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Fabricated Seafood Products

The Potential for Minced Fish

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THE PAST 10 years have been a time of change for the fishing industry. During this period, the governments of many nations extended their jurisdiction over fishing territories from 12 miles to 200 miles. Many of the nations that had been fishing these outer coastal waters now found themselves unable to do so. At the same time, the countries with large coastlines like the U.S. now had much more area to exploit.

During this same period, the realization that the resources of the ocean were not unlimited also began to settle in. It is estimated that we currently harvest about 60% of the available resource. Thus, if food production from the sea is to be increased, we must make better use of the resource already harvested, and we must use that part which is currently unharvested. In many cases, this unharvested resource is made up of fishes that are less desirable commercially than those fishes which are currently being harvested.

In the United States, the attitude toward fish and fishery products has probably improved during these past 10 years, but this increased interest does not seem to be reflected in the consumption of fish, when aggregate figures are considered. This dicotomy may be explained by two factors. First, some of the most popular products derived from fish are among the most caloric forms of fish, i.e., they often contain large amounts of breading and/or batter. These products do not appeal to the modern consumers who are diet/weight/nutrition conscious. Second, the cooking, handling and eating of fish is not as convenient as other flesh foods. Some people object to bones, others have problems with the quality of the fresh fish available in the United States, and most people don't know how to cook fish properly—they generally overcook it. Also, because of the lower fat content of fish (often less than 1%), the satiety value of fish is not as high as that of most other flesh foods. However, in recent years, fish oil has become a more desirable commodity as we learn more about its potential benefits in the human diet with respect to heart disease, cancer, and other diseases. Thus, some of the higher fat fish may become more desirable.

Let us also note a few other trends in the flesh foods area. The rapid growth of the poultry industry and the development of new flesh food-based convenience foods (e.g., nuggets) suggest additional opportunities exist for all of the meat industries, but the resulting products must be price-competitive and meet consumers' needs. Another trend has been the move away from fattier red meats. With this move away from grain-fed beef has come an increase in the consumption of comminuted (hamburger-style) meat. As the quality of the red meat from the point of view of texture/tenderness decreases, the use of mechanical tenderization (e.g., comminuting, reforming) increases.

Do all of these changes offer any opportunities for the fish industry? I believe that they do and that one of the routes the industry may take is to increase the production of fish mince. Fish mince can be used as the starting material for surimi and the whole collection of products that are then formed from the ingredient surimi. I think that this may not be the best route for most of the fishing/food industry to pursue in the development of our fishing resources. Instead, it may be better to use minced fish directly or with minimal processing.

Sources of Raw Material

There are essentially three sources of raw material for mincing.

The Underutilized Species. These species are not being fished in sufficient quantities with respect to what the biologists say is available because there is usually not sufficient incentive for fishermen to catch these fish. Though these species have often been thought of as the major source of minced fish, the cost of a directed fishery for these fish may be almost as high as for the currently caught species. Often these fish are caught along with more desirable species (e.g., the shrimp by-catch) and would take up valuable on-board space. I have sometimes defined an underutilized species as one that is catchable only when something more valuable is also around. The fisherman may be willing to bring some in for a reasonable price but it is difficult for a processing plant to plan a business around such a variable catch.

Another problem we discovered when we first dealt with underutilized species is that they may be there and unfishable for other reasons. For example, white sucker or freshwater mullet is easy to catch in the Great Lakes in the summer when they school. Unfortunately, they do this close to shore. Lakeside residents are known to shoot at commercial fishing boats that come too close to shore and interfere with the sports fish.

Thus, to be successful with underutilized species, both the fishery and the processing facilities must be developed at about the same time and properly integrated—a difficult assignment.

Industrial Fish. Those fish that are being used for making fish meal and fish oil may represent about 25%

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or more of the fish catch worldwide. A number of difficulties must be overcome before these fish can be used directly for human consumption. First, they are often caught in large quantities. Thus, various forms of mechanical harvesting (e.g., pumping) and minimal on-board handling are used. Some of these handling and storage methods make the fish unsuitable for direct human use. Second these are often smaller fish so that further processing, especially viscera removal, is difficult and/or costly. Third, the high oil content of these species makes them relatively difficult to handle and store, but this same property may someday be an asset. Again, in the future we may see this resource developed.

Food Grade Waste Materials. In some cases, fish may be too big or too small to process normally, or if the fish has had some mechanical damage, they may be a candidate for alternate forms of processing. Also, when fillets are prepared, pieces of prime quality fish flesh remain with the bone rack. These racks are available for further processing, specifically mincing. The material obtained after processing is similar in composition to a regular fish fillet.

The biggest available source of wasted fish flesh material is currently receiving a minimum of recovery effort: filleting waste. The flesh that adheres to the bones during filleting and is not subsequently recovered for anything better than fish meal or mink food may represent 10–20% of the weight of the original fish. The head also contains an additional 10–15% fish flesh.

Deboning Fish

A number of different pieces of equipment are available for separating meat from the bone so that processors can take advantage of these waste materials. Because fish are relatively soft, a simpler piece of equipment can usually be used than that which is used with red meats or poultry. A schematic of the most common type of fish deboner is shown in Fig. 1. The fish is pressed between the belt and the drum. The flesh, fat, and blood are squeezed through the drum holes. The amount of pressure being applied is fairly low so the size of the holes can be larger than those used for red meat deboning. Commercially, hole sizes of 3 or 5 mm are generally used as compared to 0.5 to 2 mm for poultry and red meat. Thus, the material obtained from the deboner has much more texture than the meat obtained from the higher pressure machines.

I have previously suggested (Regenstein, 1981) that the fish processor desiring a very high quality product might actually back off a bit from the maximum "practical" yield on the deboner to get a slightly higher quality product. The processor could then take the "waste" stream from this step and run it through a higher pressure poultry/red meat machine for the greatest yield. The two mince streams would be used differently.

An Icelandic company (Kwik) has demonstrated the feasibility of a machine for removing the fish meat from the head of a fish, or at least cod fish, but the commercial version of the equipment is not yet available in North America. The Canadians, or at least those in areas like Newfoundland, remove the cod toungues by hand or by machine and consider them a delicacy.

Norwegians have in recent years developed a floatation process for obtaining fish mince from whole small fish, particularly capelin. Further development of this technology may open up new opportunities for the direct human use of the industrial fishes.

Note that the above deboning equipment can be used, along with other types of equipment, to remove flesh from other marine animals (i.e., molluscs and crustaceans), but these uses will not be discussed further in this article.

Color

When deboning is completed, the finished product can vary in color, depending on what parts of the fish are processed. If trim waste is run through the deboner, such as the fillet trim pieces with pinbones, a very white material can be obtained. This material is commercially available and is used in many products, including fish sticks and portions, fish cakes, and seafood dishes where it is used as an extender.

If whole fish is run through the deboner, a more pinkish material is obtained since some of the blood from the backbone and kidney will become incorporated into the flesh.

If fish frames (the filleting waste without any head meat or viscera) are processed, an even darker-red-colored material is obtained since more blood is incorporated in proportion to the white flesh. More kidney tissue is also included as well as the main nerve tissue which runs dorsally along the backbone.

In the preceding discussion, we have assumed that the flesh of the fish being minced was essentially white. Clearly, if the fish is pigmented, then this color will carry through to the mince. In addition, some pigments from the skin may also become incorporated into the mince darkening it further. The fishing industry has demanded that fish products be white in color, and thus the darker forms of minces have not even been considered. The addition of blood and kidneys to the mince gives it a distinctly red color. However, if one looks at the total flesh food marketplace, the major comminuted meat is hamburger and it is very red. In fact the industry may be missing a tremendous opportunity by not thinking in terms of "Red is Beautiful."

As food scientists, we also need to be concerned with the nutritional status of those for whom we prepare the food. We need to look more closely at the total meat foods market, and in this context, the red color of frame minces also represents some increase in the iron content of the diet. Iron status is a major concern in the U.S. diet, particularly for females from puberty to menopause. Thus, the increase in blood tissue might be considered desirable. The absorptivity of fish heme and non-heme iron is clearly a topic that needs some further investigation.

Another possible beneficial effect of the blood tissue in fish mince is in the area of "meat-like" flavor. Blood tissue will affect the flavor, in addition to the color, of the final product; possibly in a direction that is favorable with respect to using fish meat as a red meat replacement.

Notice that I am proposing to use the fish meat as a total replacement for red meat, not as part of a mixture with other flesh foods. There is currently an effort being made to have fish meat approved for use in meat and poultry hot dogs at a 15% addition level. I believe

that this effort is misplaced in that it would give minced fish the same extender image that soybeans were labeled with in their earlier market development.

Stabilizing Fish Minces

Obviously fish mince must be prepared under sanitary conditions. The unfrozen material, like other comminuted meats, is susceptible to spoilage. It is generally frozen if it is not going to be used immediately. In some cases, polyphosphates and similar compounds are added to retain water, improve the texture, and retard off-flavor and rancidity development. As a comminuted product, fish mince contains a large amount of air.

The mince does not hold up as well in frozen storage as regular frozen fish because of the changes induced by mincing (e.g., tissue disruption). Of particular concern are the minces obtained from the commercially important gadoid fish (i.e., cod, haddock, hake, pollock, whiting, and cusk), where the compound trimethylamine oxide (TMAO) can be broken down, presumably by enzymatic action, to dimethylamine (DMA) and formaldehyde (FA). The latter compound is highly reactive and leads to a change in texture that is often referred to as "cottony" or "spongy." Essentially, the mince particles become crosslinked so that the water retained by the product causes the product to behave like a sponge—the water can be expelled and then reabsorbed. In eating, the moisture is all released on the first bite and the remaining dry sponge then has a "cottony" texture.

At this time, the best way to prevent this reaction from occurring is to store the fish at sufficiently cold temperatures (i.e., below −30°C) where the enzymatic activity is severely reduced. Unfortunately, the North American cold store system is not operated at this cold a temperature. Unpublished results from our lab offer two hopes. One, we have found that starch may have a beneficial effect in protecting texture. Also, if one stores mince long enough at very cold temperatures, it may subsequently be sufficiently "stable" to be able to survive the normal cold store chain.

Another way that can be used to stabilize fish minces is to wash out the TMAO. This means that large amounts of water have to be used (and apparently seawater doesn't work). The process also removes about 25% of the total protein, some of the fish fat (which might now be considered a desirable component) and most of the water soluble vitamins and minerals. This creates a potential waste stream that will require further treatment. The washing process also requires additional equipment including dewatering equipment. Even then, to maintain the gelling characteristics of the remaining material during frozen storage requires stabilization. This is usually done with the addition of additives up to 8% by weight—4% sucrose and 4% sorbitol being the usual additives of choice. The product at that time is then called surimi. Because of all the processing the minced fish receives, the raw material cost has gone up significantly from that of the starting mince. These concerns account for some of my negative attitudes towards surimi.

A small aside with respect to the study of DMA/FA induced texture changes in the laboratory. The traditional approach for measuring these changes, and therefore of testing compounds for prevention of this reaction, is to measure the formation of DMA. However, if the additives of interest works by scavenging the FA after it is formed, then this will not decrease the DMA level, but might even by the law of mass action cause a small rise in DMA formation. Thus, our laboratory is currently reexamining various functional and textural changes in conjunction with a human texture panel in

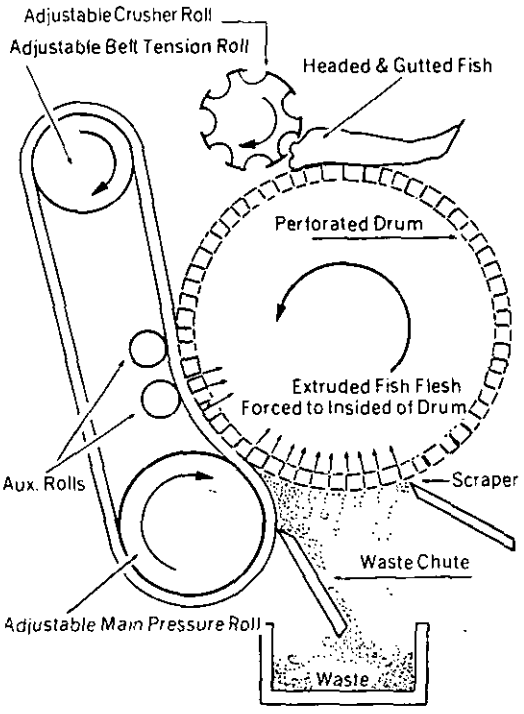

Fig. 1—**Schematic of a Belt and Drum Fish Deboner.** *(From Lanier and Thomas, 1978).*

Fig. 2—**Cayuga Brand (Cornell) Minced Fish** *in a one pound box (frozen).*

order to develop appropriate methods for following the textural changes which are occurring in these systems.

The sooner minces are used in a product, particularly a cooked product, the less problems one has during bulk frozen storage, particularly with gadoids. However, with proper storage, some minces can have a sufficient shelf-life that they can be stored, used, and even sold directly to consumers. In fact, the first market test product at Cornell with minced fish was a one-pound box of minced fish sold directly to the consumer from a fish store and from six supermarket stores (within one chain). The product is illustrated in Fig. 2. The cover was also a recipe booklet which gave suggestions as to how to use the product.

Another problem that must be addressed is that of parasites. An excellent review of the problem of fish-borne parasites has been presented by Higashi (1985). With respect to mincing and surimi production, it is probably in the best interest of the industry to ensure that the raw material being used for either mincing or surimi production does not contain worms.

Market Testing Minced Fish Products

Through Cornell's market testing program initiated

Fig. 3—**Some of the Cayuga Brand (Cornell) Minced Fish Products** *that have been market tested.*

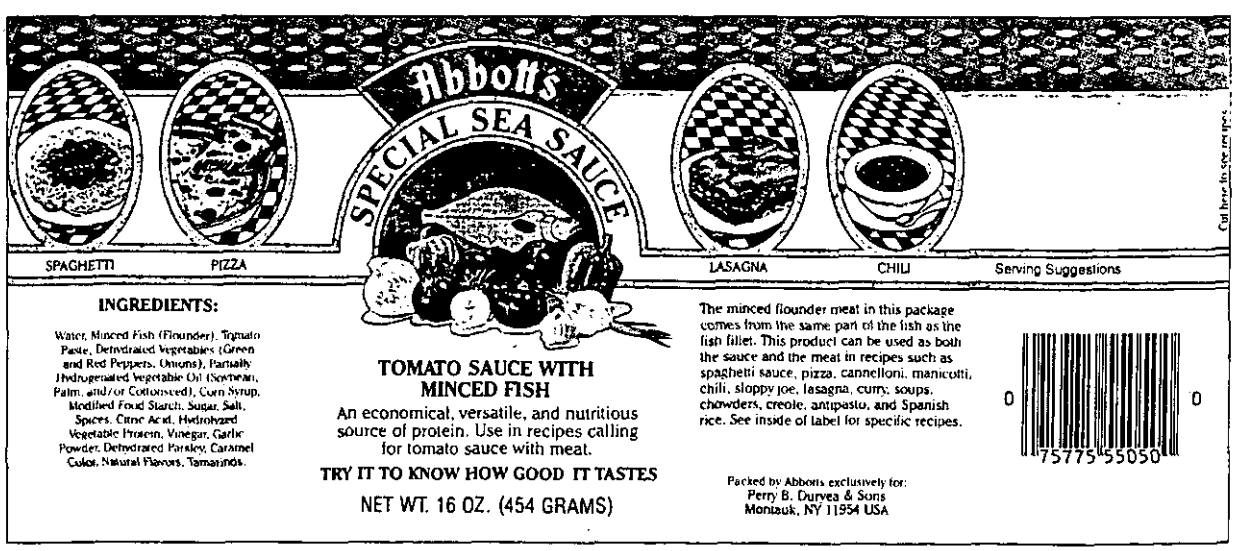

Fig. 4—**Abbott's Special Sea Sauce,** *front panel.*

by Dr. Robert C. Baker, products are manufactured in sufficient quantity so that they can be sold for an extended period of time (12 to 20 weeks) in two or more stores. During the first three weeks, demonstrators are used to give out samples of the product or of recipes prepared using the product. The demonstrators are usually in the stores only at the busiest hours. After three weeks, the demonstrators are removed and the products are sold without any further promotional support. The sales in the last three weeks of the full market testing period are then used as the criterion of success with respect to competitive products. (Because of some of the free publicity that surrounds a Cornell market test, the stores are often quite cooperative and willing to have us in their facilities, even on the condition that they release some comparative sales information to us about other competitive products.) The important point of these very limited market tests is that they prove that people are prepared to buy the product, and much more importantly, that they are prepared to repurchase the product.

The price charged in the stores was selected so as to be non-competitive with the closest identifiable equivalent products. Unfortunately, we have never had an opportunity to look at the price sensitivity of any of our products.

The use of in-store demonstrators turned out to be a fortuitous choice. It was really selected as a practical expedient because we would only be in a few stores and, thus, couldn't use most other forms of advertising. But in fact I am convinced (without any real evidence) that the ability to taste new and unusual products is crucial to the willingness of the consumer to make that first purchase.

Some of the products that have been tested by Cornell are shown in Figure 3. These are all fish-like products that served the purpose of illustrating that fish mince is of high enough quality that it can perform well in fish-like applications. However, the idea of a meat-like product made from fish mince also deserved to be tested.

A frustrating aspect of the Cornell market testing program is the fact that after the 12 to 20 weeks of market testing, the product and any momentum it generates dies. It is removed from the shelves, never to become available again. It was my feeling that if we could use a commercial label, we might be able to work with a small fish company to produce and market test a

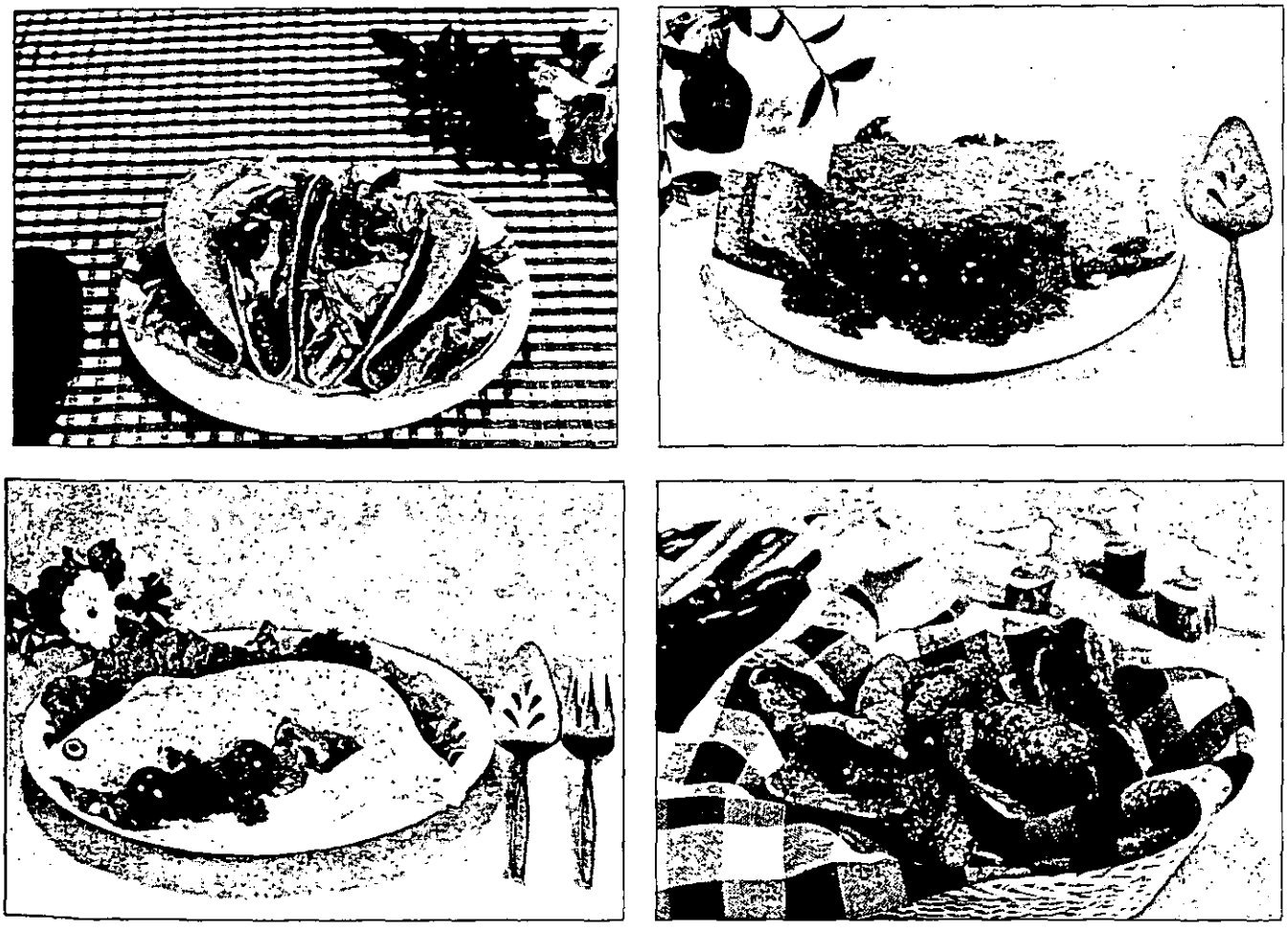

Fig. 5— **Minced Fish Products:** *(A) Tacos. (B) Fish Meatloaf. The left hand side of the loaf has been 'browned' by the addition of a gravy sauce. (C) Gelatin Fish Mold. (D) Fish Snacks. These are a mixture of fish and modified starch which are canned, retorted, sliced and deep fried.*

product. When the market test was over, the company could take over the marketing of the product and expand its distribution. (A more complete discussion of the role of the University in the development of commercial products is presented in Noyes and Regenstein, 1982.)

After many years of attempting to put such a project together, some funding was finally provided by the Mid-Atlantic Fisheries Development Foundation for such a test. Unfortunately, compromises on funding, the timing schedule, management leadership, and the choice of industrial partners, all got the project off to a poor start. It is also possible that we attempted to take too many new steps at one time: developing a new commercial product concept working with industrial partners with limited experience in the intended market, developing our first meat-like product, developing a product (Special Sea Sauce, a spaghetti sauce with 30% fish meat) (Fig. 4) for which no equivalent red meat product is generally marketed, and packaging the product in a less than desirable form (i.e., this type of product is now usually bottled rather than canned). The production runs were really not consistent with the previous experimental batches, and the final price was much higher than the initial projections. As a result, the Special Sea Sauce project was a failure. However, it does bring home the fact that in product development you cannot break all the rules and expect to succeed! A full report of this program and the problems it encountered is available from the Mid-Atlantic Fisheries Development Foundation (Baker et al., 1984: Regenstein, 1984).

We continue to develop other products capable of mass production and recipes for minced fish (Regenstein and Regenstein, 1982). We have demonstrated a number of meat-like products on various occasions, including fish tacos, fish chili's, and fish curries. Figure 5 shows some of these other products. These are all products that we believe fit the consumer's need for nutritional and appropriate foods, without having an obvious fish character. Clearly, the next big hurdle is to make a good fish-based sausage, hamburger, meat pattie, and/or fish frankfurter and, most importantly, to successfully introduce it into the marketplace. The time might just be right if the whole process can be done right! That is the challenge we all face in utilizing the potentially valuable and very available by-products of fish filleting and processing as an inexpensive and extremely nutritious source of animal protein.

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