FISH FLOUR FOR HUMAN CONSUMPTION

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ABSTRACT

A review of the scientific literature on fish flour; references to the original literature are appended.

INTRODUCTION

Economically underdeveloped countries have long needed an inexpensive source of animal protein for human consumption as a help in preventing malnutrition. The use of fish offers a possible way of alleviating this deficiency. A difficulty arises, however, in that in many of the countries where inexpensive protein is needed most, the means of preservation are least available. One approach to the solution of this problem is to dehydrate the fish in order to prevent spoilage. In the category of dehydrated fish is edible fish meal, or fish flour[1/]. Research programs therefore have been undertaken in several countries to produce a tasteless, odorless, white fish flour for use as a source of the required protein.

In this report, the following topics are discussed: problems encountered in the use of fish flour, nutritional importance, acceptance tests, and processes of manufacture.

PROBLEMS ENCOUNTERED

Some of the problems in using fish flour as a protein supplement are preservation, consumer reaction, and cost. The first two problems directly contribute to cost, since the process that makes the flour resistant to deterioration and renders it tasteless and odorless--and thus acceptable to the consumer--increases the cost.

PRESERVATION: The keeping quality of fish flour depends primarily on the low oil content of the final product to prevent it from becoming rancid. The producer, in order to supply the needs of people in various countries, must furnish a flour that can resist deterioration when stored at high temperatures and under adverse conditions. One of his essential problems, then, is to make a product that is low in oil.

CONSUMER REACTION: In countries where people object to a strong fish flavor, the flour must be refined, deodorized, or manufactured in such manner that the final product is substantially flavorless (Food and Agriculture Organization of the United Nations 1954).

The product should be of such quality that it can be incorporated in quick breads, cakes, cookies, cereals, pastries, and baby foods without lowering the appeal of these foods to the consumer.

COST: One of the difficult problems to overcome is that of cost. A factor in cost that must be kept in mind is the loss in weight of the product due to removal of moisture and oil from the raw material. Owing to this removal, less than one-fifth as much fish flour as the weight of the raw material is produced. This means in general that the cost of fish flour is more than five times the cost of the raw material, since processing costs must be included as well.

The high cost of producing fish flour for human food, in contrast to the relatively low cost of producing fish meal for animal feed, results from the palatatility, sanitation, and aesthetic requirements of the consumer. Where fish flour must

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1/ Authors often use the terms fish meal and fish flour synonymously.

meet the strictest aesthetic requirements, costs will necessarily be high, since only the more costly portions of the fish can be used.

Van Veen (1959)[2/] reports: "A good defatted and deodorized fish flour, on a protein basis, should not cost to the consumer in underdeveloped countries much more than he would pay for dry skim milk in the same area. As for the U. S. A. we have been assured by an American firm that a partially deodorized fish flour costs about 36 to 38 cents a kilogram[3/]. We think that a price of 24 to 40 cents per kilogram is realistic."

NUTRITIONAL IMPORTANCE

In any process of manufacture, the nutritional value of a food product may be reduced. Thus, there may be loss of vitamins and minerals, and the protein may be made less digestible.

Irving, Smuts, and Sohn (1952) compared white fish flour (86.2 percent protein) with bread as to true digestibility and obtained the following data: white fish protein 95.6, bread 93.8, and white fish protein and bread 92.1.

Analyses of bread made from enriched and unenriched brown flour and a comparison with daily requirement are shown in table 1 (Fishing Industry Research Institute 1958).

Table 1 - Analyses of Bread Made from Enriched and Unenriched Brown Flour and Comparison with Daily Requirement

Material and Requirement	Protein	Calcium	Phosphorus	Thiamine	Niacin	Riboflavin
	G./100 g.	(Mg./100 g.)				
Brown bread	9.0	50	160	0.3	2.0	0.13
Fish flour	80	7,000	4,500	0.13	5	0.22
2%-enriched brown bread	10.4	186	245	0.296	2.06	0.132
	G.	(Mg.)				
Daily requirement	70	800	900	1.5	15	1.8

Note: From Memorandum No. 89, Fishing Industry Research Institute, Cape Town, South Africa, 1958.

Biological value of pilchard fish flour and pilchard meal is shown in table 2 (Willmer 1955).

In order that a standardized stable fish meal may be produced that is equal in chemical and biological value to the fish from which it is derived, Levin (1959) suggests: (1) the product must be made from the whole fish with no division of products into fish meal and fish solubles, (2) the fish must be defatted and dried at temperatures that will not damage the product, and (3) the fish meal must be standardized on the basis of biological value. Both an animal assay that is accepted by nutritionists as a measurement of protein quality and a biological measurement of the identified growth factors should be obtained.

Table 2 - Biological Value of Pilchard Fish Flour and Pilchard Meal

Material	Net Protein Utilization	True Digestibility	Biological Value
Pilchard meal, factory produced	61.6	86.8	71.0
Pilchard fish flour, prepared in laboratory	62.6	82.6	75.8

Note: From Eighth Annual Report of the Fishing Industry Research Institute, Cape Town, South Africa, 1955.

The bulk or fiber content of the diet often may be a determining factor in the digestibility of protein incorporated in that diet (Nutrition Reviews 1955).

Sure (1957a) reports that fish flour was used in rat-feeding studies to determine the influence of this product on growth and protein efficiency. Small amounts of defatted fish flour were added to milled wheat flour, white corn meal, and polished rice. Gains in body weight and protein efficiency obtained were superior to those obtained in the past with dried nonfat milk solids, dried buttermilk, defatted soybean flour, brewers' yeast, cultured food yeasts, and peanut meal.

He also reports (1957b) that rats used in feeding tests in which small amounts of defatted fish flour were added to whole yellow corn, whole wheat, whole and

2/ Personal communication from A. G. van Veen, Chief, Food Processing and Preparation Branch, Nutrition Division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome, Italy, June 18, 1959.
3/ 2.2 pounds = 1 kilogram.

milled rye, grain sorghum, and millet showed definite increases in body weight. The greatest responses were secured with grain sorghum, millet, and whole yellow corn.

ACCEPTANCE TESTS

Experiments on consumer acceptance of fish flour have been conducted in a number of countries, including Chili, Thailand, and Mexico.

CHILI: Each day for 6 weeks, 140 school children in Chili received, as part of their school lunch, a 90-gram bread roll made from wheat flour containing 10-percent fish flour. Taste, smell, form, and consistency of the bread were normal, and the bread was only slightly darker than is that made from ordinary flour. There were no rejections or complaints by the children, and no digestion trouble occurred (Food and Agriculture Organization of the United Nations 1954).

THAILAND: An experiment, the results of which have not been published as yet, was carried out in the village of Nongkorn, Ubol Province, Thailand, to test the acceptability of fish flour by the people of the village. About 600 persons were given a daily ration of 15 grams of fish flour to supplement their scant intake of protein. This flour was made from "platu" and "slipmouth" fish. About 5 tons of flour can be produced from about 28 tons of fish per day. Smaller fish, which previously had little or no market, can be used for the fish flour.

If this experiment proves successful, the flour will be made available to all villages of the province (FAO Bulletin No. 2).

MEXICO: Levin (1959), citing the work of Frederico Gomez ("Studies on the Use of Deodorized Fish Flour in Malnutrition," Boletin Medico del Hospital Infantil, September 1958), reports that at a hospital in Mexico, the value of fish flour has been studied for two years, using methods of measurement such as nitrogen balance studies on children--comparing a corn-bean diet plus 10-percent fish flour with the same diet plus the nitrogen equivalent in the nonessential amino acid glycine. The results indicate that fish flour is of value as a dietary supplement.

PROCESSING

Over the years, many methods for making fish flour have been tried. These methods are basically quite similar to those for preparing fish meal (in fact, as was indicated earlier, some authors use the terms fish meal and fish flour synonymously), but greater attention is given to the sanitary and aesthetic aspects.

As also was indicated earlier, one of the major problems that must be resolved is the oxidation of oil in the fish flour. Since the ordinary methods of producing fish meal leave considerable oil in the material, the product generally is not suitable for human use unless the starting material is very low in oil content.

For this reason, attention now has turned largely to a process of manufacture based primarily on solvent extraction. This process, of which there are a number of variations, is effective in removing oil.

TENTATIVE SPECIFICATIONS FOR SOLVENT-EXTRACTED FISH FLOUR: Food and Agriculture Organization and UNICEF, agencies of the United Nations, developed the following "Tentative Specifications for Solvent Extracted Fish Flour Defatted and Deodorized." These Specifications, dated June 12, 1957, remain in effect, although they are still tentative:

"1. Starting material shall be edible fish of a known species and in a condition fit for human consumption at the start of the process. The material to be processed

shall be whole fish or whole degutted fish, or degutted fish with heads and tails removed.

"2. Handling of the fish from catch to end of processing shall be done with sanitary precautions ordinarily applied in producing human food. The fish may be dried either during the process of solvent extraction or by a preliminary stage of air drying. In either case, temperatures shall be kept sufficiently low to avoid protein damage. In general, temperatures in excess of 212° F. will result in definite damage. Lower temperatures may cause some damage under certain circumstances.

"3. Finished flour shall meet the following specifications:

"Protein (Nx6.25): content 70 percent minimum, digestibility 90 percent minimum, biological value 70 percent minimum.

"Amino Acids: Minimums of lysine 9.5 percent, tryptophan 0.9 percent, methionine 3.0 percent, cystine 1.0 percent (all as percent of protein).

"Moisture: maximum of 8 percent.

"Fat: maximum of 0.4 percent.

"Ash: maximum of 18 percent.

"Particle size: 100 percent of the flour shall pass a 100-mesh screen.

"Color: not darker than a light gray or tan; ordinary bread baked with 1 part fish flour and 11 parts of ordinary white wheat flour will not show appreciable darkening.

"Odor and Taste: the flour shall have no more than a faint fish odor and taste; and when baked in bread as described above shall have no detectable fish taste or odor.

"Storage stability: after 6 months storage at temperatures prevailing in the area of intended use but not exceeding 100° F., and when packed in closed fiber or metal containers or in polyethylene bags, the flour shall show no spoilage as judged by rancidity, mold growth, deterioration in biological value or 'flavor reversion' as judged by the criteria listed under odor and taste.

"Bacteriology: the flour shall be free of B. coli, Salmonella, and pathogenic anaerobes. The total bacterial plate count shall be not more than 2,000 per gram.

"Safety: no additives, preservatives, or solvent residues are permitted. Safety tests in at least one species of animal shall be done according to requirements of the appropriate official agency of the country where the flour is to be used. (Note: FAO and WHO advisory groups have recommended 6-months studies in rats using diets in which the fish flour is the sole source of protein, and the test should include one reproductive cycle. If there is any reason to suspect safety hazards, more elaborate tests and additional species of animals may be required. These recommendations pertain principally to products intended as supplementary foods for infants and children.)

"4. Chemical methods shall be those of the American Official Agricultural Chemists or equivalent 'official' generally-accepted methods. Amino acids may be determined microbiologically using generally accepted methods such as those described in Barton-Wright, E. C. "The Microbiological Assay of the Vitamin B Complex and Amino Acids," Pitman Publishing Corp., New York (1952), or chromatographically by the Moore and Stein procedure. Bacteriological methods shall be

official methods of the American Bacteriological Association, the American Public Health Association, or equivalent accepted methods. Biological value may be determined by the Miller-Bender or the Mitchell methods."

PRODUCTION: Some of the countries producing fish flour are South Africa, Canada, Great Britain, France, and the United States. Closely allied products are manufactured in India, Germany, and Russia. The process varies somewhat from country to country. References listed in the appended bibliography should be consulted for details on actual manufacture.

SOUTH AFRICA: Scientists in South Africa have reported that they have developed a process for making tasteless and odorless fish flour, which now is being used to enrich brown bread (Indo-Pacific Fisheries Council, FAO 1957). The flour has a moisture content that varies between 2 and 3 percent. It is light brown in color and contains no additives. The Fishing Industry Research Institute (1958) reports that the product is stable because of its low content of oil.

This fish flour has been incorporated to the extent of 5 percent in bread, biscuits, and rusks made of wheat flour (Fishing Industry Research Institute, S. Africa 1958). When the present plan is in full operation, about 5,000 tons of fish flour will be used each year (Indo-Pacific Fisheries Council, FAO 1957).

CANADA: Guttmann and Vandenheuvel (1947) report that the fish flour manufactured at the Halifax Technological Station is almost white, odorless, and tasteless and contains 2 to 3 percent moisture, 2 to 5 percent ash (mostly calcium phosphate), negligible amounts of lipids, and 94 to 98 percent protein on a dry, ash-free basis.

GREAT BRITAIN: British Patent 727,072 provides a method of powdering fish that is reported in Food Manufacture (1955) to be economical and to result in a product that is tasteless and odorless.

FRANCE: In France, the preparation of fish meal for human food consists primarily in eliminating oil from the fresh fish. It is reported in Food Manufacture (1956) that the fish flour produced by this method is tasteless and odorless.

UNITED STATES: A plant in New Bedford, Mass., which uses an azeotropic solvent method, is apparently the only company in the United States producing fish flour at the present time. Whole fish--any species of any oil content--are processed into a fish flour reported to contain 70 to 80 percent protein and less than 1 percent oil. This company reports that their product can be processed to reduce its odor and flavor or to retain its odor and flavor, depending on the taste of the consumer, and it has good keeping qualities. The determining factors in producing the fish flour at a profit are cost of fish, cost of fuel, and cost of labor (Viobin Corporation 1956).

A fish-processing company with branches in Eastport and Rockland, Me., recently announced plans to produce fish flour on a large scale. A spokesman for the firm reported that the flour will be suitable for use in such foods as bread and crackers (The Fish Boat 1959).

Anyone contemplating the manufacture of fish flour in the United States should first contact the U. S. Food and Drug Administration to make certain that his product can meet food requirements.

The Federal Food, Drug, and Cosmetic Act defines a food as adulterated if it consists in whole or in part of any filthy, putrid, or decomposed substance or if it is otherwise unfit for food. It is the view both of the Food and Drug Administration and of the consumer that the viscera of the larger fish are filthy and otherwise aesthetically objectionable. Similarly, the head, scales, and tail of large fish are

considered unfit for food. The Food and Drug Administration has not objected to the presence of tails and viscera in small herring canned as sardines as long as the feed content of the viscera is eliminated. Another requirement of the Act is that food shall not be prepared, packed, or held under insanitary conditions whereby it may become contaminated with filth or whereby it may be rendered injurious to health.

In view of the above considerations, the use of whole fish or fish containing viscera with feed in the intestines, even though heads and tails are removed, would be objectionable in the manufacture of fish flour or fish meal for human consumption. The Food and Drug Administration would not take exception to the use, for this product, of small herring that were free of feed and subject to all the conditions that control the use of herring in the canning of sardines.

INDIA: Mohanty and Roy (1955) used the meat of sharks and rays to prepare a hydrolyzed fish-protein powder--a cream-colored, flourlike powder containing 85 percent protein. They report that hydrolyzed fish-protein powder is soluble in water, that it keeps well, and that it is useful as a food for hospitalized patients and those suffering from malnutrition or duodenal and ventricular ulcers.

GERMANY: Shenstone (1953) describes a process for making Wiking Eiweiss, a soluble albumen made from fish that can be used as a substitute for egg white. Good-quality fillets of white fish are required for the preparation of this product. He reports that the final product is a slightly gray, odorless and tasteless, easily digestable powder. It may be used in aerated bakery goods, sugar confectionery, ice cream, mayonnaise, custard powder, and pharmaceuticals.

RUSSIA: Schimkat (1955) describes a method of producing dry protein from inexpensive varieties of small fish in the U. S. S. R. He states that the protein is a water-soluble, cream-colored powder with very little fishy flavor and that it contains 70 to 80 percent protein, up to 10 percent minerals, 0.5 percent oil, and up to 10 percent moisture.

SUMMARY

1. Some of the problems encountered in the use of fish flour are preservation, consumer acceptance, and cost.

2. The nutritional aspects of fish flour are currently under study.

3. Fish flour is reported to meet consumer acceptance.

4. The basic process used in the manufacture of fish flour is solvent extraction.

5. A stable, tasteless, odorless, nearly white, edible fish flour is reported to have been produced.

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