CONTROL OF FISH SPOILAGE BY ICING AND FREEZING

By H. E. Crowther*

INTRODUCTION

The average person who handles fish and shellfish, from the fisherman on the boat to the clerk in the retail store, knows through experience that in order to keep these products from spoiling some form of refrigeration must be used. But it is probably safe to say that 80 percent of the people who chill or freeze fish and shellfish do not know why the lowering of temperature preserves these products. Perhaps, if those concerned did know, they would be much more careful with icing and freezing operations, which are of paramount importance to assure quality products.

The information in this article is not entirely new. It is known by a number of people, but I am afraid that most of them are technologists—and technologists themselves handle very little fish. Therefore, this brief description of the spoilage processes of fish at various temperatures is presented with the view in mind that wider dissemination of this information will aid in bringing out the need and importance of properly chilling or freezing fishery products in order to preserve the inherent excellent quality of these products. There is no doubt that the direct results will be increased appreciation and consumption of fish and shellfish, and the benefits of these to the fishing and allied industries are self-evident.

PRINCIPAL CAUSES OF FISH SPOILAGE

The principal causes of fish spoilage are bacterial action and autolysis. Although bacteria are extremely small and may be seen only with the aid of a microscope, they can produce almost unbelievable results. A single bacterium can do little by itself—the power of bacteria lies in their number, for they grow or multiply at an unbelievable rate. Bacteria grow not by becoming larger but by multiplication. Under ideal growth conditions, bacteria multiply about once every 20 minutes. At this rate one bacterium would produce 8 in one hour, 262,144 in 6 hours, and about 68,000,000,000 in 12 hours. This phenomenal growth of bacteria is probably the reason that prompted Dr. L. B. Jensen of Swift and Co. to state that food-packing operations are likened to a race between the micro-organism and man to see who gets the food first. Unfortunately, there have been too many times when the microbes have won the race by an obvious margin, but the fish dealers have not conceded defeat. The secret of preservation is to make sure that favorable conditions for bacterial growth, such as high temperatures, do not exist.

PREPARING FISH FILLETS FOR FREEZING IN ONE-POUND UNITS IN A WEST COAST FISH-PROCESSING PLANT.

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NOTE: THIS ARTICLE IS BASED ON A PAPER ("THE FREEZING OF FISH") PRESENTED AT THE FISHERY EXPLORATION AND TECHNOLOGY SESSION OF THE GULF AND CARIBBEAN FISHERIES INSTITUTE HELD ON NOVEMBER 16, 1950, AT MIAMI BEACH, FLORIDA.

Cooperating with bacteria in the spoilage processes is autolysis or self-digestion of the flesh. Autolysis is simply the action of the enzymes of the living flesh which continue their work after the fish or shellfish dies. When the fish is living, these enzymes are prevented from attacking the living cells, but when the fish dies the protective system breaks down and the enzymes begin their softening action on the flesh. Bacterial action appears to be much more important than autolysis in the spoilage of fishery products.

Practically all foods contain bacteria, and many foods, such as meat and milk, may contain large numbers of them, but very few foods are in such an unfortunate position as fish and shellfish.

First of all, refrigeration, the one satisfactory method of keeping most food products fresh, is partially ineffective in the fisheries. Because the unusual types of bacteria which contaminate fish and shellfish are resistant to ordinary refrigeration temperatures, the "keeping time" of these products under non-freezing refrigeration is relatively short. For this reason it is necessary to take full advantage of all that is known about the preservation of fish by refrigeration.

SOURCE OF BACTERIA FOUND IN FISH

In order to understand something about the unseen enemy we are fighting, let us trace briefly where these bacteria come from and how they attack fish and shellfish. Most of the fish-spoiling bacteria are brought into the packing plant on the fish themselves. The heaviest concentrations are in the slime and in the entrails of the fish. Of course, other bacteria are picked up in the handling process from the hands of men, etc., but these are not too important for they grow very slowly under ordinary refrigeration. The bacteria of sea origin are much more hardy for they are accustomed to living in cold sea water and can grow rapidly at temperatures not very much above freezing.

Knowing where the troublesome bacteria come from—the next problem is to determine how they attack the fish and in what areas. On the skin surface and in the entrail cavity of fresh fish there are millions of spoilage bacteria, but the meat itself is sterile. The maximum bacterial growth is in the lining of the entrail cavity and in the blood vessels under the backbone. If there is a break in the skin or the cavity lining, the bacteria will quickly invade the meat. But even though the bacteria may not penetrate the meat, they still can spoil the fish by producing an objectionable, strong, "fishy-smelling" substance, such as trimethylamine, which is easily diffused into the meat or muscle.

CONTROL OF FISH SPOILAGE BY USE OF ICE

If the spoilage bacteria can grow at refrigeration temperatures, how can we control spoilage? Through work which has been carried out by Castell (1949) in Canada, we know that the temperature at which fish are stored is very important.[1/] For most common foods, storage at 37° F. is almost as effective as storage in crushed ice at 32° F, for the bacteria present will not grow at either temperature. With fish this is not the case. Experiments have shown that cod fillets stored at 32° F. kept twice as long as fillets stored at 37° F.—twice the "keeping time" with a change in temperature of only 5 degrees. This would not be important if fishing boats and plants carefully iced their fish in plenty of finely crushed ice--but unfortunately this is not always the case. Temperatures higher than 35° and 40° F. are not uncommon

1/ CASTEL, C. H. (ATLANTIC FISHERIES EXPERIMENTAL STATION, HALIFAX, N. S.) FISHERIES RESEARCH BOARD OF CANADA, PROGRESS REPORTS OF ATLANTIC COAST STATIONS, NO. 44, 8-12 (JANUARY, 1949).

for iced fish in the hold of fishing vessels. Ice will bring the temperature of fish down to 32° F. or below, but to obtain these temperatures care is required in packing the fish in ice. A shovelful of ice on top of a box of fish is not sufficient. The fish must be surrounded by ice. According to a British scientist who is now working on the preservation of fish in ice, temperatures as low as 26° F. may be obtained if the fish are properly iced. He found the average temperature to be between 30° F. and 31° F. However, to date these results have not been verified.

CONTROL OF FISH SPOILAGE BY FREEZING

This brings us to the freezing point of fish—25° to 28° F. Below this temperature our problem changes somewhat. As in the non-freezing temperature range, the bacterial spoilage processes continue to slow down as the temperature of the frozen fish is lowered, but other problems appear. First of all, much more is expected of frozen fish than of iced fish. Instead of aiming at a keeping time of several days, the frozen fish are expected to keep for many months. From the results of experimental work and from practical experience it is known that in order to maintain quality in frozen fish a storage temperature of 0° F. or lower must be maintained, and the lower the storage temperature the better the fish. Fish stored at -20° F. will be of noticeably higher quality than those stored at 0° F. Unfortunately, many of the present commercial freezers are not equipped to economically maintain temperatures as low as -15° F. to -20° F. However, there is now a general trend in designing new frozen-storage warehouses to provide for these low temperatures.

Not long ago there were two generally accepted theories regarding the freezing of fish. One was that the speed of freezing is the most important factor in maintaining the quality of frozen fish. The second was that one of the principal causes of deterioration in frozen fish during storage is fluctuation in temperature. Both of these theories have now been cast aside.

In regard to speed of freezing, it was believed that the more rapid the freezing - the better the product, because the small crystals formed by fast freezing would not penetrate the cell walls. It was reasoned that the large ice crystals which formed during relatively slow freezing punctured the cell walls and freed the juices which caused "drip" on thawing. Research has shown that the temperature of storage is far more important than the rate of freezing.

In regard to fluctuating temperatures, there is now evidence that the quality of frozen fish is dependent on the mean storage temperature - and that the main disadvantage of a fluctuating increase in temperature is to increase the mean temperature. Of course, high storage temperatures (above 10° F.) should always be avoided because of the relatively rapid rate of deterioration.

Although it has been shown that the rate of freezing is secondary to the storage temperature, some care must be exercised during the initial freezing operation. First, if the freezing is too slow, large ice crystals may form and make the product unattractive when thawed for cooking. Even more important is the possibility that a relatively warm freezer temperature may permit spoilage of the fish before the actual freezing takes place. There have been numerous instances where spoilage of large lots of fish has occurred in the freezing rooms. In some cases this has been caused by overloading a freezer room with warm packaged fillets, the packaging material acting as effective insulation against the cold air of the freezer.

Part of the trouble experienced in the frozen fish industry of the U. S. is caused by the practices of using the freezers as a means of "saving" the "not to

fresh" fish. The fish which are landed when strictly fresh are the ones which are sold in the fresh market; while fish of lesser quality often go to the freezer. This seems to be a logical step, for the producer realizes that the amount of time required to get fresh fish to market and to the consumer is much greater than the time required for the same fish to reach a safe preservation temperature in the freezer. What he may not realize is that the quality of frozen fish is directly dependent on the condition of the fish when frozen. If the fish are of questionable quality when they go in the freezer, they will be even worse when they are removed and thawed. If a fish producer intends to build or maintain his frozen fish business on quality he will freeze only strictly fresh fish.

Very few realize that one of the regular phases of deterioration of quality in fish is loss of flavor. During this phase the fish appears fresh for the flesh has no off-flavor or odor. In fact, there is practically no odor at all. But the sea-fresh flavor and odor are gone. In this stage many people condemn the species as being tasteless - not realizing that they are not eating top quality fish.

NEW PROJECT TO DEVELOP METHODS OF MARKETING "SEA-FRESH" FISH

The Fish and Wildlife Service now has underway a project by which it hopes to devise a means of enabling the fishing industry to market "sea fresh" fish and fish fillets. It is referred to as the "Freezing-fish-at-sea" project. Laboratory and pilot plant tests have indicated that it is possible to freeze at sea strictly fresh fish in the round, bring them to port, hold them in frozen storage for a period; and then remove the fish from storage, thaw and fillet them, package the fillets in the usual manner, and refreeze them.

To test the method under commercial conditions, the Service has obtained a New England trawler. One-half of the hold of the vessel will be heavily insulated and equipped with freezing equipment. The other half of the hold will be used for icing down the fish, as is now the general practice, in order to compare the quality of the frozen and iced fish and to get information on the cost of the two methods. If the freezing-at-sea process can be successfully worked out, it will have these advantages over the present methods:

(1) There will be no question of freshness, for the fish will be frozen almost as soon as they come from the water. (At present there is some question about freshness because fish caught by New England trawlers must be held in ice as long as 8 to 10 days before being filleted. The distance of the fishing grounds from the filleting plants makes it impossible to land all fish in less than this time.)

(2) The vessel can remain on the fishing grounds until it has a full load of fish.

(3) The liver and all other material now discarded at sea will be brought ashore in perfect condition for conversion into byproducts and pharmaceuticals.

(4) The shore plants and labor will be able to operate on a fixed work schedule since the round fish will be drawn from the freezer as needed. This will eliminate the troubles caused by the glut and slack seasons which now occur each year.

HAULING OUT FROZEN HALIBUT FROM AN ALASKAN COLD STORAGE PLANT FOR SHIPMENT TO SEATTLE.

Above all, however, is the advantage that all the fish and fish fillets produced by this method will be of uniform high quality.

It is realized that in this article many important phases of freezing of fish have not been mentioned, such as glazing, dehydration, and oxidation problems with oily fish. Time does not permit a complete discussion of all methods but it is hoped that the few points on the icing and freezing of fish which have been discussed will aid in producing quality fish and thus help both individual businesses and the fishing industry as a whole. What benefits the individual fish producer or dealer will benefit the industry, and what benefits the industry as a whole, benefits the individual business firm in the industry.