CANNED TUNA QUALITY IMPROVEMENT STUDIES

In the production of canned tuna, it is agreed generally that the methods used in handling, chilling, freezing, and storing the fish aboard the tuna clippers and thawing aboard or in the plant affect the quality of the canned product. As a result of the tuna industry's need for more systematic knowledge of the many variables in freezing of tuna, the Bureau of Commercial Fisheries has awarded contracts for the past three year for research in the southern California fishery. The studies have been concerned primarily with the clipper-caught tuna which are caught far from shore and brine-frozen for delivery to the cannery. Both industry and experimental conditions have been used to determine the effect of time, temperature, and physical handling during chilling and freezing on the general acceptability and yield of the precooked tuna and the canned product. Much of this research has been concerned with the factors in salt absorption during brine-chilling and the subsequent thawing. Current studies include the changes related to bacterial growth during the chilling and thawing operations. As a result of these various research phases, recommendations for improved handling, freezing, and thawing methods are being developed in cooperation with the tuna industry.

As an adjunct to the contract studies, the Bureau's Technological Field Station in southern California has undertaken recently more exacting studies of the chemical composition of the tuna species and the relation to both vessel and plant process variables. Such knowledge of the changes in chemical constituents as protein, oil, salt, minerals, water-soluble vitamins, and objective freshness indices will eventually enable better quality control at each stage of preservation and plant process. Knowledge of these changes is important also to assess the effect of preservation and process improvements. Information on the content of nutritionally-important components of the fresh-caught tuna in relation to their content in the canned product is desirable to determine the effect of natural variations in quality.

At present these long-range composition studies include an initial project on the composition variables in fish of the same lot and species in relation to adequate sampling methods. The subsequent phase will consider the application of the laboratory methods for determining composition differences in the raw, precooked, and canned fish of the same lot.

CHEMICAL COMPOSITION OF PACIFIC COAST FISH AND SHELLFISH

The chemical composition of Pacific west coast marine fish is receiving major attention at the U. S. Bureau of Commercial Fisheries' Seattle Technological Laboratory. Much of the work deals with proximate composition--the content of protein, oil, moisture, and ash.

One of the major projects in this program has been a recently completed two-year study of the variations in proximate composition of halibut meat with regard

to size of fish and different parts of the same fish. The proximate composition of tuna is now under study. The over-all plan involves determination of composition of different parts of light and dark meat in a variety of sizes with regard to species, area of capture, and season of capture. Preliminary work has been completed on albacore, skipjack, yellowfin, and bluefin tuna to determine the scope of the investigation. A more intensive study of albacore is now in progress.

Several species of rockfish and of sole are also under study. Attempts are being made to secure additional specimens in order to give adequate coverage for about 10 species each of rockfish and sole. When a series of pink salmon now on hand have been analyzed, the three-year study on this species will be terminated and a start will be made on silver salmon. Some work done on the proximate composition of Pacific cod will be continued as additional specimens representative of seasonal and area variables become available.

Work on the composition of fish meals has included proximate analysis, carbonate content, and digestibility of fish-meal protein as determined by the pepsin-digestion method. This work has been terminated and reports of the investigations are being prepared.

The sodium content of commercially frozen fish fillets and steaks is of special importance just now due to interest in low sodium diets. Some eastern processors dip the fillets and steaks in brine before freezing them. Very little brine dipping is used on the west coast. Commercially prepared samples of sole, halibut, silver salmon, cod, and ocean perch are being analyzed for sodium content. The samples include both fresh-water and brine-dipped products. Comparative results will be made available on completion of the analyses.

CONTROL OF DRIP IN CHILLED AND FROZEN FISHERY PRODUCTS

When frozen fishery products are thawed, drip in the form of a liquid exudes from the product. In most instances, this drip is lost or discarded. If the exudate is, in fact, fish protein this practice wastes food. Investigating the factors that affect the water retentivity of various frozen fishery products, to develop laboratory procedures for measuring drip, and to determine some of the constituents of drip are the objectives of a project assigned to the Seattle Fishery Biological Laboratory of the U. S. Bureau of Commercial Fisheries. This information will assist the industry to produce a uniform, high-quality fishery product retaining a maximum of the inherent goodness of the fish and provide information required in the setting up of standards or specifications for such fishery products. At present, the species studied is halibut.

The results of our studies indicate that drip or drained weight determinations are not entirely meaningful unless standard procedures for their determination are used. For example, higher drip content or lower drained weight may be obtained for a product by using a higher thawing temperature and/or longer thawing time. Because frozen fishery products are perishable when thawed, we are recommending that drip or drained weight determinations be made at a product temperature not exceeding 40° F.

FREEZING AND COLD STORAGE OF PACIFIC OYSTERS AND FRESH-WATER FISH

Research on the freezing and cold storage of Pacific oysters and fresh-water fish is being carried out cooperatively by the Seattle Fishery Technological Laboratory of the U. S. Bureau of Commercial Fisheries and the Refrigeration Research Foundation. The work for several years has included storage-life studies on various species of fresh-water fish from the Great Lakes and Central States areas, evaluation of antioxidants for extending the frozen storage life of Pacific oysters, and storage-life studies on Pacific oysters. Earlier reports have been published of work on fresh-water fish and on the application of antioxidants.

Currently, the research on Pacific oysters is being confined to methods of freezing. The major objective of this phase of the work is to produce an individually-frozen oyster. Two methods of freezing the oysters individually have been attempted; immersion in brine-glucose solutions of various concentrations, and blast freezing. Immersion-freezing proved unsatisfactory, due to salt pick-up by the oyster meats, and the development of rancidity during subsequent frozen storage. The blast-freezing method has been very successful when the frozen oysters were glazed with either ice, 2-percent corn sirup solids, or 1 percent ascorbic acid, prior to storage.

The blast-frozen oysters were placed separately on metal trays which were held in a blast freezer at -20° F. until the oysters were thoroughly frozen. The frozen oysters were removed from the trays and separated into 4 groups. One group was placed in polyethylene bags without further processing. The other three groups were glazed with either water, 1-percent ascorbic acid, or 2-percent corn sirup solids. Samples of each of these were then placed in polyethylene bags. Each bag contained approximately 3 dozen individual oysters. The bags of oysters were all stored in fiber cartons in a 0° F. room.

The group without a glaze deteriorated rapidly. After 4 months, dehydration and oxidation caused the samples to be judged on the borderline of acceptability. The ice-glazed, corn sirup solids-glazed, and ascorbic acid-glazed samples were in excellent condition up to 8 months of storage. After 10 months, the edges had begun to discolor, causing the meats to have slight off-flavors. However, the product was still edible.

These results indicate that individually blast-frozen oysters glazed with either ice, corn sirup solids, or ascorbic acid may have commercial value from the standpoint of ease of separation and storage life.

NEW PRODUCTS FROM FISH OILS

Marine oils have been used in the past for the manufacture of soaps, paints, and varnishes, shortenings, linoleum, and numerous miscellaneous nonfood products including lubricants and greases. During the past 20 years, the United States domestic market for marine oils has been declining. Partly as a result of increasing industrial research on competitive oils, such as linseed and soybean oils, marine oils have been used less and less. Also, certain undesirable characteristics, such as instability due to autoxidation and ease of rancidification, make marine oils less desirable as raw materials. At the same time, there are strong indications that the European export market, which at the present time consumes a major part of the United States production of marine oils for margarine manufacture, etc., may decline to the point where domestic markets would be unable to make up the difference in stabilizing present and future oil economies.

In an effort to help divert possible economic trouble that could jeopardize the future security of the United States marine-oil industry, the U. S. Bureau of Commercial Fisheries in 1953 began a limited-scale program of investigating the chemistry of marine oils. The principal aim in this early work was to carry out basic research on chemical syntheses involving the polyunsaturated fatty acids--so unique to marine oils--and report the findings to potential users (industrial labs, etc.). In 1954, this program got an added boost with the congressional approval of the Saltonstall-Kennedy Act. This law sets aside a portion of the funds derived from duties on imports of fish and fishery products to be used for the support of government research in behalf of the fishing industry.

At the Bureau's Fishery Technological Laboratory in Seattle, investigations of chemical syntheses involving fatty acids from marine oils have been and are continuing to be carried out. Some of the products of these syntheses include monoglycerides, amines, amides, quaternary ammonium salts, fatty alcohols, alkyl halides, epoxides, xanthates, and sodium alkyl sulfates. These products are unique to marine oils in that they are derived from fatty acids having 14 to 24 carbon atoms and from 0 to 6 ethylenic double bonds.

Several problems are associated with research on new products from marine oils. Air oxidation is the chief problem when handling polyunsaturated compounds. Owing to their high degree of unsaturation, the fatty acids and their derivatives are readily polymerizable in many organic reactions. Polymerization and decomposition reactions result in undesirable side-products that cause difficulty in the purification of many fatty-acid derivatives. Nitrogen is used continuously in our work as a means of providing an inert atmosphere. A centrifugal molecular still is often used to purify the liquid products. With this still, for example, it is possible to separate about a liter of products from polymeric substances in from two to three hours.

The problem of chemical reactivity is sometimes a determining factor as to the type of products obtainable from marine-oil fatty acids. For example, synthesis of alkyl halides from the corresponding fatty alcohols does not proceed in the clear-cut manner as for the lower members of the aliphatic series. Also, primary and secondary halogen atoms attached to C_{18} to C_{22} carbon-chain molecules have been found to be very slow to react and the yields far from theoretical.

Preliminary to much of the organic synthesis work, studies were carried out on methods of separating mixtures of long-chain polyunsaturated compounds. Separations by low-pressure fractional distillation are limited by the amount of decomposition and polymerization that can occur. Separations of these compounds are best carried out by low-temperature fractional crystallization and/or fractional crystallization of urea-inclusion compounds of the corresponding straight chain derivatives.

Another important activity of the marine-oil program at the Seattle Laboratory is the coordination of contract research with universities and other institutions on problems associated with the chemistry of marine oils. Presently, there are three basic and one applied research contracts actively being carried on. The three basic research programs under contract are at the Hormel Institute, University of Minnesota at Austin. These include (1) the determination of the structure and analysis of highly unsaturated fatty acids in marine oils, (2) the study of chemical reactions of marine-oil fatty acids, and (3) the study of the chemistry of the odor problem in marine oils. At the School of Mines and Metallurgy of the University of Minnesota, the applied research contract is carried out on the investigation of the utilization of marine-oil derivatives in ore flotation.

STUDIES ON CHEMICAL COMPOUNDS FORMED DURING SPOILAGE OF FISH

Bacterially-induced spoilage is the most important quality change that occurs in fresh fishery products. A number of interrelated factors together produce the conditions which lead to this quality change and at the present level of technological knowledge it is not possible to completely prevent this change.

The outer surfaces and intestinal tract of all live fish and shellfish are normally inhabited by the bacterial flora of their normal environment--the sea. After capture, and death of the animal the natural defenses against bacteria are removed and the organisms multiply and gain access to the normally sterile tissues. During subsequent handling, until the product reaches the consumer, there are opportunities for additional bacterial contamination. It is not possible wholly to eliminate the conditions through which seafoods are contaminated, nor is there an economical method available to completely inhibit bacterial growth without altering the desirable fresh character of seafoods.

Practices such as careful evisceration, washing, careful handling of fish, use of clean ice, and washing and disinfection of holds, boxes, and other equipment have evolved through the years and have been very important in reducing the degree of contamination. Adequate icing and rapid distribution of fishery products have reduced the biochemical activities of the bacteria and the length of time that the organisms are in contract with the product before it reaches the consumer. The application of these practices has done much in reducing the rate of quality deterioration due to bacterial growth. However, these inovations have not eliminated bacterial deterioration and it still poses a serious problem.

In order to develop new practices that will further decrease the rate of bacterial growth in fishery products additional basic knowledge of the spoilage process is needed. Some of the aspects of this problem that merit attention are: (1) The nature and concentration of some of the lesser known compounds that are formed by bacteria in spoiling fish. (2) The evaluation of the resulting compounds in respect to their effect on flavor and odor of fish. (3) The study of the biochemical activities of some of the predominant groups of organisms that are found on spoiling fish.

At the Seattle Fishery Technological Laboratory of the U. S. Bureau of Commercial Fisheries, we are determining the content of compounds (metabolite) in fish resulting from bacterial activity. Efforts thus far have been mainly directed toward the development of analytical methods which will be used to estimate these metabolites in spoiling fish. In the future it is hoped that work can be started on the estimation of some of the lesser known metabolites such as the carbonyl compounds. It would also be interesting to evaluate the effect of some of the known bacterial metabolites, such as trimethylamine, formic acid, etc., on the flavor and odor of fish.