>
</tr>
<tr>
<td>&lt;10,000 daltons</td>
<td>34</td>
<td>36</td>
<td>44</td>
</tr>
<tr>
<td>&lt;5,000 daltons</td>
<td>37</td>
<td>--</td>
<td>49</td>
</tr>
<tr>
<td>&lt;1,000 daltons</td>
<td>15</td>
<td>--</td>
<td>39</td>
</tr>
</tbody>
</table>

1Fillets stored on ice for 6 days.

Fig. 1 shows the oxidation of the SR membrane by the concentrations of copper and iron found in the LMW fraction of flounder and mackerel muscle. Iron was a more powerful catalyst than copper at all concentrations. At the concentrations found in the LMW fraction of flounder and mackerel white muscle (approximately 40 ppb) there is not much difference between the activity of copper and iron, but at the concentration of iron found in red muscle (200 ppb) approximately 4 times as much oxidation occurred. This suggests that the concentrations of copper and iron found in the LMW fractions of fish muscle are capable of promoting lipid oxidation.

Fig. 2 shows the production of thiobarbituric-reactive substances (TBARS) over a 27 h period by 0.79 µM copper and iron. Iron stimulated SR-catalyzed lipid oxidation more than copper at all times examined. A lag phase occurred for 16-20 hrs for both iron and copper. This is much different than a model system containing 15 µM iron in which substantial oxidation occurred within 30 min (Hultin et al., 1982).

Catalysis of lipid oxidation by iron (0.36 µM or 20 ppb) and copper (0.79 µM or 50 ppb) in the absence of ADP with varying NADH concentrations is shown in fig. 3. Maximum lipid oxidation occurred at 50 µM NADH for both copper and iron. The observed NADH optimum was lower than previously observed for the model system (McDonald and
Figure 1. Production of TBA reactive substances by varying concentrations of iron and copper. The reaction was run at 6°C for 20 hr with 0.1 mg sarcoplasmic reticular protein per ml 0.12 M KCl, 5 mM histidine buffer, pH 6.8 and 0.1 mM NADH.
Figure 2. Production of TBA reactive substances as a function of time in the presence of 0.79 uM Fe and Cu and 0.1 mM NADH. The reaction was run at 60°C with 0.1 mg sarcoplasmic reticular protein per ml 0.12 M KCl, 5 mM histidine buffer, pH 6.8.
Figure 3. Production of TBA reactive substances by 0.36 μM Fe and 0.79 Cu, with varying NADH concentrations. The reaction was run at 6°C for 20 hr with 0.1 mg sarcoplasmic reticular protein per ml 0.12 M KCl, 5 mM histidine buffer, pH 6.8.
Hultin, 1987). The conditions for the two experiments differed in iron concentration (0.36 μM vs. 150 μM), assay time (20 h vs. 30 min) and by the presence of a NADH regeneration system in these experiments, but an optimal NADH concentration existed for lipid oxidation in both cases. At the optimal concentration of NADH the iron activity was much higher than the copper activity, but as the NADH concentration was increased or decreased the difference between the two activities decreased. This suggests that at NADH concentrations other than optimal, copper could have an important role in SR-catalyzed lipid oxidation.

The effect of ADP concentrations on copper- and iron-catalyzed enzymic lipid oxidation is shown in fig. 4. Maximal activity was observed at an ADP concentration approximately equal to the metal concentration (0.36 μM Fe or 0.79 μM Cu). This agrees with other observations in our laboratory where optimal enzymic lipid oxidation occurred when iron:ADP concentrations were 1:1 (Erickson, 1987). Iron was a more powerful catalyst than copper at the optimal ADP concentration and it remained more effective at all ADP concentrations examined. Iron-catalyzed SR oxidation fluctuated more with varying ADP concentrations than copper-catalyzed lipid oxidation suggesting that ADP is more important in iron-catalyzed enzymic lipid oxidation. ADP could be stimulating the Fe-catalyzed lipid oxidation by maintaining the ferric ion in a soluble, mobile state. This again suggests that copper could be an important catalyst of SR-stimulated lipid oxidation when in situ ADP concentrations are not optimal.

Table 3 shows the stimulation of SR-catalyzed lipid oxidation using the LMW fractions of flounder and mackerel muscle as the sole source of iron and copper. Very little oxidation occurred in the presence of the LMW fractions. Only the LMW fraction of mackerel red muscle catalyzed any substantial oxidation in 5 days. The lack of activity could be due to the presence of antioxidants in the LMW fractions or it could be due to the chelation of the metals to compounds which prevent metal–enzyme interactions or change the oxidation-reduction potential of the metals.

<table>
<thead>
<tr>
<th>Metal Source</th>
<th>nmol TBARS/mg SR protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td>Flounder LMWF (20 ppb Fe; 20 ppb Cu)</td>
<td>--</td>
</tr>
<tr>
<td>Mackerel LMWF (white muscle)</td>
<td>--</td>
</tr>
<tr>
<td>(30 ppb Fe; 30 ppb Cu)</td>
<td></td>
</tr>
<tr>
<td>Mackerel LMWF (dark muscle)</td>
<td>--</td>
</tr>
<tr>
<td>(120 ppb Fe; 30 ppb Cu)</td>
<td></td>
</tr>
<tr>
<td>20 ppb FeCl₃</td>
<td>5</td>
</tr>
<tr>
<td>50 ppb CuSO₄</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 4. Production of TBA reactive substances by 0.36 uM Fe and 0.79 uM Cu with varying ADP concentrations. The reaction was run at 6°C for 20 hr with 0.1 mg sarcoplasmic reticular protein per ml 0.12 M KCl, 5 mM histidine buffer, pH 6.8.
The iron and copper concentrations found in the low molecular weight water-soluble fraction of winter flounder and mackerel white muscle muscle were very similar. At this concentration (40 ppb) iron produced slightly higher levels of TBARS than copper. Mackerel red muscle contained approximately 4 times as much LMW iron but had about the same concentration of LMW copper as flounder and mackerel white muscle. The concentration of iron found in the LMW fraction of red muscle was a much more effective catalyst of SR-stimulated lipid oxidation than the concentrations found in flounder and mackerel white muscle.

Lipid oxidation catalyzed by both copper and iron showed optimal concentrations of NADH and ADP, but iron was more strongly inhibited than copper when NADH and ADP were not at optimal levels. This suggests that even though iron is a more powerful catalyst than copper under optimal conditions, copper could be an important contributor to in situ lipid oxidation.

REFERENCES


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EFFECT OF CO₂-O₂ MODIFIED ATMOSPHERE WITH PRESSURIZATION ON THE
KEEPING QUALITY OF COD FILLETS AT 2°C

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INTRODUCTION

The highly perishable nature of fresh fish is well known. The
primary cause of spoilage of unfrozen lean fish is the growth and met-
abolic activities of bacteria. The most common spoilage bacteria of
fish, and other fresh muscle foods, are gram-negative, aerobic psych-
rotrophs, especially Pseudomonas spp. (Orydzia and Brown, 1982).
Such bacteria are capable of causing deterioration of fish with the
production of obnoxious odours and off flavours, during refrigerated
storage.

Recently there has been increased interest by the fishing indus-
try in modified atmosphere (M.A.) packaging using a carbon dioxide
(CO₂)-enriched environment to extend the shelf life of refrigerated
fresh fish. Carbon dioxide gas is a relatively safe and effective
bacteriostatic agent which has been used for the preservation of fresh
meats, poultry and produce since the 1930's (Baker et al., 1986;
Wolfe, 1980). A number of studies have reported that a CO₂-enriched
atmosphere can have a beneficial effect on the shelf life of various
seafoods. Barnett et al. (1982) found that Pacific salmon stored in
an atmosphere containing 90% CO₂ were still acceptable up to 21 days
at 0°C. Rock cod fillets in 80% CO₂ had lower levels of ammonia and
trimethylamine (TMA), as well as lower bacterial numbers, in compari-
son to samples stored in air (Mokhele et al., 1983; Brown et al.,
1980). Cod (Cann et al., 1983), haddock (Stansby and Griffiths,
1935), swordfish (Lannelongue et al., 1982), turbot (Gauthier et al.,
1986), shrimp (Layrisse and Matches, 1984) and crab (Parkin and Brown,
1983) have also been reported to have improved keeping quality (40–
200%) under CO₂-enriched storage conditions.

A previous study by our lab (Woyewoda et al., 1984) was unable to
show such a significant improvement in the shelf life extension of cod
fillets using modified atmosphere storage. Inadequate exposure of the
fillets to the gas mixture may have been a factor. In this study we
attempted to maximize the surface area of the fillets exposed to the
gas mixture by placing them on support pads. In addition, an initial
pressurization treatment was evaluated in an attempt to accelerate the
uptake of CO₂ by the fish flesh.
MATERIALS AND METHODS

Fresh Atlantic cod (*Gadus morhua*) fillets were purchased from a local fish plant the day after catching. They were packed in 10 lb polyethylene containers surrounded with ice and immediately transported to the laboratory (< 1 h). Upon arrival, each fillet was trimmed to a weight of approximately 200 g, washed under cold, running tap water and drained.

**Modified Atmosphere**

The fresh fillets (5 per bag) were placed on a porous nylon pad (24 x 15 x 0.5 cm) and put in a cryovac barrier bag (40 x 24 cm; 3 mil polyethylene/1 mil nylon with oxygen transmission rate = 88 cc/24 h/100 in²/mil thickness at 25°C, 50% RH; carbon dioxide transmission rate = 549 cc/24 h/100 in²/mil thickness at 25°C, 50% RH). Each package was evacuated and sealed with vacuum sealer, back flushed with a 60% CO₂:20% O₂:20% N₂ gas mixture, inflated and resealed. Half of the MA packaged fillets were subjected to a pressurization treatment, while the inflated bags were packed in ice, using a retort to facilitate maximum absorption of the gas mixture by the fillets. The fillets were pressurized at 45 p.s.i. above normal atmospheric pressure (total 4 atmospheres) for 1 h. Control fillets were similarly packaged in barrier bags except that they were filled with air and not pressurized.

All of the bags were stored at 2±1°C until assessed for quality at 0, 2, 5, 7, 9, 12 and 15 days.

**Microbiological Analyses**

A single bag from each treatment was selected at random each sampling day. Thirty gram samples were excised aseptically from each of three fillets per bag, diluted in sterile 0.1% peptone with 0.5% NaCl (w/v) and stomached for 1 min in a model BA 6021 Stomacher (A. J. Seaward; Edmunds, England). Serial dilutions were prepared and plated in duplicate on Plate Count Agar (Difco, Detroit, MI) with 0.5% NaCl to enumerate total aerobes, anaerobes and psychrotrophs. Lactic acid bacteria were enumerated on MRS agar (Difco) with 0.5% NaCl.

All plates were incubated at 21°C for 72 h except for the psychrotroph plates which were held at 7°C for 10 days. The anaerobe plates were incubated in Gaspak anaerobic jars (BBL; Cockeysville, MD).

**Trimethylamine Analysis**

Fifty gram samples were removed from each of three fillets per treatment and extracted with 7.5% trichloroacetic acid (TCA) and analyzed for trimethylamine according to the method of Dyer (1945).

**Surface pH Determination**

Surface pH measurement of the fillets were obtained using an
Orion surface pH electrode and Acument pH meter. pH values were obtained for at least two sites on each side of the fillets.

**Drip Measurement**

The volume of fluid released upon storage of the fillets was measured by pouring the liquid into a graduated cylinder as each bag was opened. Drip was expressed as a percentage of the initial weight of the fillets.

**Raw Quality Grading**

Raw fillets were judged for overall acceptability by four expert graders on each sampling day according to the following scheme:

Acceptability
1. excellent
2. highly acceptable
3. low acceptability
4. reject

**Taste Panels**

An informal taste panel evaluation of the fillets was carried out by four expert graders. On each sampling day, two fillets from each pack were removed, wrapped in plastic film, placed in 1 lb cardboard packages and stored at \(-30^\circ\text{C}\) until evaluated (approximately one week after the 15th day). For each session the fillets were thawed, wrapped in aluminum foil and baked at 230°C for 15 min. Each panelist received four samples, along with a fresh reference sample (R). The reference samples were untreated fillets frozen at \(-30^\circ\text{C}\) on day 0 of the study. The panelists were asked to compare the samples to the reference on the basis of flavour and overall acceptability.

**RESULTS AND DISCUSSION**

Those fillets stored in the presence of the CO\(_2\)-enriched modified atmosphere (MA/MAP) were found to have significantly lower total aerobic plate counts (TAPC) than the controls packaged in air (Fig. 1). The TAPC of the controls exceeded 10\(^6\) colony forming units per gram (cfu/g) after 5 days at 2°C, while the MA/MAP stored fillets required 15 days to reach this level. The TAPC for the pressurized and non-pressurized MA stored fillets were not statistically different which suggests that the pressurization treatment did not enhance the bacteriostatic effect of the CO\(_2\) gas.

The psychrotroph counts (results not shown) were similar to the TAPC for each group of samples indicating that those counts obtained at the mesophilic temperature were representative of the numbers of bacteria capable of growth during the storage of the fish at 2°C.

The major safety concern with the use of modified atmosphere packaging is the potential it has for creating conditions favourable for anaerobic bacteria. The growth and toxin production of *Clostridium botulinum* is of particular concern (Hintlian and Hotchkiss, 1986).
FIG. 1. Total aerobic bacterial counts on cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▽, air control (AC).

FIG. 2. Anaerobic bacterial counts on cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▽, air control (AC).
The results for the anaerobic bacterial counts showed that those fillets stored in the presence of 60% CO₂:20% O₂:20% N₂ (MA/MA) had lower counts than the control fillets on each sampling day (Fig. 2). The reduction of anaerobic counts was probably a result of the bacteriostatic effect of CO₂ and the relatively high concentration of O₂ (20%) which was used.

A number of studies of meat, poultry and fish stored under modified atmosphere conditions have noted a shift in the microflora from primarily gram-negative bacteria to a the predominance of a gram-positive flora, especially lactic acid bacteria (Lannelongue et al., 1982; Enfors et al., 1979; Sanders and Soo, 1978). The lactic acid bacterial (LAB) counts were generally found to be lower for the fillets packaged in the CO₂-enriched environment than the controls (Fig. 3). However, the LAB counts of the MA/MAP fillets increased steadily after 5 days and their numbers at 9 days (10⁵ cfu/g) was at the same level as their total aerobic counts at 9 days. These results indicate that the microbial flora of the MA/MAP samples had indeed shifted towards a predominance of LAB during the latter part of the storage period. Conditions which are selective for the growth of LAB can be beneficial since members of this group are capable of inhibiting the growth of other types of bacteria which contribute to spoilage (Roth and Clark, 1975). It has been suggested that high numbers of LAB contribute to the beneficial effect of CO₂ on the shelf life of meat and seafood.

Chemical analysis of fish quality consisted of the measurement of trimethylamine (TMA) production. TMA is a bacterial breakdown product of trimethylamine oxide (TMAO). Based on an unacceptability level of 15 mg TMA-N/100 g (Woyewoda et al., 1984) the control fillets were considered spoiled at day 9 while the MA/MAP fillets took at least 15 days to reach this level (Fig. 4).

One of the theories concerning the mechanism by which CO₂ inhibits bacterial growth, is the formation of a weak organic acid (carbonic acid) on the surface of the flesh which lowers the substrate pH (Stathan, 1984). This was not found to be the case in this study. Measurement of the surface pH failed to show any dramatic decrease in pH which might account for the bacterial inhibition by CO₂ (Fig. 5). This is probably a result of the high buffering capacity of the fish flesh.

Storage of fish muscle in high concentrations of CO₂ has been reported to cause excessive drip (Fay and Regenstein, 1982; Villedumure et al., 1986). Fish stored in the presence of 60% CO₂ did have higher drip losses, particularly on day 12 and 15, than the controls (Fig. 6). However, at no time during this study did the drip exceed 5 percent of the total weight, and would not be considered excessive.

The raw quality grading (overall acceptability) was consistent with the TMA values. The control fillets were judged to be spoiled after 9 days, while the MA/MAP fillets were acceptable up to and including day 15 (Fig. 7). The taste panel assessments (data not shown) of the samples were also in agreement with the raw grading scores and TMA values.
FIG. 3. Lactic acid bacterial counts on cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▼, air control (AC).

FIG. 4. Trimethylamine production in cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▼, air control (AC).
FIG. 5. Surface pH values of cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▽, air control (AC).

FIG. 6. Drip production as percentage of initial weight of cod fillets at 2°C. •, Modified atmosphere with pressurization (MAP); □, modified atmosphere (MA); ▽, air control (AC).
FIG. 7. Raw quality grading of cod fillets at $2^\circ$ C (1 = excellent; 2 = highly acceptable; 3 = low acceptable; 4 = reject). • Modified atmosphere with pressurization (MAP); ▲, modified atmosphere (MA); ▼, air control (AC).
CONCLUSIONS

1. The M.A. of 60% CO₂: 20% O₂: 20% N₂ was effective at reducing total aerobic bacterial counts.

2. The M.A. did not appear to enhance the growth of anaerobic bacteria.

3. Lactic acid bacteria appear to predominate in M.A. packaged fillets.

4. Trimethylamine production was inhibited by the M.A.

5. M.A. did not cause a significant decrease in surface pH of fillets or result in excessive drip.

6. Sensory evaluation generally confirmed the beneficial effect of the M.A. as indicated by reduced bacterial counts and TMA production.

7. There was no significant difference between pressurized and non-pressurized M.A. packaged fillets.

REFERENCES


PURIFICATION OF OMEGA - 3 FATTY ACIDS FROM FISH OILS USING HPLC: AN OVERVIEW

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INTRODUCTION

The National Marine Fisheries Service (NMFS), and the National Institutes of Health (NIH) have entered into a joint research venture which is anticipated to span the next decade. The agreement assures researchers, who are studying the therapeutic value of fish oils, a source of fish oils and fish oil concentrates produced and quality controlled/quality assured by the NMFS Charleston SC Laboratory. The NMFS laboratories at Gloucester, MA and Seattle, WA were tasked to find a method for the production of highly purified fractions of the two major fatty acids of interest to the medical community, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). This paper offers some considerations for the separation of the ethyl esters of these and three other fatty acids at >90% purity using reverse phase high performance liquid chromatography.

RESULTS AND DISCUSSION

The stationary phase of choice for the separation of fatty acid esters is a hydrocarbon (C18) bonded to a solid support (Scholfield, 1975, Wille et al, 1987, Tokiwa, 1981, Bascetta et al, 1984). Columns prepacked with this packing are available through several suppliers. Columns 1 and 2 (Table 1) are examples of the columns obtained from two different suppliers. Columns with small pore size solid support, such as Column 1 with 8 micron pore size, have greater resolution and higher purity of eluted fractions than columns with larger pore sizes such as Column 2 with 20-30 micron pore size. Purity is given as percent of the total fatty acids as determined by capillary GLC analyses. Therefore, impurities in the fractions are other fatty acids.

Solvent choice depends on desired purity and end use of the eluted fractions. Ethanol and water are the solvent system chosen for this research, because they are food grade materials. This is a consideration for an end product which might be consumed by humans. The
solvents require no special handling or waste disposal measures and do not oxidize. If, however, none of these considerations is of import to a particular application, tetrahydrofuran (THF), methanol, and water will yield higher purity fractions of EPA and DHA (Table 1). THF is potentially explosive and requires special OSHA considerations for its safe handling and waste disposal, is toxic, as is methanol, and oxidizes readily, which is undesirable when in contact with fish oil which is prone to rapid oxidation.

Table 1. Purity of eluted EPA/DHA fractions from a feedstock of 57% EPA/31% DHA using different solvent systems on an analytical column.

<table>
<thead>
<tr>
<th>Solvent</th>
<th>(\text{ZEPA/\text{ZDHA}}) Column 1 (8\mu)</th>
<th>(\text{ZEPA/\text{ZDHA}}) Column 2 (25\mu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THF/MeOH/H2O</td>
<td>99/95</td>
<td>99/89</td>
</tr>
<tr>
<td>EtOH/H2O</td>
<td>98/92</td>
<td>97/87</td>
</tr>
</tbody>
</table>

The greater the concentration of EPA and DHA in the feedstock, the higher the purity of the eluted EPA and DHA (Table 2). We are working with a feedstock which has been highly concentrated in EPA and DHA by urea fractionation at the Charleston Laboratory and contains almost 50% EPA and 25% DHA. When using a feedstock furnished by the Seattle Laboratory, which has been cycled through their super-critical CO2 system and is 79% EPA or 79% DHA, purities of close to 100% can be recovered.

Table 2. Purity of eluted EPA/DHA using THF:methanol:water as the solvent system on an analytical column with differing purity of feedstock.

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>(\text{ZEPA/\text{ZDHA}})</th>
<th>Eluant</th>
</tr>
</thead>
<tbody>
<tr>
<td>32/19</td>
<td>99/82</td>
<td>99/82</td>
</tr>
<tr>
<td>57/31</td>
<td>99/89</td>
<td>99/89</td>
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<tr>
<td>79% EPA</td>
<td>99.9% EPA</td>
<td>96% DHA</td>
</tr>
<tr>
<td>79% DHA</td>
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If purity is of paramount importance, peak slicing is recommended. The back sides of the eluted peaks yield the highest purity. This is definitely the case with DHA (Figure 1b).

Figure 1. HPLC separation of fish oil concentrate (48%/24%, EPA/DHA) using ethanol:water on a.) analytical column, b.) preparative column, and c.) production column.
The first portion of the eluant can be discarded in favor of the higher purity eluant at the end of the separation. Yields are sacrificed to purity in this mode of collection. Yields of about 70% are the norm when collecting the entire peak.

The column size and loading will depend on production requirements. Five fatty acids have been successfully separated on analytical, preparative, and production scale columns (Figure 1). Production requirements for the analytical scale are 20mg of fish oil at a flow rate of 3ml/min with a run time of 25 min. On a preparative column, 10 grams can be loaded at a flow rate of 50ml/min with a run time of 65 min. On a large column, 60g were successfully separated at 250ml/min with a run time of 180 min.

This report is intended as an overview of the possibilities for HPLC in the production of high purity fractions of EPA and DHA. Capital equipment costs for fully automated sample injection and fraction collection systems range from $28K to $120K. There are obviously a wide range of options, including the imaginative deployment of multiple small systems, to achieve desired production goals.

REFERENCES


HEALTH MESSAGES ABOUT SEAFOOD

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INTRODUCTION

Enthusiasm about the health benefits associated with consuming omega-3 fatty acids from seafood has generated media attention, marketing flamboyance and new product development, especially fish oil concentrates (1-7). Processors and retailers, usually hesitant to tout health benefits of foods are finding health a handy hook for promoting seafood (8). Nutrition has never had it so good (9). Nutrition information and health messages are currently flourishing in a sea of regulatory leniency and public confusion. Yet, in spite of or perhaps because of the hype, where there is still mass misunderstanding of basic nutrition issues, as fundamental as total fat intake for example, seafood is enjoying unprecedented publicity and vigorous demand. It is the latest "health food"(10).

By and large, consumers seldom select foods primarily for their health benefits. Quality and convenience consistently outrank nutrition as reasons for a purchase decision. Yet new awareness of the fact that eating seafood is good for you, wider availability of fresh seafood and improved seafood retailing are all contributing to an increased demand for seafood in supermarkets and restaurants. Presumably, bold health claims are also strengthening the demand for seafood products and supplements (11).

OBSERVATIONS

Health Claims: Health claims are an important aspect of communicating nutrition and health information. The permissive climate surrounding health claims for foods follows the much ballyhooed Kellogg's bran cereal campaign (12). With the endorsement of the National Cancer Institute, which has no jurisdiction over food labels, nutrition or health claims, Kellogg's advertised its bran cereal as an aid to deterring some forms of cancer. Although many dispute the quality of the data suggesting a protective effect of dietary fiber against certain cancers, this widely publicized advertising with its attendant controversy had at least three effects. First, it focussed attention on the possible benefits of wise food choices. In a sense, it made the gravel road between food and health a paved pathway. Second, it undermined the authority of the FDA to regulate health claims by sidestepping the usual approval procedures and involving another federal agency, The National Cancer Institute. Third, The Kellogg controversy hastened the publication of proposed regulations for health messages on food labels.
In August, the FDA proposed regulations which set forth criteria for evaluating health claims and information on food labels and point-of-purchase materials (13). This proposal recognizes the need for greater dissemination of health and nutrition information pertaining to food.

Advertising Messages: Advertising is a key factor in product marketing. Advertising and labeling communicate image and information about a product. Product attributes may be conveyed indirectly by association or directly with statements or comparative data. Statements about health benefits and nutritive value are frequently misleading or untrue. Take the example of this ad (14). Often what is unsaid is as important as what is stated. Some statements capitalize on consumer confusion or ignorance. For example, the claim that a product is made using only vegetable oil belies the fact that the oil may be highly saturated or constitutes more than fifty percent of the energy value of the food.

While the nutritional merits of unprocessed seafood obviate the need for advertising subterfuge, nevertheless, seafood advertising shares the troubles of other product categories when it comes to nutrition confusion. Sometimes the facts are wrong, as in the previous example. Sometimes the issue is misunderstood (15). And sometimes freedom of expression just tells half the story (16).

Marketing Magic: Marketing magic is another facet of health messages. An oft repeated bit of folklore regarding omega-3s is that they are present in cold water fish (8, 17). This wisdom presumably comes from romanticizing the Eskimo environment or marketing Arctic fish. The fact is, all fish and shellfish have some omega-3s. Some have more than others and some have higher proportions than others even if when the total fatty acid content is fairly low. A person wishing to choose fish for their abundance of omega-3s however, will find the greatest amounts in the oiliest fish, no matter whether the fish lives in marine or fresh water or both, as illustrated by tuna, rainbow trout and salmon.

The relationship between total fat content and omega-3 fatty acid content is illustrated in these scatter diagrams of finfish from the Northern Hemisphere and the Southern Hemisphere (18, 19).

Experts: Authority figures and experts, like everyone else, make mistakes (20). Quotes are taken out of context; source material may be out-of-date; and inappropriate extrapolations or conclusions may be drawn (21). And if you're not careful, the fish gets thrown in with the veal (20). Understandably, consumers are confused.

Wishful Thinking and the Application of Imaginary Data: There is currently a good deal of wishful thinking about omega-3s which is aided by the application of imaginary data. The publicity being given to fish oil supplements is an ideal case in point (6, 16). Its advertising is misleading, the citation of data selective and biased, and it substitutes
wish for information. In their rush to cash in on the good news generated by the Eskimo studies and other clinical data, fish oil promoters have decided we do not have to to wait for controlled studies. They are satisfied with results from clinical trials on small numbers of subjects. They have no qualms extrapolating from epidemiological data. Some of it very weak, to giving advice to individuals for the management of blood cholesterol.

Fish oil supplements are marketed mainly on the assumption that taking them will lower a person’s cholesterol level (16). In some individuals it may. In others however, fish oil supplements may have no effect on blood lipids and in still others they may actually be accompanied by an increase in cholesterol levels. You do not hear about these possibilities from the fish oil floggers. And we have very little information about the long term effects of fish oil in diets as rich in total fat as ours.

The sellers of fish oil supplements have also eschewed the need to define a safe and effective dose. Can everyone benefit? Are benefits available only with high doses as some studies suggest? Is long term consumption safe in the presence of other medications especially anti-coagulants and aspirin? Let’s face it. Caution doesn’t sell.

As promising as omega-3 fatty acid research appears, worrisome safety issues have not been resolved. Processing techniques exist to remove virtually all nasty chemicals that may be present in fish oils, especially those from fish liver, but different brands vary in the amount of undesirable residues that may be present. They also differ in how they have been refined. Here is what FDA has found (22, 23).

These data make it clear that the assumption of adequate refining may not be justified. The problem with many nasty residues and contaminants is that just as fish do, we store them in our liver. Amounts that seem vanishingly small on an individual dose basis, may accumulate with long term supplement use. Presently, a purchaser of fish oil preparations has no way of knowing whether or not he is enriching his own contaminant reserves.

The FDA studies have also shown that label information is inadequate in other ways. In nearly all samples analyzed the amount of EPA and DHA was demonstrably below the level stated on the label, in some instances as much as one third below. It would appear that regulatory standards and careful monitoring are in order.

Guilt by Association: When facts are missing, perhaps a little fear will do the trick. Call it guilt by association. Fear generated by unsubstantiated claims about the safety of our seafood supply undermine consumer confidence as surely as reassuring nonsense about nutritional or health value. The difference is that the falsity works in different directions.
Last June, The Coast Alliance, a non-profit public interest group, issued a report with a press release that began:

"The almost unmonitored and unchecked polluting of New England's coastal waters poses a serious threat to the nation's fish eaters and - ultimately - the sea itself and the life that inhabits it" (24).

This alarming statement achieved its purpose: the attraction of media attention with press articles and media interviews. The issue quickly and quietly died. But how many people turned away from seafood, all seafood? Just when people are re-thinking their red meat consumption they are being frightened about the safety of the fish supply.

Let me emphasize that I decry as loudly as anyone the use of any waterways as sewers and I recognize the potential threat to health of these extremely nasty substances but we have very little evidence to suggest that eating fish will make you ill. In fact, the evidence is just the opposite.

What is objectionable about this sensationalism is that there is no evidence that people in America are getting ill from the chemicals unfortunately being dumped into our waterways. We may be living on borrowed time, no doubt, but there is a quantum leap between chemicals in the waters and illness from eating cooked fish muscle.

Unquestionably people get ill; very ill, from eating seafoods harvested from contaminated waters. But the contaminants that we know make people sick come from raw sewage. Without doubt, the seafood preparation guaranteed to do the trick is eating such seafood raw. But that is a far cry from a "serious threat to the nation's fish eaters."

SUMMARY AND CONCLUSIONS

In summary, people are becoming aware of the benefits of eating seafood, thanks in part to health claims, advertising, journalism, and retailing activities. All these endeavors can benefit from awareness of facts, including what we know and don't know; refusal to endorse or commission mythology and wishful thinking; and the avoidance of sensationalism masquerading as truth.

What to Do: To protect against false claims and misleading or fraudulent advertising, we as health professionals must ensure that the seafood business has:
1. a clear understanding of the nutrition issues being addressed

2. an understanding of the complexities underlying both health and marketing issues

3. the facts

Where data do not exist, the seafood industry can support efforts to commission the appropriate research. They must resist the temptation to invent the facts they seek or wish.

Lest I leave you with the impression that all seafood and health messages are fraudulent or misleading, here are some examples that have avoided the pitfalls mentioned above.

1. Responsible journalism (25, 26);
2. Facts (27, 28);
3. Health by association (29);
4. Appropriate use of experts.

After all, the data support the health claim implied in the bumper sticker from the Massachusetts Division of Marine Fisheries: "Is health your wish? Eat more fish."
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NOMENCLATURE AND LABELING OF FISHERY PRODUCTS
A MARKETING DILEMMA

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This paper will describe the nomenclature problems that industry, government and consumers have in properly identifying fishery products in national and international trade. It also will discuss the steps taken by the National Marine Fisheries Service (NMFS), the Food and Drug Administration (FDA), and the National Fisheries Institute (NFI) to address the nomenclature problem.

PROBLEM IDENTIFICATION

The lack of standardized market name nomenclature in the interstate marketing system has created confusion at all levels of the market strata from processor to the ultimate consumer. The confusion is caused by several reasons. The main reason is the variation in common market names used for a given species from different areas or regions of the country. Another problem arises when industry markets a less commercially known species using an existing well-established market name of a more desirable fish which has a higher value in the market. Still another problem is created when, in some instances, state regulatory authorities have authorized the use of a well-established market name (applied and recognized to a species from another state or region) to be applied to a species from a totally different family or genera harvested and marketed in their state.

When such products enter interstate commerce, they are considered mislabeled by FDA and subject to seizure and legal action as misbranded products. Further, the lack of standardized market names creates confusion in the orderly worldwide marketing of United States produced and processed seafood.

FDA POLICY AND PROCEDURES FOR DETERMINING ACCEPTABLE COMMON OR USUAL NAMES FOR FISHERY PRODUCTS

Current provisions of the Federal Food, Drug and Cosmetic Act and the Fair Packaging and Labeling Act offer guidelines as to the names by which fishery products or other foods may be designated. The Act
require the label to bear a statement of the identity of the food by its common or usual name and prohibits labeling which is false or misleading in any particular. Where there are no established common or usual names in the United States, the label must bear an appropriately descriptive term informatively revealing the identity and nature of the food. FDA considers the question of what constitutes "the common or usual name" or "an appropriate descriptive term" for a food as a name or term in general usage and readily understood by the ordinary individual or consumer in the United States. Often the common name associated with its systematic biological classification or the common market name applied to the species in the country of origin, for an imported fish, is helpful in determining what does constitute an appropriately descriptive non-misleading name. Neither the common name applied by ichthyologists nor the common name used in another country may be used, however, if it conflicts with the common or usual name used by consumers for another species in the United States or if it is in any way misleading to United States consumers.

In considering whether or not a designation may be misleading, FDA looks to the courts for clarification and guidance as well as to the Act and its regulations. The comments of the Supreme Court of the United States, June 2, 1924, provide such clarification and guidance. The Court said,"... The Statute is plain and direct. Its comprehensive terms condemn every statement, design, and device which may mislead or deceive. Deception may result from the use of statements not technically false or which may be literally true. The aim of the statute is to prevent that resulting from indirection and ambiguity, as well as from statements which are false. It is not difficult to choose statements, designs, and devices which will not deceive. Those which are ambiguous and liable to mislead should be read favorably to the accomplishment of the act...."

FDA in considering the question of what constitutes an appropriate label designation for a seafood, must determine appropriateness based on the basic facts in each instance. Actually determining an acceptable name where none previously exists is not easy. It is much easier, however, than the problems encountered when FDA is called upon to settle a controversy concerning the name to be used throughout the United States when the same fish is known by a different name in different parts of the country.

Another problem arises when people wish to market a less well known or less commercially acceptable fish under the name of a more desirable fish. When called upon to settle controversies or when asked for guidance in developing acceptable names for seafood, FDA looks to several areas for resource material. The main resource for nomenclature of fish found in this country is currently the 4th edition (1980) of Common and Scientific Names of Fishes from the United States and Canada, published by the American Fisheries Society. Should the fish not be
indigenous to North America, or if it is some other type of seafood, recognized experts such as those at the Smithsonian Institution in Washington, D.C. or the National Marine Fisheries Service may be contacted.

Also, the FDA refers back to previous correspondence relating to the specific issue in which a precedence has been established for a particular species.

When working with controversial problems, it would be desirable to have an established standardized market name for every type of fishery product. However, since this luxury is not yet available, each issue must be decided on a case by case basis on its own merit. To illustrate this point, FDA often receives requests to label fish other than *Lutjanus campechanus* as "Red Snapper." The name "Red Snapper," however, has been preempted by many years of consistent consumer usage as meaning only the fish *Lutjanus campechanus*. Because of the high esteem in which this fish is held by consumers and the relatively limited catch, numerous attempts have been made to substitute other less expensive fish for this species. Substituted, less desirable species have included other members of the family Lutjanidae, groupers, and a number of West Coast rockfish of the genus *Sebastes*. The West Coast rockfish have, until recently, been distributed locally and thus have been beyond the reach of the Federal Food, Drug and Cosmetic Act. Some of the states on the Pacific coast have officially sanctioned "Pacific Red Snapper" or "Pacific Snappers" as an alternative name for such members of *Sebastes* genus. These fish are quite different from *Lutjanus campechanus* (Red Snapper) in appearance, flavor and texture, and are generally regarded as inferior by consumers familiar with *Lutjanus campechanus*. The current policy of FDA is that the labeling or sale of any fish other than *Lutjanus campechanus* as "Red Snapper" constitutes a misbranding in violation of the Federal Food, Drug and Cosmetic Act. Further, labeling of rockfish as "Pacific Red Snapper" is acceptable only in those West Coast states which have sanctioned that term.

Economic deception is not the only problem connected with misnamed seafood. Sometimes issues of public health are very much involved. As reported in the FDA Consumer (July-August 1982 issue) in 1982, the Health Department of Ulster County, NY, reported to FDA a double mystery when it asked the agency to assist in an apparent incident of food poisoning. The first question: Why did two men become ill shortly after eating a fish dinner at a restaurant? The answer: The two were suffering from scombroid poisoning, a severe gastric illness resulting from eating fish containing high quantities of the compound histamine. After the diagnosis, the Health Department placed the large lot of fish still remaining at the premises of the dealer who had supplied the restaurant under embargo. An analysis of the fish from the restaurant and the dealer showed the presence of histamine, with the sample from the restaurant containing the highest amount. The second question then
arose: Why did the fish shown on the menu as "Red Snapper," an ocean
delicacy, have high levels of histamine, unusual for this kind of fish?
The answer: It was not "Red Snapper," but Mahi-Mahi in a fish taken off
the Pacific coast of South America. Mahi-Mahi is so predictably high in
toxic histamine that FDA samples and examines each lot imported into the
United States or automatically detains it upon entry.

The FDA found that the fish mislabeled "Red Snapper" had been shipped
from Ecuador and processed in Panama. Had the fish been labeled
Mahi-Mahi, it would never have made it ashore since FDA has an automatic
detention for Mahi-Mahi from Ecuador.

While consumer usage has given a narrow meaning to some common fish
names, other names have come to identify more than one species. An
example is the term "Sardine." Commercially the name "Sardine" has come
to signify almost any small, canned clupeoid fish. To avoid confusion,
FDA recommends that all "Sardines" bear labels showing the place where
produced and the nature of the ingredients used in preserving and
flavoring the product. Thus, a small fish of the clupeoid family, caught
upon or near the shores of Norway and packed in oil, or smoked and packed
in oil, is properly labeled with the phrase "Norwegian Sardines in Oil," or
"Norwegian Smoked Sardines in Oil" with the type of oil being
designated. It also is suggested that the particular fish to which the
term sardine is to be applied should be placed upon the label, for
example, "Pilchard," "Herring," etc. Also, not all fish of the family
Clupeidae are entitled to be called "Sardines." Many members of this
family have well established identities of their own, i.e., Scotch
herring, Polish herring, Alewives or River herring, and others. FDA
would regard the labeling of these other fish as "Sardines" as

In addition to its regulations, FDA also issues policy statements to
provide and identify appropriate designations for seafood. These policy
statements are issued as official "Compliance Policy Guides and Import
Alerts." To date they have been issued to cover caviar, crabmeat, common
or usual names of crustaceans, capelin versus smelt and red snapper.

A number of seafood items are also covered by standards of identity,
or common or usual name regulations. Standards of identity exist for
various styles of pack of oysters, salmon, shrimp and tuna. Common or
usual name regulations have been established for Pacific whiting,
bonito, crabmeat, Greenland turbot and several other seafood items.

When interested parties wish to receive an opinion from FDA as to an
acceptable name to use for a seafood item (or any other food item under
FDA jurisdiction), they may ask for an informal opinion. Generally this
only involves correspondence between the party and either one of the FDA
field offices or the Division of Regulatory Guidance in the Center for
Food Safety and Applied Nutrition (formerly the Bureau of Foods). A
more formal response may be requested in the form of an advisory opinion
which will carry the designation of official agency policy. Anyone may file a citizen's petition to establish a new regulation such as a Standard of Identity. More likely in the case of seafood names, a petition may be filed to propose or amend an existing regulation for a common or usual name. Often there is a difference of opinion about the appropriate common or usual name of a food. For example, a new engineered seafood, such as imitation crab, may not have a common name, or a species of seafood which has not previously been offered as food in this country may not have an English name. In such cases, FDA welcomes suggestions for appropriate common or usual names. These suggestions would most likely be in the form of a citizen's petition. The names suggested should be descriptive of the food and not be misleading or deceptive. The names should represent the new food rather than be suggestive of the name of another already accepted food.

NATIONAL MARINE FISHERIES SERVICE POLICIES AND PROCEDURES FOR DETERMINING COMMON OR USUAL NAMES FOR FISHERY PRODUCTS.

Currently individuals or firms can request guidance from the NMFS in establishing an acceptable or preferred common name for a species described by its scientific name. After the request is made, the NMFS will check to see if the species is listed in the American Fisheries Society's "List of Common and Scientific Names for Fishes from the United States and Canada," or in FDA’s precedence letter files. If the species is not listed in these sources, the NMFS will work with FDA’s Division of Regulatory Guidance to determine an acceptable common or usual name and/or market name for the species.

To date, NMFS policy has been to encourage the industry to voluntarily comply with all federal and state laws and regulations as they relate to properly labeled fishery products. In an effort to aid the industry to comply with such laws in the most equitable manner, the agency continues to develop closer working relationships with FDA in all areas of food safety and labeling.

THE NATIONAL IDENTIFICATION AND LABELING PROGRAM PLAN FOR FISH AND FISHERY PRODUCTS

The increasing demand for both foreign and domestic fishery products will only continue to aggravate an already existing nomenclature problem. For example, at the consumer level, where acceptance of fishery products is of major importance, fishery product labeling can be confusing and sometimes misleading. Furthermore, the majority of consumers will not be likely to spend the time to inform themselves about the increasing number of species now available in the retail market place.

In view of these current and certainly inevitable future difficulties, the National Marine Fisheries Service (NMFS), the National Fisheries
Institute (MFI), and the Food and Drug Administration (FDA) have undertaken a comprehensive project that will aid in resolving future nomenclature problems. The primary objective of this project is to develop an improved nomenclature system and standardize market names for fishery products.

The final result of the project will be to implement an improved seafood products identification program which should yield two important benefits:

1. A plan designed to build consumer familiarity and acceptance of seafood products which will promote seafood consumption, and

2. A plan which will provide a comprehensive identity and labeling framework which will provide the tools needed for voluntary compliance by both industry and government.

The national program on seafood product identification has the following components:

I. NMFS, FDA and USDA Study Group -- Coordination and Regulatory Task:

Through an established Interagency Study Group at the agency's headquarters levels, review and propose resolutions to complex seafood labeling issues for consensus decision making by NMFS, FDA and United States Department of Agriculture (USDA) policy makers.

There is no specific budget for the study group and the issues to be addressed will be those provided from various sources as identified.

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II. Official List of FDA/NMFS Approved Market Names for Fishes -- Development Project:

Develop, publish, distribute and maintain a list of acceptable market names of food fish species for use by government, industry and consumers.

CURRENT STATUS:

Work on the list is almost completed and is scheduled for release as a joint FDA/NMFS Interim Guideline in the Federal Register early
1988 as a notice of availability for use and comment by all interested parties. It is proposed at this time to be available for public comment and use for a period of six months.

Contact Persons: Donald R. Maher, NMFS Project Leader, National Seafood Inspection Laboratory Pascagoula, MS

Mary Snyder, FDA Project Leader, Division of Regulatory Guidance, Center for Food Safety and Applied Nutrition, Washington, DC

III. Edibility Data Bank -- Research Project:

Test the major U.S. food species and establish edibility profiles for each species. Publish the profiles for industry and consumer use and publish the protocol and test methods as the formal methodology for determining the edibility characteristics of species. The edibility profiling of species is carried out at the NMFS technology laboratories in Gloucester, MA, Charleston, SC, and Seattle, WA.

CURRENT STATUS:

Work has been completed on about 100 species, and others are being completed as species are identified and made available for testing.

Contact Person: John Wekell, Project Coordinator, Seattle Laboratory, Seattle, WA

IV. Universal Product Code for Seafood -- Development Project:

Develop and implement a standard nomenclature and numbering system for random weight fish and fishery products sold at retail for inclusion in the Universal Product Code System.

The project is being executed under a multi-year (FY86, 87 and 88) S-K Grant #NA 85AAHSK145, by NFI's National Fisheries Education and Research Foundation.

CURRENT STATUS:

Work on schedule with contract requirements.

Principal Investigator: Robert Collette, NFI, Washington, DC

Technical Monitor: James R. Brooker, NMFS, Washington, DC

As part of this program the project leaders for the "Official List of FDA/USDC Approved Market Names for Fishes" have provided the Foundation
a draft list for food fish containing some 1000 commercial food fish, of
world wide distribution, which are marketed in the United States.

CONCLUSION

The National Marine Fisheries Service considers that the successful
completion of all phases of the National Identification and Labeling
Program Plan for Fish and Fishery products will (1) provide a system
containing the framework and tools necessary for increasing consumer
awareness and wider usage of fish and fishery products, (2) will provide
both industry and government with a tool for orderly marketing through
standardized market names and eliminate conflicts between government
regulatory agencies and industry in interstate commerce, (3) will
provide a mechanism for authorizing and approving market names for fish
and fishery products traded in national and international commerce and
(4), most importantly, the program will provide the ultimate consumer
with properly identified products in the retail market.

While the competitive nature of the food industry will continue to
produce nomenclature problems, the successful completion and publication
of the "National Identification and Labeling Manual for Fish and Fishery
Products" should provide both government and industry with the tools
required to resolve these problems.
APPENDIX 1

PRINCIPLES DEVELOPED AND USED BY FDA AND NMFS IN SELECTING ACCEPTABLE
COMMON MARKET NAMES

The principles developed by the NMFS and FDA in selecting common and
market names for each species are listed in order of priority as
follows:

1. The list shall be a compendia of existing scientific, common and
market names for food fish, shellfish and fishery products only.
Common and scientific names shall not be originated for this
list.

2. The "American Fisheries Society's (AFS) List of Common and
Scientific Names of Fishes and Aquatic Invertebrates from
the United States and Canada" shall be the primary authority
for scientific and common names of fishes and shellfish. In
the absence of an AFS assigned scientific and common name other
authorities will be used in the following priority of use:

   o FAO Species Catalogues and/or Species
   Identification Sheets.

   o Source country primary authority for scientific and
   common names of fishes.

3. The Food and Drug Administration and the NMFS jointly shall be
the authority for the market names of fish and fishery products.

4. The National Oceanographic Data Center shall be the authority
for the twelve (12) digit Taxonomic Code assigned to each
species.

5. Market names shall reflect broad, current, and appropriate usage
of vernacular nomenclature in the labeling of food fish,
shellfish and fishery products that will add to stability and
the universality of names applied to food fish and fishery
products.

6. Market names are established for (a) individual species, and
(b) species grouped together that are recognized in trade and
commerce, and by consumers as having similarities, such as
edibility characteristics, that make them indistinguishable
from each other as products for human food purposes.
7. A market name representing multiple species will apply only at scientifically discrete levels of taxonomic classification, however, it may also comprise multiple species classified in two or more families and/or genera.

8. Individual species within a family or genus for which a market name has been established may be identified more precisely by the addition of a "modifier" to the market name when conditions or unique characteristics warrant more precise identification of the product. Reasons and conditions for more precise identification follow:

   o Prior (grandfather) labeling regulations.

   o Demonstratively significant characteristics (for food purposes) which distinguish one species in commerce from other closely (taxonomically) related species.

9. Species for which there are no acceptable and assigned common names in the English language will bear the market name in use for other taxonomically similar species until such time as a more precise market name is assigned. Reasons and conditions detailed in Item 7 shall prevail in assigning more precise market names.

10. Fish and fishery products intended for use as food may bear either the assigned market name or the complete common name of the species on the label.