USE OF FROZEN SALMON FOR CANNING[1/]

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INTRODUCTION

During past years a relatively small portion of canned salmon has been prepared from frozen fish. Occasionally, during gluts, more fish have sometimes been brought to a cannery than could be handled, and where cold-storage facilities were available, such fish have sometimes been frozen and canned as soon as the glut was over. Such a situation has developed particularly in the Puget Sound area and other areas where cold-storage facilities are available and where the canneries have only a relatively small capacity.

In recent years frozen fish have been canned in an increasingly large amount for other reasons. Concerns which do not have canning facilities in areas where salmon are abundant have been buying frozen fish in Alaska or Canada and bringing them to locations where they have such canning facilities. The fish are then thawed and canned. This situation has developed especially in areas where the normal fish runs (salmon or other species) have been unusually low. In order to be able to continue the operations of such canneries, there has been a tendency to look for fish elsewhere. If the distance from the fishing grounds to the cannery is so great that the fish cannot be successfully preserved in ice, the only alternative has been to freeze them. In some instances the frozen fish have been held a considerable number of months before they were thawed and canned. The practice of freezing salmon for later canning has also further been encouraged by an excess of facilities suitable for handling tuna. The tuna industry in the Pacific Northwest has expanded rapidly in recent years. During several of the past years, when tuna could not be caught in abundance in this area, vessels equipped with refrigeration were available in excess of the needs of the tuna industry. Such facilities, it was felt, might be diverted to the transportation of frozen salmon from distant fishing grounds to canneries in other areas.

Tuna have been successfully frozen and canned for a considerable number of years, and ordinarily no great difficulty is encountered. In applying the same technique to canned salmon, however, certain difficulties may arise which are avoided when tuna are canned. Salmon are canned by a process in which the fish are cooked and heat-processed in the sealed can, whereas tuna receive a "pre-cook" before being placed in the can. This pre-cooking process gives a chance for certain undesirable products which may have formed while the fish were frozen to escape. Furthermore, the skin and often the dark meat lying just beneath and which contain much of the oxidized oil are removed before tuna are canned. Accordingly, with regard to canning of frozen salmon it is necessary to examine the situation very carefully, and it is not sufficient to conclude that merely because frozen tuna can be successfully canned the same must also apply to frozen salmon.

During the past two years, the Fish and Wildlife Service technological laboratories at Seattle and Ketchikan have been carrying out experiments on the canning of frozen salmon. Salmon have been canned from fish which had been frozen round and

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stored under different conditions and the resulting packs compared for quality against fish canned from samples which had not been frozen. Relatively large samples, consisting of a considerable number of cases, have been packed and examined. Tests on these packs are still continuing but a number of general conclusions have been drawn so far. These will be discussed without specific reference to any scientific data which will be published at a later date after the tests have been completed.

There are three types of changes which may take place when using frozen salmon for canning that do not ordinarily occur when fresh (unfrozen) fish are canned. The first change involves bacterial spoilage of the fish during the freezing process; the second, deterioration, including oxidation of the fish after it is frozen and while it is being held in the frozen state in cold storage; and the third, alterations in the salmon which are brought about directly by the freezing process. The first two of these involve changes which can be eliminated or greatly minimized by proper handling techniques; the third, which is beyond control by proper handling techniques, can be held to a minimum by limiting the storage period of the frozen fish.

BACTERIAL SPOILAGE OF SALMON DURING FREEZING

Undoubtedly, the most serious and yet the most easily prevented change which may take place in frozen salmon is bacterial spoilage during the freezing process. This takes place when the fish are frozen at an exceedingly slow rate--many hours elapse before the fish are frozen completely through to the center. This difficulty is encountered when inadequate freezing facilities are available and a larger quantity of fish frozen than the refrigeration capacity of the freezing equipment is designed to handle. Such a situation often occurs on vessels where space is at a premium and it is impossible to carry a large reserve of refrigeration. In the case of refrigerated tuna boats, fish are usually frozen in brine wells and it is easy to place more fish in the well than the system was designed to handle. Poor circulation of the brine may cause extremely slow freezing to take place at certain locations in the brine well.

REMOVING CANS OF SALMON FROM RETORT AFTER PROCESSING AT A SERVICE TECHNOLOGICAL LABORATORY.

In freezing, even when proper circulation of the brine takes place and no overcrowding of the wells is attempted, the outside of the fish first starts to freeze,

and the frozen zone gradually moves to the center. Whereas the outside portion of the fish may start freezing within a few minutes after the fish is placed in the brine well, the center of the fish may not be frozen for 12 or more hours. During the first few hours after the fish is placed in the brine well, the temperature at the center of the fish may be only slightly lower than it was when the fish was placed in the brine. If bacteria are present within the center of the fish, spoilage will continue for some hours after the fish is placed in the brine well. If the brine well is overcrowded and inadequate refrigeration and circulation of the brine is present, the length of time required for freezing the center of the fish ordinarily may be extended from one-half a day to several days. Under such circumstances extensive bacterial spoilage may take place in the centers of some fish in the brine well even though the fish were in prime condition when placed in the well. It is extremely difficult to cull out partially spoiled fish when they are thawed for canning since spoilage is present only at the center of the fish and may be easily overlooked. This spoilage, moreover, is of the type that will render the fish inedible and subject to seizure by the Food and Drug Administration. Hence, if such fish should be canned, it is necessary to open the entire pack and re-process those which have not spoiled, an exceedingly expensive and undesirable procedure.

Fortunately, this difficulty can be completely eliminated by using an adequate refrigeration capacity and making certain that the system is not overloaded. If this difficulty is to be eliminated, a person with the necessary technical knowledge of the capacity of the equipment must be present at the time the fish are frozen.

DETERIORATION OF FROZEN SALMON IN COLD STORAGE

The most important change which takes place in frozen salmon in cold storage is oxidation of the oils and pigments of the fish. This is a chemical change whereby oxygen from the air combines chemically with the fish oil and fish pigments to form new chemical compounds which alter the flavor and appearance of the fish. The color of the fish may be altered considerably. This takes place in two ways: the normal pink or red color of the salmon fades to a more-or-less colorless hue as a result of the oxidation of some of the pigment. An even more objectionable change may take place in the oil directly beneath the skin. In some cases this oil oxidation changes the color of the normal salmon hue to a dark brown or nearly black color, giving a very unsightly appearance to the canned product. Accompanying these color changes are alterations in the flavor of the fish oil. The fresh oil has a bland, somewhat fishy flavor; upon oxidation, the oil acquires a sharp, penetrating flavor which is known as rancidity. Development of rancidity, if carried to an extreme condition, makes the fish inedible.

Changes brought about by oxidation during cold storage are further accentuated by canning. Thus, fish which have reached an incipient stage of oxidation and show only a slight or no off-flavor after thawing and canning, may have a strong off-flavor. For example, pink salmon, which appear to be in good condition after six months storage at 0° F., will yield a canned product having a definite off-flavor even though the thawed fish would have been of satisfactory quality had they not been canned.

The five species of salmon are not affected to the same extent by the action of oxygen during cold storage. Pink salmon are by far the most prone to oxidation. This species may become completely rancid within a few months of the time it is placed in cold storage, whereas the other species protected only by mediocre means,

oxidize to such a small extent that they usually can be held without serious deterioration for at least nine months. Pink salmon are seldom cut into fillets or other dressed forms and then frozen. Since their storage life is of an exceedingly short period, they cannot be marketed before becoming inedible. When pink salmon are stored round and if protected adequately by an ice glaze, they can be stored for about six months before evidences of rancidity and oxidation become pronounced.

Most of these changes due to oxidation can be minimized by using good handling practices during cold storage. One of the best ways to minimize these changes is to hold the fish at as low a temperature as possible. Fish stored at 0° F. will keep more than twice as long as fish stored at 20° F. In addition to the use of low storage temperatures, it is important to protect the fish in such a way that oxygen from the air does not reach the meat or oil. For whole fish, this is best accomplished by providing a good ice glaze of sufficient thickness when the fish are first put in cold storage. If such fish are held for a sufficiently long period, the ice glaze may disappear by evaporation. In such cases, it is important to replace the glaze before it has disappeared by re-glazing or spraying the fish if they are to be held for any extended period of time. The ice glaze should be applied immediately after the fish have been completely frozen.

CHANGES CAUSED BY FREEZING

When fish are canned, usually a small part of the protein rises to the surface of the can and coagulates to form a white substance resembling egg white, commonly known as curd. Ordinarily, this curd forms in such a small quantity as to be unnoticeable. Frozen fish have a tendency to form more curd than fresh fish. Apparently the freezing process causes a certain amount of denaturation which gives a product more curd than would be the case if the fish had not been frozen.

The curd is more objectionable in canned fish when the main bulk of the fish has a bright color, contrasting sharply with the white color of the curd. Thus, chum salmon, which have a very light color, even without the curd, are not seriously impaired even with a considerable quantity of curd. When fish having a bright red color (such as chinook or sockeye salmon) are canned, there is a marked contrast between the color of the curd and the color of the canned fish. A small amount of curd formed with such fish will be readily noticed and may detract considerably from the appearance of the canned product. Accordingly, the increase in curd formation brought about by canning frozen fish is a less serious problem with chum and pink salmon than it is with the other species, especially when the fish have been stored for only a short period of time. When salmon stored in the frozen state for several months are canned, the curd will be dark and discolored, and this is objectionable for all species.

All salmon contain a certain amount of body oils, the amount varying from a very small percent in the case of chum salmon to more than 10 percent of the weight of king and sockeye salmon. Ordinarily, this oil is dispersed throughout the fresh or frozen salmon. When salmon is canned, however, some of the oil is released from its combination with the tissues of the fish and works its way to the top of the canned fish. It can be noted that there is a certain amount of moisture mixed with oil at the surface of an opened can. This oil, which is known as free oil, represents only a part of the oil in the can since most of it is still combined in the tissue of the fish. Fish which contain only a small percentage of oil in the meat will give a very small amount of free oil, whereas the more oily species, such as chinook and sockeye, yield a very appreciable amount of free oil.

In certain markets the presence of free oil is considered as giving the canned salmon a premium value, and fish which have less than the average amount of oil

would be considered of inferior grade. It has been found that when salmon are frozen thawed, and canned, the amount of free oil is lower than in cases where the fish have not been frozen. Some free oil is always present, but there is a definite decrease in the amount. This lowers the value of the pack in the eyes of certain brokers, especially in the case of the more oily and expensive species, such as canned chinook salmon. The nutritive value of the fish has not been diminished because the total oil content of the canned salmon remains the same. It is merely that more of the oil is held within the tissue of the fish canned from frozen salmon than is the case of fish which had never been frozen.

In addition to these changes resulting in loss of free oil and excessive curd in salmon canned from frozen fish a definite change in the texture of the fish is noticeable. Salmon canned from frozen fish tends to be firmer and appears drier than that canned from fresh (unfrozen) fish. Many individuals do not find this objectionable when it is present to a slight extent and some even prefer it to the softer, moist texture of a normal pack. In many instances, however, the texture becomes excessively firm and even tough. The salmon seems much drier and has a definite "woody" texture noticeable when eaten. This is especially true of packs prepared from salmon frozen and stored for periods longer than two months and it is objectionable to most people. Apparently these alterations in the texture of the fish are related to the changes which cause loss of free oil and presence of excessive curd in salmon canned from frozen fish.

These changes resulting in loss of free oil, formation of curd, and development of undesirable texture in salmon canned from frozen fish are changes for which there is no simple remedy as yet. However, neither the curd nor free-oil problem is extremely detrimental but does cause a slight lowering in the quality of the fish.

Table 1 - Summary of Importance of Various Problems in Canning Different Species of Frozen Salmon

Problem	Relative Importance				
	Chum	Pink	Silver	Sockeye	King or Chinook
Spoilage[1]	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Oxidation[2]	XXX	XXXXX	XXX	XXX	XXX
Curd[3]	XXX	XXX	XXX	XXXX	XXXX
Free oil[3]	X	XX	XXX	XXXX	XXXX
Abnormal texture[3]	XXX	XXX	XXX	XXX	XXX

1/ THIS PROBLEM CAN EASILY BE OVERCOME BY USE OF PROPER TECHNIQUES IN FREEZING THE FISH.
2/ THIS PROBLEM CAN BE GREATLY REDUCED OR ELIMINATED IF ADEQUATE TECHNIQUES ARE APPLIED IN STORING THE FROZEN FISH AND IF IT IS NOT ATTEMPTED TO STORE THE FISH FOR TOO LONG A PERIOD OF TIME.
3/ THESE PROBLEMS CANNOT BE COMPLETELY CONTROLLED BY PROPER FREEZING AND STORAGE TECHNIQUES, BUT CAN BE HELD TO A MINIMUM BY NOT STORING THE FROZEN FISH FOR TOO EXTENSIVE A PERIOD OF TIME.

XXXXX FACTOR OF CONSIDERABLE IMPORTANCE.
XXXX FACTOR OF IMPORTANCE.
XXX FACTOR OF SMALL IMPORTANCE.
XX FACTOR OF VERY SMALL IMPORTANCE.
X FACTOR OF NEGLIGIBLE IMPORTANCE.

Table 1 summarizes the relative importance of the problems of spoilage, oxidation, curd, and free oil when different species of salmon are canned from frozen fish. Spoilage of the fish before they are completely frozen can be a very serious problem with any of the five species. The least difficulty is encountered with the other problems when frozen chum salmon is canned. Frozen pink salmon can be successfully canned provided adequate care is taken to protect it against oxidation in cold storage. With silver, sockeye, and king salmon, even with the best freezing and storage handling methods, some small though definite decrease in quality of the canned salmon will result.

RECOMMENDATIONS

In order to obtain the highest quality pack of canned salmon, it is recommended that wherever possible unfrozen fish be used. When frozen salmon are used for canning, the pack will always be slightly inferior even though the utmost precautions are taken and the best technical knowledge is applied to the freezing and cold storage of the fish. If such technical knowledge is used throughout the processing of the fish, it should be possible to obtain a product which is perfectly marketable even though slightly inferior to the best packs of unfrozen fish. Adverse quality changes are greater for salmon which have been frozen for long periods even though proper storage procedures are observed. For this reason it is recommended that the length of storage for the frozen fish be held to a minimum. To minimize quality changes during storage, periods longer than two to three months at 0° F. are not recommended. If frozen fish must be used, it is of extreme importance to use the best modern knowledge of freezing and storing techniques. If such practices are ignored, packs will result anywhere from being of extremely low quality to an extreme case where the pack is completely inedible and must be discarded or re-processed at considerable loss to the packer.

REFRIGERATED LOCKER STORAGE OF FISH AND SHELLFISH

Too frequently the locker operator and user fail to realize that fish as well as other foods have a maximum storage life even in the frozen state. The dry atmosphere of the storage room and the difficulty encountered in sealing the product away from air contribute most to shortening storage life.

Several changes take place in locker storage which must be guarded against by adequate packaging to exclude air. One change, common to all frozen fish, is a gradual removal of moisture from the flesh over a prolonged storage period in the relatively dry atmosphere of the cold-storage room. This drying renders the fish tough, fibrous, and insipid. The other change which occurs with certain oily fish is an oxidation resulting in development of rancidity, fading or other changes in the pigments of fish having colored flesh (as salmon), and development of off-colors (usually yellow or brown) sometimes known as "rust." These changes eventually render the fish flesh inedible. A guide by Stansby and Harrison (1942) and Stansby and Dassow (1942) for selecting a packing method and estimating the storage life of frozen salt-water fishes asserts that, in general, a locker storage life of at least six months may be expected for the most properly packaged frozen fish.

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