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The Role of Fish in Meeting the World's Food Needs

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It is universally accepted that basic human needs are food, clothing, and shelter. Such a listing ignores the need for oxygen and water; these are, after all, taken for granted because they are not yet limiting factors in his environment. It is not by accident that food is listed before clothing and shelter. It is the only one critical to human survival. Our need for food is relentless, a fact of which we are constantly reminded at least three times per day, every day of our lives.

The world's human population, now at about 4 billion, is increasing at the rate of 2 percent/year, which means that it will reach about 8 billion within one generation. Unchecked, it is bound to outstrip any food production rate possible. Even if we ignore the impending energy shortage, there has to be a concern regarding the future of the world's food supply. There is no doubt that we can raise the food production efficiency of our arable land to a point, but its area is limited (about 8 billion acres). While we in the United States have generally enjoyed a higher standard of living than that of many others around the world, the effects of our technological advances in travel and communications have essentially melded the world's people, and the shortages in any large segment will affect the rest of the world. At present it is reported that there are only three major net food exporting countries in the world—Canada, Australia, and the United States—and already the large food reserves of this country have dwindled to a level so low that some economists have started to express concern. After all, there are too many factors that can readily curtail our food production which is one of the reasons a country tries to maintain food reserves.

Man's protein sources include plants and animals. Affluent populations have grown accustomed to the gustatory advantages of animal protein. However, the conversion ratio (lb feed/lb meat) of beef is about 10 to 1; hog, about 4 to 1; and poultry, about 2.5 to 1. From this we can see that the rising competition for grains is bound to push their prices to such high levels that the economics of producing beef will soon become less favorable, making it more costly and scarce. This situation will, of course, put economic pressures on hogs, sheep, poultry, and seafoods.

Many countries have already turned to the sea to obtain their protein foods, and the intensified fishing efforts worldwide have depleted many conventional species such as haddock, flounder, halibut, tuna, scallops, and lobsters. International management schemes have evolved in an effort to stem the decimation of the world's marine resources, but these efforts have been generally inadequate and extensions of national jurisdictions to 200 miles of the adjacent seas are proposed by many nations and already adopted by a few of them.

There is no doubt that seafoods play a significant role in supplying the world's protein needs. The world's per capita consumption is about 35 lb as against about 12 lb for the United States. However, the full potential of that role may not be reached until fish farming replaces fish hunting. The advantages of fish farming over conventional fishing are many:

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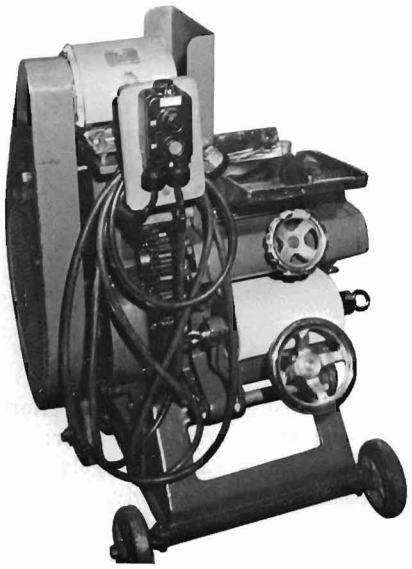
1) Harvest is proportional to effort and much simpler and safer;
2) Conditions can be largely controlled (contaminants, disease, temperature, salinity, etc.);
3) Size of crop can be predicted and stocks easily and reliably assessed;
4) Genetics can be manipulated to improve yield, improve resistance to disease, shorten generation times, etc.;
5) Habits and life processes can be studied;
6) Feeding of fish can be controlled;
7) Operation not vulnerable to overfishing;
8) Requires no expensive fishing gear, ships, ship maintenance, and ship insurance;
9) Requires no sailing energy and time;
10) It is not dependent on weather;
11) Time between slaughter and process is very short insuring top quality;
12) No need for international agreement.

Fish are the most efficient converters of food, having a conversion ratio of about 1.5 to 1. Fish also require much less space than other animals (e.g., catfish space requirements are about 2,500 pounds per acre; silo systems can reportedly produce about one million pounds of fish per acre.) These facts suggest that fish for human use will eventually be produced largely by fish farming. However, the situation regarding the needs of protein for humans is already quite critical, and there are some things that can be done in the interim to increase the utilization of fish and fish products.

The technological research facilities



Photos show meat/bone separators used by the Northeast Utilization Research Center, NMFS, NOAA.

of the National Marine Fisheries Service (NMFS), NOAA, U.S. Department of Commerce in Gloucester, Mass., College Park, Md., and Seattle, Wash., have the goal of increasing the yield of the presently landed commercial fish products. Other research is directed towards increasing the landings and/or value of commercial fish. In collaboration with industry and Sea Grant colleges, a large portion of the effort is directed in a program to improve the New England commercial fishing industry.

Of the fish that are landed, only a relatively small proportion is normally used for consumption. For example, in shellfish about 15 percent of the landed weight actually goes into human food. In groundfish, about 30 percent goes into human food. In laboratory tests, we have shown that deboning machinery permits the recovery of an additional 10-20 percent of fish flesh in the form of minced meat. Shellfish (e.g., crabs and lobsters) can also be processed by automatic equipment which permits recovery of significant amounts of additional fish flesh. It has been estimated that in New England alone the additional fish meat that can be recovered by these processes is about 57 million pounds per year (King and Carver, 1970).

The machinery used for recovering the meat from finfish is basically of two types. One type is such that the product is pushed against the outside of a rotating perforated cylinder. The pressure put on this product forces the soft flesh through the perforations in the cylinder and the meat which passes through the holes collects inside the cylinder in a minced form. The undesirable materials such as the bone, skin, and scales stay on the outside of the cylinder and are collected elsewhere. A second principle involves forcing the product into a perforated cylinder under sufficient pressure to expell the soft flesh through the perforations while the undesirable materials are pushed to the end of the cylinder, collected, and removed. In addition to recovering meat from the processing of by-products of conventional species, this machinery can process fish which otherwise are not processed, either because of the bone structure which prevents filleting or because of the size which makes filleting too expensive for the yield. The fish are generally processed whole except that the head and viscera are removed. Laboratory tests have shown that fish processed in this manner yield from 62 to 93 percent of original weight as edible meat. In general, the smaller fish account for the larger percentage yields and the large fish

account for the smaller percentage yields (King and Carver, 1970).

The principles that are employed commercially to automatically debone shellfish include separation by specific gravity, that is, by floating in a liquid, usually brine, with a specific gravity such that it optimizes the separation of flesh from bone or cartilage. Centrifugation is a modification of the principle of separation by specific gravity that accelerates the separation. In addition, there are developments using pressure (e.g., air pressure or water pressure) to push out the meat and vacuum to pull the meat out of the cartilaginous sockets. Shaking has also been found to be effective.

Another way to take advantage of the presently available fish proteins is to encourage fishermen to land species which are presently underutilized, such as Jonah crabs, mahogany quahogs, Pacific rockfish, and certain oysters. Although markets have to be developed for most of these products, which presently have a low value, their food value is theoretically as great as those of the species that are presently landed. It behooves us to encourage the industry to use these species not only because it permits the fisher a greater range of products that he can handle, but it also increases the amount and variety of marine protein that is available to the consumer and, in addition, it helps to maintain a species balance at sea. That is, if we fish for many species rather than for a selected few, there is a higher probability that the selected few will not be fished to extinction.

One of the outlets for the minced meat is in the production of blocks. There is presently a shortage of fillet blocks used mainly in the production of fish sticks and fish portions: two products which account for tremendous amounts of the fish that are consumed in many of the developed countries. Minced flesh can be used as a matrix for the manufacture of various types of rolls such as shrimp roll, etc., or it can be made into a paste as is done by the Japanese. They produce a paste called surimi, a basic material which can then be used to produce a wide variety of foods, including soups, sausage products, and others (Miyauchi et al., 1973). In underdeveloped countries, salting seems to be a popular way to preserve fish. Thus, fish caught during glut can be preserved for the future or for inland transport where there is no refrigeration. For this purpose, at least two or three rapid salting techniques have been developed, and the NMFS has accounted for one of these (Anderson and Mendelsohn, 1972).

The use of mechanically recovered fish flesh is not without problems. The product does not resemble conventional products in physical appearance, and its texture, color, and flavor are not as stable as those of conventional products. Sometimes the product can contain bones, not always large bones but nevertheless bones which are undesirable and that may, in the case of feeding of children or elderly people, even be dangerous. A water-wash during the production of minced meat can improve the color of the product mainly by washing from the fish flesh the blood pigments and dark lining of the body cavity which disparage the esthetics and quality of the minced meat. The minced flesh of carp which is dark has been used as a component of frankfurters or hamburger. Hamburger mixed with up to 50 percent fish is as acceptable as plain hamburger (King and Flick, 1973). This represents certain advantages. It decreases the cost of hamburger without altering its eating quality. It improves the protein value since hamburger, which is ordinarily quite high in fat—up to 25 and 30 percent—is replaced by protein which could contain as low as one-half percent fat, and there is an overall reduction in calories. There is considerably less total fat since one-half of the fat has been removed, and this means that the total saturated fat is also halved. The small amount of fat that is added is polyunsaturated which, from a medical standpoint, improves the mixture of dietary fat. This is especially important since hamburgers and frankfurters are eaten selectively by the young, and it has been suggested that the cholesterol intake of the young has a lasting adverse effect.

The problem of texture depends largely on processing parameters. If minced fish flesh is used, as suggested earlier, as a component in hamburger, there is no problem. If the minced fish is used by itself, there is a noticeable toughening that reflects denaturation of the protein to a degree that is dependent, among other things, on the size of the openings through which the fish flesh is made to pass in the deboning operation. The smaller the openings, the greater the texture degradation.

The incidence of bone depends upon the nature of the raw material and of the parameters of the process. Obviously, fish having small bones and structured in particular configurations can be problematical. By varying the pressure, one can minimize the incidence of bones. If the openings in these recovery machines are small enough, 3 mm or less, the incidence of bone is not considered to be a problem. When the openings are less than one mm in size, any bone fragments getting through are so small that they cannot be detected by a trained panel.

LITERATURE CITED

Anderson, M. L. and J. M. Mendelsohn. 1972. A rapid salt-curing technique. J. Food Sci. 37:627-628.

King, F. J., and J. H. Carver, 1970. How to use nearly all the ocean's food. Commer. Fish. Rev. 32(12):12-21.

King, F. J., and G. J. Flick. 1973. Beefish patties. Mar. Fish. Rev. 35(7):31-33.

Miyauchi, D., G. Kudo, and M. Patashnik. 1973. Surimi—A semi-processed wet fish protein. Mar. Fish. Rev. 35(12): 7-9.

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