THE PRODUCTION OF SILAGE FROM WASTE AND INDUSTRIAL FISH: THE ICELANDIC EXPERIENCE

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INTRODUCTION

For many years there has been interest in Iceland for finding new ways for utilizing pelagic fish, fish waste, and fish viscera as an alternative to fish meal. The main emphasis has been on a cheaper process that could work aboard large and small fishing vessels or in small isolated places with too little fish production for operating a fish meal plant economically. One of the processes that has been considered is conservation by acids or bases, with or without hydrolysis (Arnesen et al. 1981; Raa and Gildberg 1982).

Research on fish silage began in Iceland about 20 years ago. At that time it was mainly focused on preservation with addition of ammonia to the fish and keeping the pH above 10. This silage was separated and dried or concentrated. Feeding trials on calves were reasonably successful but due to lack of interest in the method, these tests were soon abandoned. For the last 10–15 years, the Icelandic Fisheries Laboratories have intermittently been running trials and experiments on silage production using various organic and inorganic acids. Many different aspects of fish silage have been considered such as different raw materials, reclaiming of acids, corrosion of metals in contact with silage, processing methods, methods to control the level of hydrolysis, etc.

Today there are five companies that produce silage on a commercial basis in Iceland, one from viscera and bycatches on board two trawlers, two from fish offal, and two that produce silage from capelin. The total production of fish silage during the last two years was about 10,000 tons each year (Arason et al. 1984; Arneson et al. 1981; Dagbjartsson et al. 1976).

Today the main effort is to find new users for silage and/or silage concentrate and to make it economical for factory trawlers to use their offal for silage instead of discarding it.

RAW MATERIALS

The available raw material for silage production in Iceland can be divided into three categories.

1. Viscera and bycatches.
2. Filleting operations.
3. Pelagic fish.

Today most of this is used for fish meal production. Yearly some 100,000 tons of offal and bycatches are discarded that could have an export value of about eight million U.S. dollars if all of it where used for producing animal feeds. For silage production, raw material freshness is of as great importance as for the production of other animal feeds from fish.

PRODUCTION METHODS

Producing silage is simple. The fish material is finely comminuted and mixed with formic acid 2%–3% (w/w) depending on the material.

The types of equipment for producing silage differ, however, from one raw material to another:

1. When producing silage from viscera, one can use high-speed, low-quantity mincers and keep the silage moving with a circulation pump or other inexpensive equipment. The pump can be any acid-proof, low-speed, positive-displacement pump.
2. When producing silage from filleting waste, the machinery must be more rigid, and the mincer has to be a low speed type that can handle fish skin and bones and will not break down even if foreign objects get into it. The pumps also must be very rigid. We have found that piston pumps or force-
When producing silage from industrial fish such as capelin the mincer can be high-speed, and usually must have a high output to be able to handle large quantities of fish in a short time. The silage must be mixed by screws in the tanks.

The fish is ground and acid added to reduce the pH to around 4.0. The bacteriological activity is thereby stopped, but the fish enzymes will break down the protein chains so that the fish takes on a liquid consistency. At a certain stage the enzymatic action is stopped by short-term heating, e.g. 80°C for 10 minutes. To avoid oxidation of the fat, an anti-oxidant is added.

**PROCESSING**

Seven years ago silage production from viscera and bycatches on board a stern trawler was started (Figure 1). A semiautomatic processing unit was used on the vessel, consisting of a buffer tank with level control, grinder, automatic acid unit, and storage tank with a circulation pump. This type of production line is used both on board a trawler and on shore (Arason and Harðarson 1982a and 1982b; Jónatansson 1983). A similar silage production line has been installed in another stern trawler of the same company as the first. The system has worked well. All fish viscera and scrap fish have been collected aboard the trawlers with good results. It appears that the system can handle quantities amounting to 20%–25% of the total catch, and this involves very little extra work by the crew (Arason and Harðarson 1982a).

The annual catch for these trawlers is 3,000–4,000 tons, so one trawler can produce 750–1,000 tons of silage per year. When the vessel comes to harbor, the silage is pumped to tanks in a fish meal factory. After the fish oil is removed, the silage is concentrated in a stickwater evaporator and concentrated to about 50% dry matter prior to mixing with other raw material for fish meal production. This process is shown schematically in Figure 2 (Arason et al. 1984).

The silage is sold to the fish meal factory for the same price as capelin. The yearly value of the catch is increased by 3.2% by the silage production. The process aboard a factory trawler, however, is more complicated due to more fish frames, heads, etc. A schematic
Various experiments have been done to make direct use of the silage concentrate instead of processing it into fish meal along with conventional raw material. The concentrate contains about 60% dry matter and has a syrupy consistency (Arason et al. 1984).

The silage concentrate has been used as an additive in grass pellets for feeding ruminants. The pellets contained 15%–20% silage concentrate, which increases the protein content of the pellets and acts as a binding
agent (Arason and Guðmundsson 1984; Arason et al. 1984).

In Iceland, some 2,000 tons of semi-moist fish feeds containing 45% unconcentrated silage have been produced using formic acid. The silage is made from whole fish and is subsequently mixed with grains to form semi-moist pellets (Arason and Guðmundsson 1984).

The corrosive effects of silage were studied with respect to acid type, concentration, temperature, and fat content. The results indicate that low-fat silage is more corrosive than silage with about 10% fat content. Silage can be stored in ordinary steel tanks if the temperature does not exceed 20°C. Above 20°C the silage must be stored in tanks made of stainless steel or plastic (Figure 4)(Arason et al. 1984).

Considerable work has also been carried out to evaluate the main physical properties of fish silage, i.e., the viscosity, heat convection coefficients, and the rate of autolysis (Figure 4)(Arason et al. 1984).

NUTRITION

Composition of the silage depends on the type of raw material used. In Table 1 we can see a typical composition of the main silage products.

It is possible to standardize the fat and protein content during processing. The fat and water content can be changed by separation and evaporation. The hydrolysis can be stopped any time, and we can thereby influence the types of proteins in the product.

Hydrolyzed silage with short peptides has mainly been used in feeds for fish, mink, fox, chicken, and pigs, and silage with less broken down proteins has been fed to ruminants (Guðmundsson et al. 1979).

The silage is pasteurized when the desired degree of hydrolysis is attained, measured by viscosity. The silage can be stored again for later use or processing.

Many different kinds of acids have been tried for making silage. The most popular one is formic acid, which is organic and penetrates well into cells. In low
Figure 4. Corrosion of containers for viscera silage.
Table 1. Proximate analyses of different silage types.

<table>
<thead>
<tr>
<th></th>
<th>Dry matter</th>
<th>Protein</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silage—Icefish trawler</td>
<td>14.6</td>
<td>12.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Silage—Factory trawler</td>
<td>18.0</td>
<td>14.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Whole capelin</td>
<td>15.0</td>
<td>13.0</td>
<td>15.0</td>
</tr>
<tr>
<td>De-oiled viscera silage</td>
<td>18.0</td>
<td>15.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Concentrated silage</td>
<td>47.5</td>
<td>40.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

concentrations formic acid has no harmful effects on animals. A blend of acetic acid and sulfuric acid, as well as blends of propionic acid and formic acid, also have been tried in Iceland. The latter mixture is more economical than formic acid alone but has the limitation that it cannot be used for salmon feed. Today full-strength formic acid is the most popular for making silage 2%–3% (w/w). The cost of the acid is about 25% of the sales price of the silage. It is possible to reclaim up to 50% of the acids when concentrating the silage, and this is a way to lower the acid cost.

MARKETING

Fish silage has not been an easy commodity to sell for some of the reasons listed below.

1. Silage is competing with known and well-established products like fish meal, soya meal, and other products.
2. It is not a known product.
3. Feed producers are generally not equipped to handle the liquid material.
4. Customers are not willing even to try silage or silage concentrate unless they have guarantees of constant deliveries and a stable product.

There has been a steady market for silage from whole capelin for many years, particularly in Denmark which annually uses about 60,000 tons, of which Iceland has supplied 3,000–5,000 tons per year. This silage has mainly been used for feeding pigs, chicken, and fur animals.

In Iceland there have been several outlets for silage over the years: as an additive into grass meal pellets, and as a feed for salmon, fur animals, pigs, and sheep. It also has been used as an additive in fish meal production for some special meals.

The fur industry in Scandinavia has shown some interest in the product, but so far the actual sales have been limited. The feed industry in Norway increasingly has been using silage concentrates as a component of semi-moist pellets for salmon and fur animals.

ECONOMICS

In our opinion the method can be used economically in the following situations:

1. Where small quantities of fish offals do not justify investment in a fish meal plant or small-scale transportation. We consider silage production more profitable than fish meal plants for places with less than about 5,000 tons per year of fish waste.
2. Conventional trawlers. Silage production is a very cheap way to increase profits if tanks are already on board that can be used to hold the silage. If tanks have to be built specifically for the silage, the profitability becomes almost nil.
3. Factory trawlers. Both fish meal and silage production are marginal. Silage production costs less in investments but the fish meal is a well-known product and in big demand.

CONCLUSION

Our work on fish silage in Iceland mainly has been concerned with the technology and economics of making silages out of fish offals that otherwise would have been discarded. Apparently simple operations, such as mincing fish offals, adding acids, and ensuring thorough mixing, are not so simple after all. Our trials with marketing fish silage or fish silage concentrates as a special commodity to the feed market show that we need more experience in handling silages on a routine basis and we should introduce detailed product specifications.

To gain this experience we are now attempting to process more fish waste as silage, and to use it as an additive in fish meal production. While doing this we will continue to specify the silage concentrates as feed
components and continue our efforts to make this product a commercial one in its own right.

REFERENCES


QUESTIONS AND ANSWERS

Q. You indicated that capelin silage is exported from Iceland to Denmark.

A. (Dr. Valdimarsson) Yes. It’s not concentrated. It’s simply minced, mixed with acid, and shipped directly. In fact, Denmark is the only large-scale user of fish silage. They use about 60,000 tons a year.

Q. What quality control parameters do you have on the solids? I presume it’s sold from one organization or company to another, and the variation in quality could be quite large.

A. (Dr. Valdimarsson) We have been measuring total volatile nitrogen, pH, trimethylamine, and the viscosity of the silage. It has been increasingly common to stop the hydrolysis by heating, and the viscosity has been used as a parameter.
CREAMY FISH PROTEIN

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ABSTRACT

Although fish such as pollock, pink salmon, and menhaden are valuable resources obtained in large quantities, effective food engineering processes for these fish on a large scale at a reasonable cost are not available yet. At this time only pollock surimi is used for boiled fish paste. Furthermore, in order to maximize gelling, most of the soluble proteins, minerals, fish oils, etc. have to be removed. Thus, surimi has a low yield, on the order of 20%, and requires large amounts of salt, sugar, or phosphates to be added to prevent a decrease in gelling.

Recently we reported on a newly developed method of treating whole fish meat, including the bones, with enzymes, thus retaining the effective contents of the original fish in an emulsified protein mixture. We have investigated the functional characteristics of the enzyme-treated fish meat mixture as food material. In addition, we are developing new processing methods that will overcome decreased gelling due to enzymatic treatment, and we are elucidating methods that process foods in emulsified, solid, or gelled forms. Finally, we are clarifying application of this technology to fish heretofore unrecognized as useful, and to specific parts of ordinary fish and shellfish for their processing.

Pollock, pink salmon, and snow crab are skinned, eviscerated, finely ground, and treated with protease enzymes to form an emulsified protein mixture (creamy fish protein, CFP) mainly consisting of peptides of 40,000–70,000 molecular weight. CFP does not coagulate upon heating. The enzyme-treated proteins retain the amino acid profiles and mineral content of the processed fish, and do not contain preservatives or additives. By blending with vegetable proteins, eggs, and edible oils, CFP can effectively create digestible, smooth-textured food preparations which have a potentially large application as new food material.

INTRODUCTION

I am reporting here on the manufacturing and uses of a new food product produced from marine protein by enzyme processes. The fish protein produced by this enzyme process is a completely new, creamy-textured fish product. We call it creamy fish protein (CFP).

Creamy fish protein uses the fish in its natural state, without loss of any components of the fish. Its outstanding nutritional value and unique properties make it well suited to a wide range of uses, such as processed food, pet food, and feed applications. Also, the manufacture of creamy fish protein is an extremely efficient use of marine resources.

This report contains the background of creamy fish protein and a basic description of research on the enzyme process. The CFP production method is discussed, as well as the characteristics and applications, markets, and future uses for CFP.

SCOPE OF TECHNOLOGY

Marine products are used as food, and also as feed and fertilizer components, but a large portion is also discarded as waste. Our research is directed at developing new manufacturing technologies to make more efficient use of these resources, especially by the use of enzymes. Enzyme process technology can be applied both to edible and nonedible uses, and can enable the use of all material components.

This report is about the creamy fish paste used for edible food products. However, there is also an application in the feed and fertilizer field, which we call bioflour. This is a new, high-quality fish meal with high nutritional value.

Pollock, pink salmon, menhaden, and sardines are valuable food resources that are harvested in great quantities. There has been considerable research aimed at making the most efficient use of these fish in such products as FPC (fish protein concentrate) and marine beef (sardine powder produced by an ethyl alcohol extraction process). Unfortunately, these have not yet
Table 1. Nutritional information for creamy fish protein and meat for three species (per 100g).

<table>
<thead>
<tr>
<th></th>
<th>Red salmon</th>
<th></th>
<th>Pollock</th>
<th></th>
<th>Snow crab</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meat</td>
<td>CFP</td>
<td>Meat</td>
<td>CFP</td>
<td>Meat</td>
<td>CFP</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>18.7</td>
<td>16.9</td>
<td>15.7</td>
<td>14.1</td>
<td>14.8</td>
<td>8.7</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>11.2</td>
<td>10.8</td>
<td>0.7</td>
<td>0.2</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>0.7</td>
<td>1.4</td>
<td>0.9</td>
<td>1.7</td>
<td>1.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Calories (kcal)</td>
<td>184.7</td>
<td>173.3</td>
<td>72.9</td>
<td>61.4</td>
<td>68</td>
<td>46</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>14</td>
<td>183</td>
<td>42</td>
<td>158.9</td>
<td>90</td>
<td>18,500</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>0.5</td>
<td>1.2</td>
<td>0.6</td>
<td>1.0</td>
<td>0.5</td>
<td>4.05</td>
</tr>
</tbody>
</table>

CFS MANUFACTURING

As a result of detailed research, we were able to develop creamy fish protein as a new, paste-type material which does not require thermal hardening. For the CFS manufacturing process, raw materials may be any type of fish, including shellfish or a wide variety of marine resources.

After removing viscera, skin, and fins, wash lightly. Bones and shells are rich in important nutritional minerals such as calcium, iron, and also chitin and chitosan, and may be used as ingredients. If bones and shells are not used, they are removed. After this process, the materials are ground to a size of 100 microns or smaller. Next, protease is added and allowed to work under moderate, carefully controlled conditions. Then the product is briefly heated to deactivate the enzyme. The protein has now been broken down to the point that it will not coagulate when heated, so it is possible to thermally sterilize the product to provide longer life. This produces a creamy-textured fish protein. CFS needs no preservatives, and when refrigerated or dried will remain stable for a long time.

Pollock meat primarily consists of large-molecule protein with molecular weight above 100,000. In CFS, however, the large molecule protein appears to be broken down by hydrolysis into peptide molecules with molecular weights of around 40,000 and 20,000.

For food products for which creamy consistency is well suited, CFS may be made from any type of fish or shellfish. Fish and shellfish that have been tested and used as CFS include pollock, cod, salmon, trout, capelin, hake, herring, sardines, whiting, tuna, eel, crab, shrimp, lobster, and scallops. CFS has a moderate fish taste like the original fish, and often it is a desirable flavor. Fish taste of CFS can be reduced by using
treated fish meat, if necessary. We can also obtain odorless CFP using treated white flesh such as pollock meat.

**NUTRITIONAL PROPERTIES OF CFP**

Pollock, red salmon, and snow crab CFP are generally lower in fats and protein and higher in minerals such as calcium and iron than fish meat CFP, because CFP contains both soluble fractions and bones (Table 1).

The amino acid patterns are unaffected by enzyme activity. Both pollock and red salmon have an exceptionally good amino acid balance. The higher concentrations of lysine and threonine in CFP may compensate for the lower levels of these amino acids in vegetable protein, providing greatly improved nutrition.

To further study the nutritional characteristics of CFP, we did a growth test using rats. As protein sources, our feed with CFP made from pollock showed better growth than standard feed, and feeds with soy protein and egg protein (Figure 1). In this test, we performed a partial hepatectomy on the tenth day of the study. This was to observe the recovery of the rats after the operation, and also to study the regeneration of the liver. The results show that CFP provided the best weight gain after the operation, suggesting that it may be an excellent nutritional source for convalescents. A partial hepatectomy by Higgins and Anderson (1931) involved removal of two-thirds of the rat liver. They reported 75% of the original liver weight had been reached after one week, and normal liver weight was reached after two to three weeks.

Our research shows that CFP made from pollock provides the best results in terms of liver weight at three and five days after hepatectomy (Figure 2). This
Figure 3. Salmon body weights, fed different diets.

demonstrates that CFP is an excellent nutritional source, with the necessary nutritional components in good balance, for liver regeneration. However, our rat experiment did not show any difference between normal pollock meat and pollock CFP. Possibly this is because the absorption rate of digested fish protein is fairly high, so that no difference appeared between enzyme-treated protein and untreated protein.

To test the absorption rate of enzyme-treated protein, we did a growth test on young fish with undeveloped digestive organs. One-week-old salmon were fed with standard feed and with sardine CFP. The CFP-fed fish were 27% larger after 40 days, and 80% larger after 80 days than those on the standard feed (Figure 3). Salmon, trout, eels, red sea bream, and other fish showed the same excellent results. This confirms that CFP has excellent digestive absorption, because it is enzyme-processed protein.

The high nutrition level of CFP appeared again in a high blood pressure control experiment. When a 5% CFP powder supplement was added to the diets of rats with naturally high blood pressure (SHR rats), the blood pressure of all CFP rats decreased greatly over 15 days, whether on pollock, salmon, sardine, crab, or shrimp CFP. After 15 days, the CFP was removed, and the rats returned to standard feed. The blood pressure of all test groups increased. These results show that CFP is effective in controlling increases in blood pressure.

The effectiveness of peptides derived by enzyme action from fish protein in controlling high blood pressure has recently been reported, and the effectiveness of CFP is thought to be due to its peptide component. We suppose that calcium absorption is also enhanced because the calcium in CFP is in very small grains and dispersed with the peptides in the form of an emulsion. Calcium is also known to be effective in controlling high blood pressure, so the remarkable effect of CFP in blood pressure control is probably caused by the combined effect of peptides and calcium.

Calcium is important not only for bone formation, but also for controlling arteriosclerosis, heart disease, and psychological stability. It is also a nutrient in which many Japanese are deficient. The potential for calcium supplements from fish and shellfish in the form of CFP is a significant development which has attracted considerable notice. Because of nutrient content, CFP-containing foods are recommended and are used in Japanese school lunch systems.

APPLICATIONS OF CFP TO FOOD PRODUCTS

As a food base, quick-frozen CFP has no character change after thawing, and there is also no large character change with repeated freezing and thawing. In the
Table 2. Comparison between creamy fish protein and surimi.

<table>
<thead>
<tr>
<th></th>
<th>CFP</th>
<th>Surimi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material requirement</td>
<td>Fresh, frozen, or steamed</td>
<td>Fresh</td>
</tr>
<tr>
<td>Oil in raw material</td>
<td>Adjustable</td>
<td>Removed</td>
</tr>
<tr>
<td>Minerals</td>
<td>Unchanged</td>
<td>Almost lost</td>
</tr>
<tr>
<td>Additives</td>
<td>None</td>
<td>Saccharides and sodium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>polyphosphate</td>
</tr>
<tr>
<td>Taste</td>
<td>Moderate taste</td>
<td>Almost none</td>
</tr>
<tr>
<td>Frozen stability</td>
<td>Better than surimi</td>
<td>-</td>
</tr>
<tr>
<td>Refrozen</td>
<td>Possible</td>
<td>Impossible</td>
</tr>
<tr>
<td>Bacteria count (per gram)</td>
<td>Less than $10^3$</td>
<td>Less than $10^6$</td>
</tr>
<tr>
<td>Compatibility with other food</td>
<td>Very good</td>
<td>Limited</td>
</tr>
<tr>
<td>Heat coagulation in fish protein</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Powder form</td>
<td>Possible</td>
<td>Impossible</td>
</tr>
</tbody>
</table>

In the case of slow freezing, small viscosity changes do occur; however, the original consistency returns by stirring. In surimi and ordinary fish meat, refreezing causes abrupt texture deterioration, so CFP appears to be an easier-to-handle food base.

As explained earlier, because CFP has become emulsified by the enzymatic hydrolysis of high-polymer proteins, protein coagulation through heating is minimal. Furthermore, combining CFP with vegetable oil yields minute grain sizes, and the dispersion is stable. Thus, applications to fluid or flowing food products are quite suitable.

Generally oils and fats in fish are high in polyunsaturated fatty acids; therefore they are prone to oxidation even when frozen. CFP, however, does not oxidize and deteriorate as readily as ordinary fish meat. The addition of vitamin C or vitamin E inhibits most oxidation (Figure 4).

In CFP, fats and oils are surrounded by protein layers in an emulsion which inhibits oxidation. Also, a deactivation process in making CFP contributes to a deactivation of oxidase in fish. Furthermore, such antioxidants as vitamin C and vitamin E become more effective because they are uniformly dispersed in CFP due to its emulsified character. Thus, CFP is a superior material for ingesting stable fatty acids such as EPAs (eicosapentaenoic acids) and DHAs (docosahexaenoic acids) in fish.

For forming solid foods, it is possible to prepare a material that retains its shape and has gel strength by combining CFP with a variety of food bases that promote gelling. In this way, you can alter gel strengths to prepare foods with completely new characteristics and textures.

CFP can be mixed with surimi to form many new types of products:

- Various sheet products can be made by using different kinds of CFP. The texture is softer, and closer to a seafood texture than if surimi is used also.
- By adding CFP made from real crabs, we can obtain a flavor and texture close to real crab meat as in crab kamaboko.
- Imitation scallop is made like a hamburger patty. We have high hopes for this seafood product as a healthy food source with lower saturated fat and cholesterol.
- Imitation smoked salmon is made by mixing smoked salmon CFP and pollock surimi. The product has a taste and texture close to real smoked salmon.
- A chip-type product is made to have a fiber-like texture that is totally different from surimi. We are looking at various ways of using it to produce meat-texture seafood, such as a meat-texture sausage. These are healthy foods with lower fat and cholesterol.

CFP is also mixed with food products such as starch, egg, dairy products, vegetable protein, oils, etc.:

- A fish tofu steak is made with a mixture of soy protein and CFP. This combination of vegetable protein and fish protein provides a desirable amino acid balance.
- We can make cheese-like products by mixing milk protein with CFP.
- We can make a custard with 10% pollock CFP, with almost no trace of fishy smells.
Other applications include CFP as an additive in many types of frozen products, a seafood cup soup with CFP, and CFP-added snacks that have been introduced in markets by a major consumer group in Japan.

Following is a summary of the nutritional features of CFP:

1. CFP retains the nutritional balance of fish and shellfish.
2. It is rich in digestible protein, and low in fat, especially no saturated fatty acids and cholesterol.
3. It needs no chemical preservatives or additives, and is an extremely nutritious seafood. CFP may be helpful in controlling high blood pressure.

Table 2 summarizes some comparisons between CFP and surimi. The CFP process is superior to the surimi process in several ways:

1. Product yields differ by type of fish, but in general CFP with bone yields 60% to 65%, and CFP without bone yields 30% to 35%. Both are much higher than the surimi process.
2. The CFP process is economical because it consumes less energy. For example, surimi products require 5 to 10 times the weight of water, but CFP uses one to two times the weight of water.
3. The process equipment required is not as expensive as for surimi.
4. Frozen stability is good, and the products can be refrozen after thawing. This greatly expands the products' use as a food material.

FUTURE USES FOR THESE PRODUCTS

CFP, when used in making bread, could help alleviate the worldwide food problem. CFP made of pollock and cod will work very well in bread because no fishy odor is detected even if 10% to 30% is replaced by CFP. CFP in dry powder form can be stored at room temperature and can be easily blended with flour in bread recipes.

Bread is low in lysine, an essential amino acid. About 30% pollock CFP paste (or 6% pollock CFP powder) doubles the nutritional value of bread. This fact is extremely important in our search for the solution to the world food supply problem occurring now and into the twenty-first century. I expect CFP to be a valuable contribution to the problem because of its unique features.

ACKNOWLEDGMENTS

I wish to express my appreciation to Dr. Keisuke Tsuji, of the Japanese National Institute of Health and Nutrition, for his dedicated research on the effect of CFP lowering blood pressure using the SHR rat.

REFERENCE


QUESTIONS AND ANSWERS

Q. I'm curious where CFP is being produced today?
A. Our first plant was built in western Japan in Tottori Prefecture. As much as 3,000 metric tons can be produced there.

Q. Usually when you apply hydrolysis on fish material you have bitterness, and you haven't mentioned any bitterness. How do you explain this problem? And I have the same question concerning fish taste. And my last question to you is, what is the dry matter content of paste form CFP?
A. Selection of an enzyme depends on the kind of fish, the particular CFP used as an ingredient, and how the final product is used. Peptides with a medium molecular weight should be the main component. Endo-peptidases are suitable, and we get better results with exo-peptidases.

CFP from refined pollock meat does not have fish taste; CFP from salmon, crab, etc., usually has moderate and desirable fish taste.

The powder product from paste is about 20% to 25%.

Q. Can you use fatty fish for producing creamy fish protein?
A. Yes, we can remove fats in the centrifuge, if necessary.

Q. What is the cost?
A. Material cost for CFP without bones is nearly 40% less than for surimi. If bones are used as well, the cost should further improve.

Q. I'm not a surimi man, but from what you say this industry has invested hundreds of millions of dollars into surimi production. And it sounds like your product is a better product. It can be made more cheaply, and has more uses. Did I miss something somewhere?
A. We suggest that under the same production scale, the cost is lower than surimi. But we have only a small plant in this state. Scale is very important I think. In the same conditions, same volume, the
CFP product is better than surimi.

CFP does not compete with surimi, but complements it because CFP can be produced from many kinds of marine resources not suitable for surimi production. Combinations of CFP and surimi can be very useful for new food applications.

Q. Do you find it necessary to have a very special size reduction process for the CFP with bones to avoid a gritty mouth feel from the bone? Does it have to be extremely finely divided? Does the product, the raw material, have to be ground very finely in order to avoid bone crunch?

A. Under 100 micron powders we can't detect it. We can obtain such a product by grinding and enzyme treatment in the CFP production process.

Q. How do you explain the very white color of your product? Usually hydrolysates of seafood produce a brown color. And I have been very surprised by the very white color.

A. CFP has a color from the fish. Refined pollock meat has no color; it is very white. But we usually use backbones, so CFP with bones has a slight color.
BIO-FISH FLOUR

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Yoichi Shirakawa and Yoshikazu Shoji
Asahi Denka Kogyo K.K.
Tokyo, Japan

ABSTRACT

The biotechnological fractionation method is a new process developed to maximize the value of fish components. The method consists of enzyme reactions and the separation of the mixture into components.

The conventional fish meal process involves cooking, pressing, and drying at high temperatures. In contrast, the biotechnological fractionation method is characterized by mild processing conditions; the temperature is kept under 75°C throughout processing. As an improved process for fish meal, a low temperature drying process has been developed.

In the low temperature process, a cooking method is used. In the biotechnological fractionation method, instead of cooking, an enzymatic reaction at low temperatures is applied. Bio-fish flour is a product of the biotechnological fractionation technology. Controlled enzyme reactions and mild processing conditions, along with strict quality control, assure high digestibility and excellent nutritional value of bio-fish flour.

The high protein digestibility and richness in essential fatty acids of bio-fish flour meet the requirements of animals and fish with immature digestive systems.

INTRODUCTION

We believe that the biotechnological fractionation method, which we have developed using enzyme technology to produce a high-quality fish flour, is well suited to this conference’s theme, the use of “one billion pounds of protein.” We believe this method will become a means of maximizing the hidden nutritional value of fish.

The enzyme process described in the “Creamy Fish Protein” paper by Y. Shoji, in this proceedings, is the same as that used to produce bio-fish flour. The application of the product is as a feed and fertilizer. This enzyme-processed marine product was developed to maximize the nutritional value.

SCOPE OF THE TECHNOLOGY

The biotechnological fractionation method is used to produce the following fish flour products:

- Bio-fish flour is the general name for fish flour made from fresh fish.
- Brown bio-fish flour is a trade mark for our new fish flour made from fresh sardines.
- White bio-fish flour is a trade mark for our new fish flour made from fresh pollock waste.
Figure 1. Products from biotechnological fractionation.

Table 1. Specifications for bio-fish flour.

<table>
<thead>
<tr>
<th></th>
<th>Brown bio-fish flour</th>
<th>Brown bio-fish flour (PM)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>65% min.</td>
<td>70% min.</td>
</tr>
<tr>
<td>Crude fat</td>
<td>12% max.</td>
<td>12% max.</td>
</tr>
<tr>
<td>Crude ash</td>
<td>16% max.</td>
<td>12% max.</td>
</tr>
<tr>
<td>Moisture</td>
<td>6–9%</td>
<td>6–9%</td>
</tr>
<tr>
<td>Pepsin digestibility</td>
<td>98% min.</td>
<td>98% min.</td>
</tr>
<tr>
<td>NaCl</td>
<td>3% max.</td>
<td>3% max.</td>
</tr>
<tr>
<td>Volatile basic nitrogen</td>
<td>0.15% max.</td>
<td>0.15% max.</td>
</tr>
<tr>
<td>Soluble N/Total N x 100</td>
<td>35% max.</td>
<td>–</td>
</tr>
<tr>
<td>Anti-oxidant (Ethoxyquin)</td>
<td>100–150 ppm</td>
<td>100–150 ppm</td>
</tr>
</tbody>
</table>

*High protein grade made by partially removing ash.
The biotechnological fractionation process uses a partial hydrolysis of fish protein with protease enzymes under controlled conditions. The entire process takes place at mild temperatures of less than 167°F (75°C). As a result, the nutritional value of all components of the fish are maximized in producing a new high-quality fish flour.

During the biotechnological fractionation process, the fish is separated into fish oil, soluble components, and fish meal with bone. Each of these components has high nutritional value and is refined and mixed for various application purposes. Bio-fish flour is produced by drying fish solubles and fish meat, and can be separated into bio-fish flour PM (high protein) grade and bone powder by sifting (Figure 1).

During the process for producing bio-fish flour from sardines, enzymes are added to fresh sardines and allowed to react at temperatures between 50° and 55°C for 30 minutes, after which the mixture is briefly heated to deactivate the enzyme. The components are separated into oil, emulsion, and cake in the centrifuge. The cake and emulsion are mixed and then dried at a maximum temperature of 75°C or 167°F (Figure 2).

The specifications for bio-fish flour are shown in Table 1. The high-protein PM grade is suitable for fish fry and milk replacement for piglets and calves.

A conventional process for manufacturing fish meal is shown in Figure 3. The biotechnological fractionation method is different from the conventional process in that an enzyme reaction is used in place of the
Table 2. Measurement of residual sulfhydryl group in model experiment and commercial samples.

<table>
<thead>
<tr>
<th></th>
<th>Free sulfhydryl (mM/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minced sardine samples</td>
<td></td>
</tr>
<tr>
<td>Freeze-dried</td>
<td>3.5</td>
</tr>
<tr>
<td>90–100°C x 2 h coagulated, then freeze-dried</td>
<td>0.45</td>
</tr>
<tr>
<td>90–100°C x 2 h coagulated, then dried 2 h at 100°C</td>
<td>0.22</td>
</tr>
<tr>
<td>Commercial samples</td>
<td></td>
</tr>
<tr>
<td>Bio-fish flour</td>
<td>0.97</td>
</tr>
<tr>
<td>Brown fish meal</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Table 3. Effect of extracted lipids on the growth of eel fry.

<table>
<thead>
<tr>
<th></th>
<th>Brown bio-fish flour</th>
<th>Brown fish meal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fry</td>
<td>70</td>
<td>71</td>
</tr>
<tr>
<td>Average weight</td>
<td>0.24 g</td>
<td>0.25 g</td>
</tr>
<tr>
<td><strong>After 31 days</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of fry</td>
<td>63</td>
<td>64</td>
</tr>
<tr>
<td>Average weight</td>
<td>0.83 g</td>
<td>0.68 g</td>
</tr>
</tbody>
</table>

Table 4. Vitamin and mineral content of brown bio-fish flour.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitamins</strong></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>Non-detectable</td>
</tr>
<tr>
<td>B2</td>
<td>1.06 mg/100 g</td>
</tr>
<tr>
<td>B6</td>
<td>0.52 mg/100 g</td>
</tr>
<tr>
<td>B12</td>
<td>37 μg/100 g</td>
</tr>
<tr>
<td>Choline</td>
<td>0.44%</td>
</tr>
<tr>
<td>Niacin</td>
<td>23.4 mg/100 g</td>
</tr>
<tr>
<td>Folic acid</td>
<td>16 μg/100 g</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>3.19 mg/100 g</td>
</tr>
<tr>
<td>Biotin</td>
<td>44.0 μg/100 g</td>
</tr>
<tr>
<td><strong>Minerals</strong></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2.65%</td>
</tr>
<tr>
<td>Iron</td>
<td>31.9 mg/100 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>3.65%</td>
</tr>
<tr>
<td>Sodium</td>
<td>776 mg/100 g</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.40%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>204 mg/100 g</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.47 ppm</td>
</tr>
<tr>
<td>Copper</td>
<td>0.57 mg/100 g</td>
</tr>
<tr>
<td>Zinc</td>
<td>14.2 mg/100 g</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.79 mg/100 g</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.01 μg/100 g</td>
</tr>
<tr>
<td>Total chrome</td>
<td>0.7 ppm</td>
</tr>
<tr>
<td>Aluminum</td>
<td>44 ppm</td>
</tr>
</tbody>
</table>

Source: Japan Food Research Laboratories

cooking stage, and the product is dried at a low temperature. By using this method, we try to avoid the loss of nutritious components and prevent deterioration of protein and oil through thermal chemical reactions, which was the major weakness in the traditional method of processing fish meal.

The protein in bio-fish flour shows evidence of better in vivo absorption, and it suffers less heat denaturation. Lipids in bio-fish flour are heat-stable omega-3 fatty acids. Bio-fish flour has a high vitamin content and has a growth-promoting effect.

The results of protein heat denaturation measured in residual amino acid sulfhydryl groups, in a model experiment and in commercial samples, are shown in Table 2. There is a correlation between sulfhydryl group reduction and drying temperature. The residual amounts of sulfhydryl groups in bio-fish flour are higher than in brown fish meal, demonstrating that bio-fish flour protein shows less denaturation during heating.

In bio-fish flour, extracted lipids have high iodine value, low peroxide value, and low acid value, which indicates that deterioration by oxidation is low. The extracted oil contains polyunsaturated fatty acids rich in omega-3 fatty acids such as eicosapentaenoic acid and docosahexaenoic acid, and has a high concentration of phospholipids. Cholesterol and phospholipids play important roles in the growth and development of shellfish and fish fry. The stability of brown bio-fish flour lipids over time shows that there is good stability in storage. We used an emulsion-type ethoxyquin as an anti-oxidant.

The effect of oil extracted from bio-fish flour and brown meal on the growth of eel fry shows approximately 35% better weight gain with brown bio-fish flour than brown meal (Table 3). In this experiment bio-fish flour lipids and brown fish meal lipids were extracted with ether, then the solvent was evaporated. One part lipids was added to 100 parts feed. Fat quality in brown bio-fish flour is higher because it is processed at lower temperatures than in traditional methods. The
Table 5. Results of digestibility test of brown bio-fish flour and white bio-fish flour on piglets using the Cr₂O₃ method.

<table>
<thead>
<tr>
<th></th>
<th>Digestibility</th>
<th>Nutritional value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude protein (%)</td>
<td>Crude fat (%)</td>
</tr>
<tr>
<td>Brown bio-fish flour</td>
<td>95.7</td>
<td>97.3</td>
</tr>
<tr>
<td>White bio-fish flour</td>
<td>95.1</td>
<td>100</td>
</tr>
<tr>
<td>White fish meal</td>
<td>91.0</td>
<td>91.0</td>
</tr>
<tr>
<td>Brown fish meal</td>
<td>87.0</td>
<td>78.0</td>
</tr>
</tbody>
</table>

Source: Japan Scientific Research Institute

¹Digestible crude protein.
²Total digestible nutrient.
³Digestible energy.

Improved growth rate of the eel fry verifies the higher quality of extracted lipids.

Table 4 shows that brown bio-fish flour is rich in essential vitamins including the vitamin B group. This is because lower temperatures control the loss of those vitamins. The mineral content of brown bio-fish flour is not different from ordinary fish meal (Table 4).

In a study of the effect of bio-fish flour on the growth of Lactobacillus, the addition of brown bio-fish flour shows a 3% increase in protein and a 30% increase in Lactobacillus over the levels produced with the standard diet. Bio-fish flour is 10 times more effective than the standard diet. This was more than expected and shows the existence of an "unknown growth factor."

We tested the digestibility of brown bio-fish flour and white bio-fish flour using piglets (Table 5). In this experiment 10 piglets weighing 33.4–40 kg were tested for 16 days. Both brown bio-fish flour and white bio-fish flour showed better protein and lipid absorption than conventional white fish meal or brown fish meal, indicating that digestible crude protein, total digestible nutrients, and digestible energy of bio-fish flour are higher.

We conclude that bio-fish flour contains oligopeptides with good absorption, good amino acid balance, omega-3 fatty acid-rich lipids, and highly absorbable minerals and vitamins. It is highly digestible, nutritious, and is an excellent feed material for piglets, chicks, juvenile fish, etc. The new fish meal produced by the biotechnological fractionation method has great practical value.

PRODUCTION

There are about 120 conventional fish meal plants in Japan, and their total capacity is 38,000 tons per day. Our bio-fish flour plant is located on the Pacific coast of Japan in the Kashima area near Tokyo. It has a production capacity of 150 tons per day, and has been operating since January 1987. Sardines are the raw material, caught in fishing grounds within 50 km, or 31 miles, of the coast. The raw material has a TVN (total volatile nitrogen) of 10% to 20%, and is stored between 5° and 10°C, or 41° to 50°F. In other words, we are careful to use fresh sardines as raw material.

Our creamy fish protein plant for food application is located in southwestern Japan in Tottori Prefecture. At present, our creamy fish protein and bio-fish flour plants are in separate locations, but we are planning to construct a joint creamy fish protein and bio-fish flour plant so we can utilize the resources better. We are now researching the best location, not only in Japan, but also overseas.

APPLICATION

The Japanese domestic market for bio-fish flour for fish feed includes sweetfish, rainbow trout, eels, sea bream, and yellowtail. It is sold as a milk replacement for piglets and calves, and it is also used as a growth factor for fermentation.

The high digestibility of brown bio-fish flour makes it well suited to animals with underdeveloped or weak digestive systems, such as fish fry, juvenile fish, piglets, or calves, and it can be used with better results than regular fish meal. Brown bio-fish flour is also suitable for chicks which require highly digestible protein.

The concept of "bio-fish flour" is well suited to the efficient use of Alaska's underutilized protein resources. It is one means of utilizing the many fish species, a blessing of nature we receive from the ocean.
THE AQUATIC LEATHER INDUSTRY: OPPORTUNITIES FOR SMALL MANUFACTURERS IN ALASKA

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Juneau, Alaska

In the subsistence economic system of Alaska, there is no classification for waste. Every group of coastal people has a use for fish skins. Food is the primary use, and secondary uses include clothing, household goods, and harvesting equipment. Since the cash-demand market system has spread in Alaska, the secondary uses of skin have been disappearing gradually. As the market system responds to consumer demand for boneless and skinless products, millions of skins are being wasted. Three years ago the cash-demand market system began to identify a new and growing demand for Alaskan aquatic leather. In response to the demand, two Alaskan companies collaborated to place the wasted skin by-product of the canned salmon industry back into the flow of commerce. Aquatic leather is a new industrial material with commercial application and consumer appeal that will support a statewide manufacturing industry. Alas-Skins, Inc., an aquatic leather tannery, and Alaskans Leather Product Manufacturing Co., Inc., an aquatic leather sewing factory, both located in Juneau, are the pioneers of that industry. Together they produce “Alaskins” products.

Subsistence technology, access to resource, applied science, accurate market analysis, and a supportive retail sector have been combined to make Alaska an international aquatic leather industry leader in 1990. The leadership is founded and sustained by the tourist industry. In 1985 the Alaska Association of Manufacturers estimated that only 5% of shelf space in Alaska’s gift shops held products made in Alaska. The marketing strategy that has driven Alas-Skins leather is focused on the remaining 95%. Wholesale manufacturing of finished goods bought by Alaska gift shops has sustained a doubling of gross sales of aquatic leather goods for three successive years. The domestic markets for aquatic leather will continue to sustain industry growth into the foreseeable future. The limits to industry growth will be defined by product development and production capacity over the next five years, rather than by access to resources or limits in the domestic market.

To a large extent, the aquatic leather industry is developing outside of the focus of state and federal economic planning. The public sector economic model is based on a history of resource extraction and external demand for raw material. State tourism promotion is designed to increase service sector jobs, while export of value-added products is a secondary effect of foreign trade.

The Alaskins model views tourism as the market element for in-state, value-added manufacturing. To the aquatic leather industry, the primary motivation for international trade is technology transfer and a market for excess factory capacity. The difference in focus has effectively made the Alaska aquatic leather industry irrelevant to the public planning process at this time, and has restricted access to in-state public and private capital sources. Production financing will remain the primary expansion mechanism for the aquatic leather industry until the public economic planning process gains experience and understanding of the role of manufacturing in a fully diversified economy.

Wasted fish skin is available on every continent in quantities to sustain a fully developed aquatic leather industry. The Alaskins model is a fully integrated factory replication plan that can be applied profitably in a wide variety of business environments. The plan was developed in response to business inquiries generated by national and international publicity of our industry. In the current period of political and economic realignment, there is a great demand for small-scale, owner-operated and production-financed manufacturing models. The demand seems to be greatest for turnkey factories using simple, low-energy methods to make consumer goods from local fish species sold in tested markets.

Environmental and social considerations enhance the marketability of a model for any location. Because

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the Alaskins model was developed on green principles and practices, it shows more promise of easy integration into a wider variety of economic systems and management structures than other models. Corporate planning and development strategies of growth by replication appear at this time to be equally applicable to domestic and foreign markets for industrial material, finished goods, or technology transfer. But the Alaskins model remains untested. The first domestic replication will be completed this year, and the first foreign application of the model will probably be completed in 1991.

Alas-Skins leather was the first integrated aquatic leather tannery and product manufacturer to enter the marketplace. Eel leather, developed in Hawai'i, opened the market and established a worldwide reputation by Korean manufacturers. The eel success prompted other Korean firms to tan and manufacture salmon leather from Alaska cannery waste. Canada developed a salmon leather tannery that failed to attract product manufacturers until a joint venture was entered with manufacturers in Thailand. In 1989 an Australian firm initiated a venture to tan several species in Nova Scotia. Numerous other countries are now involved in aquatic leather research and development. In 1989 Alaska lost development momentum through failure to fund and build a leather science laboratory in Juneau. The opportunity loss has been more than compensated by aggressive public relations efforts that stress the environmental soundness of replacing "exotic" leathers of endangered reptiles with a salmon look-alike that would otherwise be a polluting cannery waste. Made in Alaska USA adds a valuable media and market dimension that elevates our label over similar and even superior foreign-made goods.

It is an unfortunate business reality that specific information on tanning formulas and production techniques are proprietary information that cannot be made public. Each species has associated development costs that exceed $50,000, and when products are developed, they represent a corporate asset of $100,000. Development of formulas under contract to parties with access to wasted skins of foreign species is a maturing profit opportunity that will spread the use of aquatic leather beyond Alaska. To our knowledge, Alas-Skins, Inc. is the only tanner offering that service. It is our intent to spread the use of "aquatics" as rapidly as possible and to profit both ourselves and Alaska's fisheries.

QUESTIONS AND ANSWERS

Q. Have you tried shark and dogfish?
A. We can tan the leather, but we can't get the material. We have to do it in about 60 pound lots, and we've got our hands full. We'd like to try it, but every time we bring in a new species, it costs about $50,000 to perfect it, to turn it into leather we can sew and make products out of. Unless we already know it's sellable, and that we can make things out of it ourselves, we can't afford to take on new species. We'd like to do be able to work with every species in Alaska, just in case the industry for that particular kind of fish says, "We don't want the skins anymore."

Q. Does the way the salmon is skinned affect the quality?
A. It does. It affects our consistency. Some canneries skin them and leave a quarter inch of meat, because that's what the particular client wanted. Others just want to get the skin out of the way, and they use a machine that catches it at the tail and rips it off. Those are real good. The weight we're getting is 4 to 12 hides per pound. The ones that have no meat on the back we have to treat a little differently, because some are too thin. With those we have a problem we call window shading. It means that when you're done, you hold it up to the light and you could read a paper through it. We have to throw those out.

There's no consistency in the product coming from the canneries. Because we have to take what they've got, we have to be able to sort and use all of it that we can. If we get hides with holes and nicks, that have been treated badly, we don't get full use. We use a lot more skins to make the same amount of products. Fortunately the end products go in at a price that's comparable to snake and lizards. We could not compete with cowhide.

Q. What kind of skinner is best to use?
A. We don't use a Skinner. We buy skins in 50 to 100 pound wet lock boxes from the canneries. They skin all of them. Right now we have to take what they've got. We hope at some point to skin them ourselves and offset some of the cannery costs of skinning. Sometimes we buy the skin for more than what they're getting for the meat.

Also, a lot of water comes in the package. We'd like to get a closer handle on that. As we get bigger and the market improves, we hope to get much more consistent hides and get a lot more use out of the hides. We may identify what kind of machine skins them best and gives us the best product. But as a wasted by-product, we really don't have much control.

Q. Do you make other products besides wallets?
A. Yes. That's product development. We have briefcases. We started using the wasted by-prod-
ucts of the herdsmen up north, combining arctic reindeer with fish skins. It looks like a very successful product line. And we do have halibut. There's nothing in the world to say you can't make skirts and leather jackets, and leathers for motorcyclists. Boots are going to be the next big hot one.

We can make salmon leather inlays from three different colors of salmon. Natural colors are black, white, cream color, and gray. And we dye the salmon. We can combine salmon and reindeer, because they're more expensive than any other kinds of skins. The more you can combine aquatic hides with other kinds of mammal leather, and still get the bang for being an exotic salmon leather product, the better you are in the market.

Footwear, boots, are going to make us rich. I'm convinced of it. We've had a lot of calls for boots, and we don't produce boots because that's a different game. That requires a cobbler, and that's a trade and a craft. Boot makers are not easy to find, especially to bring up to Alaska to make things out of salmon leather. We've not had a great deal of success in that, although we have over 300 standing orders for boots at $300 a pair. We hope to attract a boot manufacturer once we have enough standing orders.