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STEPS IN THE HANDLING OF FROZEN FISH IN THE FREEZER WAREHOUSE

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The operators of refrigerated storage warehouses and freezers make up one of the most important links in the chain of frozen food distributors. It is necessary for them to have a broad knowledge of the products being handled in their establishments if the consuming public is to be offered frozen foods meeting high quality demands. It is not possible for the warehouse operators to improve upon the products which are delivered to them for safe keeping, but by maintaining high standards of operation they can insure that high quality products delivered to them will proceed in the line of marketing without deterioration due to faulty storage practices. The science of food refrigeration has advanced at present to a point where there are specific rules for succesful storage of almost all food products which are preserved by this method.

The fish producers pioneered in the field of freezing food products for future consumption as early as 1917. Many of the early attempts to store this highly perishable food product met with failure due to the inadequacy of knowledge of the approved methods of handling. These early attempts also placed additional responsibility on the operators of refrigerated warehouses since they were included in the chain of distribution. While much has been accomplished in the way of establishing improved practices, there are still many failures not only in the handling of fish, but in other products.

In order to successfully handle a frozen food storage warehouse, an understanding of the general peculiarities of the products being stored is desirable. Fish, including shellfish, should be classified into two broad groups according to the oil content of the flesh. Those fish which store oil or fat in their livers are generally referred to as non-oily and should be classified into one group for handling purposes. Typical representatives of this class are: cod, halibut, haddock, and swordfish. The second group contains those which have oil or fat distributed throughout the tissue composing the flesh and should be considered as fatty fish. Into this group should be placed such species as salmon, mackerel, herring, and others. The percentage of oil in the flesh of these two groups varies over a wide range; however, the flesh of the non-oily fish contains less than three percent, while those to be considered as the oily

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group contain considerably more than three percent fat. The nature of deterioration in storage is, within certain limits, dependent upon the particular type of fish.

If shellfish were to be classified according to the fat content it would fall into the non-fatty group; however, the greatest cause of deterioration of shellfish in frozen storage is caused by the discoloration and the development of an off flavor due to the chemical which gives it the natural pinkish color. This chemical change is greatly hastened by even slight dehydration.

In any discussion of methods of handling frozen fish, it is necessary to consider to some extent the changes that occur naturally and cause deterioration of both the fresh and the frozen fish. There are three primary types of spoilage which are responsible for the deterioration: first, the action of bacteria with which the seafood becomes contaminated from handling after removal from the water; second, the oxidation of the oil composing a portion of the flesh; third, the action of substances contained within the tissue, which are known as enzymes.

When the fish are frozen and stored at a low temperature the action of bacteria is almost entirely arrested, and for all practical considerations, spoilage from that cause is eliminated. The second type of spoilage is the oxidation of the oil or fat contained in the flesh of the fish, which imparts a rancid odor and flavor. In instances where the fish are of an oily variety and are stored frozen over a considerable period of time, this spoilage is often of serious consequence. In general it is not possible to state with any degree of accuracy the length of time fish may be held in cold storage before being marketed. Some of the oily species are stored over considerably longer periods than others, and only those which are held for periods exceeding six months are likely to deteriorate from the oxidation of oil. Where the fish are properly glazed with a coating of ice, or covered with moisture-proof wrappings, reaction between the oxygen of the air and the oil is reduced to a minimum and oxidation is not a factor for much concern.

The enzymes are substances contained in the flesh of the fish which build up and tear down the tissues during the life processes. These reactions are common to all forms of animal life and are automatically controlled so long as the animal is alive. Upon death the enzymes which build the tissue are inhibited but those which tear down the tissues may remain active. The temperature at which the tissue is stored has a definite effect upon the rate or speed of this reaction. In fish which are stored at a temperature of 30°F. the rate is much greater than in those which are frozen and stored at 0°F. or below. This accounts for the value of freezing as a method of preserving foods for future use. While the action of these enzymes will eventually cause complete spoilage of any animal tissue as a food, they cannot be considered entirely detrimental as the process of "ripening" is necessary for meats derived from warm-blooded animals. Such "ripening" is not necessary nor desirable for fishery products, however, as the texture and composition of the flesh are such that the flavor is available without ripening. There is no method known at present for the prevention of the enzyme action in frozen food products of animal origin; but it can be greatly reduced by low temperatures. It is considered advisable to freeze and store fish at as low a temperature as is economically possible.

This varies between 0° and 10° above zero F., with a minimum of fluctuation.

"Quick-freezing" has never been defined--there are a great variety of ideas as to just what constitutes a quick-frozen product. Each firm is apt to refer to its own method as quick-freezing regardless of the condition under which the results are accomplished. Much depends upon the rate at which freezing proceeds through the tissue, and it is generally conceded that fish frozen at the low temperatures are superior to those frozen at higher temperatures. The Newfoundland Government has recently issued instructions to its seafood inspectors. These instructions contain the definition of a quick-freeze as; "the process used is such that the fall in temperature of the fish during freezing from 32° F. to 25° F. occurs at a speed which insures a minimum disturbance of the tissue structure." This may or may not be an adequate definition of what constitutes a "quick-freeze."

The temperature of the cold storage room should be held constant at all times, and not permitted to fluctuate over a wide range. It will pay dividends in quality to make a thorough check of the storage room temperatures at intervals to obtain definite data on the range of fluctuation. After an analysis of the data thus gained it can easily be determined whether or not the controls are functioning properly. If it is found that they are not holding the room at the proper range of temperature, definite knowledge of changes to be made in the equipment will be available.

In the case of small warehouse operators it may not be economically feasible to set aside certain rooms for use of fish only. Storing fish with other foods does not offer insurmountable difficulties because it has been found by actual experimental tests that fish can be stored successfully together with other products without imparting "off odors." If the operator of the warehouse is satisfied that the products are all properly wrapped for the greatest protection, dairy products and fish can be placed in the same room without transfer of odors. The only requirement for the storage of fish and other products together in the same cold storage room is that both products should be properly protected by wrapping in a recognized moisture-vapor-proof material.

The problem of odor transfer in cold storage rooms is one of long standing and fraught with much misconception. In order to obtain direct data dealing with the subject the scientific staffs of both the U. S. Department of Agriculture and the U. S. Fish and Wildlife Service have studied it. Butter was selected to be stored with fish because of its delicate flavor and its reputation for absorbing the odor of other products when stored with them. The services of an expert "butter taster" were used in the tests since the flavor was the controlling factor.

Butter was wrapped in the usual wrapping material and placed into a sealed tin container. Several samples were prepared using different species of fish in all but one, in this one only butter was placed and was used as a control. The fish fillets were individually wrapped in a cellulose base moisture-vapor-proof material which is commonly available on the market. Samples of butter were removed from the sealed cans at intervals and examined for odor and flavor by an expert and graded according to the standard for butter. Table

1 contains the results of this test.

Table 1.--Change in quality of 93 score butter when stored in a refrigerated locker at 10° F. with packaged fish.

Storage of samples	Average Score of Butter Stored			
	7 days	14 days	32 days	337 days
Butter without fish.....	93.0	92.0	91.5	91.0
Butter with sole.....	93.0	92.0	91.5	91.5
Butter with oysters.....	93.0	92.0	91.5	91.5
Butter with salmon.....	93.0	92.0	91.5	89.0

The favorable results of this test and similar ones have been questioned by many warehouse operators and others since it is felt that some careless fish packers or locker plant operators may not be successful in such storage practices. It cannot be over emphasized that these results are due to proper wrapping. The only way in which an operator of a warehouse can be certain of the success of storing different food products in the same room is to assure himself that the products are properly wrapped, in safe wrapping material, when he accepts them for storage. This can be done by making a spot check of the products when they are delivered at his warehouse.

Another problem which confronts the warehouse men is that of the so-called storage life of fish. This again depends largely upon the quality of the product when delivered to the warehouse and the care with which it has been wrapped or otherwise protected from the dry atmosphere of the storage room. There are, however, some precautions which can be taken by the operator of the warehouse. The most important of these is the constant temperature of the cold storage room. When fish are stored with only an ice glaze, the humidity of the room is of prime consideration, and unless steps are taken to hold a saturated atmosphere in the room, the glaze will evaporate quickly and thus cause deterioration due to dehydration or freezer burn.

Table 2 gives the storage life as determined by experimental practice and has been recommended for guidance of locker operators, but applies as well to the operator of any cold storage warehouse or to any distributing warehouse.

The factor over which the warehouse operator has little control is the quality of the product delivered to his establishment for storage. By proper handling of the product he can assure his clients that the quality will not deteriorate unnecessarily due to his faulty methods of operation. One important consideration is the prompt handling of the products delivered to the warehouse whether already frozen or to be frozen by him. The promptness of this handling goes a long way toward the delivery of the product to the consumer in the best possible condition.

Fish should never be packaged and placed in the warehouse without first being frozen in a regulation freezer until hard frozen. If fish in packages are delivered to a warehouse, it is the responsibility of the operator to assure himself that they are frozen hard before placing them in the warehouse for storage. If it should happen that the fish are only partially frozen and

are piled in the warehouse after the general method there is considerable likelihood that internal heating will occur and those packages in the center of the pile will be completely spoiled when removed. Such cases have been recorded a number of times, with serious monetary losses to the operator.

Table 2. Estimate of the Probable Storage Life of Frozen Fish 1/

Species	Round or headed and gutted	Wrapped and packaged
	Months	Months
Butterfish	6- 8	10-12
Cod	8-10	10-12
Croakers	6- 8	8-10
Flounders (and sole)	8-10	10-12
Grouper	6- 8	8-10
Haddock	8-10	10-12
Halibut	8-10	10-12
Lake herring	6- 8	8-10
Lingcod	6- 8	8-10
Mackerel		
(Spanish)	6- 8	6- 8
(Boston)	6- 8	6- 8
Mullet	6- 8	8-10
Porgie (scup)	8-10	10-12
Pollock	8-10	10-12
Pike (all species)	6- 8	8-10
Rosefish (ocean perch)	6- 8	8-10
Red snapper	6- 8	8-10
Rockfish	6- 8	6- 8
Salmon (except pink)*	6- 9	6- 9
Sole	8-10	10-12
Smelt	8-10	8-10
Sablefish	6- 8	8-10
Sea trout	6- 8	6- 8
Shrimp	6- 8	8-10
Whiting	8-10	10-12
Whitefish	8-10	8-10

*Pink salmon does not keep well when wrapped.

1/ It is often of value for a warehouse operator or a frozen fish producer to obtain an idea of the period of time that his product can be expected to remain in a salable condition. The above table contains such an estimate expressed in months in storage. The times shown in the table are based on the assumption that the fish were in first class condition when landed and that they were prepared and frozen without delay. It should also be understood that the temperature in the storage room is held at a minimum of fluctuation and other approved conditions. The estimated times are based upon experimental data and general commercial practice.

In cases where the freezer is in the building with the storage space, the frozen fish should be transferred from one to the other with as little delay as possible.

Many of the failures of satisfactorily freezing fish have been attributed to the fact that the fish were not "quick-frozen." It is now recognized that the constant storage temperature in the warehouse may have as great or greater influence upon the success of freezing fish as the rate at which it is originally frozen. Even the effect of extremely fast freezing can be off-set by a wide fluctuation in the temperature of storage rooms, since the fluctuation in room temperature causes a growth of the size of the ice crystals in the tissue.

Boxes and cartons of frozen food products, particularly fish, should be piled in the warehouse with care to insure free circulation of the cold air around and between them. Due to internal heating the center of a tight pile of cartons of fish has been known to defrost even at a room temperature of 0° F. This is explained by the enzyme action within the flesh of the fish, particularly where the fish is packed in corrugated paper cartons, which furnish good insulation. The piles should also be spaced well away from outside walls of the building or if the wall is next to a room carrying a higher temperature.

Fish which are frozen in the round, or those which are too large to be wrapped in moisture-vapor-proof material, should be glazed with a heavy coating of ice to prevent freezer burn or dehydration. In order that the glaze can be maintained it is necessary to examine them in the storage room at frequent intervals to be sure that the glaze has not evaporated. Reglazing should be done as soon as the condition of the glaze indicates it is necessary. Water for this purpose should be as cold as possible without freezing in the sprayer, so that it will freeze almost instantly when sprayed on the cold fish. In many cases where large fish are frozen on expansion coil shelves in a sharp freezer they are left in the freezer longer than is necessary without the protection of the glaze. This practice often results in serious losses due to freezer burn and actual loss of weight due to dehydration. The correct practice in the case of large fish is to remove it from the sharp freezer and glaze promptly so as to reduce losses to a minimum.

Fig. 1. Sharp freezing large fish. Tnese unglazed fish are subject to dehydration.

Table 3. Time Required for Ice Glaze to Evaporate from Surface of the Fish

Species of fish	Weight in grams	Weight of glaze, grams	Weight of glaze, % of weight of fish	Duration of glaze, days
Mackerel.....	434	56	13.0	18
Haddock.....	964	142	15.3	22
Cod.....	2588	252	9.8	28
Flounder.....	293	64	21.9	20
Eel.....	296	41	13.8	14
Pollock.....	4270	472	11.1	33

Source: Special Report #7, Walter Stiles.

When it is necessary to load frozen fish directly from the warehouse into refrigerator cars or trucks the order should be placed with the transportation firm sufficiently early to allow ample time to chill the carrier thoroughly before it is loaded. Usually this is twenty-four hours, unless the carrier containing frozen products has just been unloaded. If precooling is required it can be accomplished by loading the bunkers with a 30 percent salt and ice mixture and let stand with the doors closed. When the temperature of the car or truck has reached approximately that of the cold storage room the loading operation can be safely started. Loading should be completed as rapidly as possible. Conversely when a car or truck of frozen fish is received at the warehouse for storage, the unloading should be carried forward as rapidly as possible without delay if the best results are to be obtained. It has also been recommend that ice and salt mixture should be used for transport of frozen fish regardless of the season of the year, since it is difficult to forecast sudden changes in the weather.

When packages of fish are received at the warehouse and it is found that they have defrosted during transit, the operator should make a careful examination of the entire lot. This is not only for the protection of his own interests, but the information should be given to the client so that he may know that possible damage has occurred. Those packages which are found to be entirely defrosted should be examined with particular care. If it is determined they can be refrozen and remain in good condition, they should be placed in a freezer without delay. In determining whether or not the fish should be refrozen, an allowance of approximately 24 hours freezing time should be made. If it is questionable whether the quality will be maintained by refreezing, a prompt disposal of them should be recommended to the owner even though it entails some loss.

As a general rule, fish which have only partially defrosted can be refrozen with a reasonable assurance that a first class product will result. In any case, any attempt to refreeze fish which are packaged in original corrugated shipping containers will probably result in failure. The cartons contained in the shipping case should be unpacked and placed in the freezer individually so that they will refreeze as rapidly as possible. Repacking in the larger container should not be undertaken until the contents of the smaller ones are completely frozen.

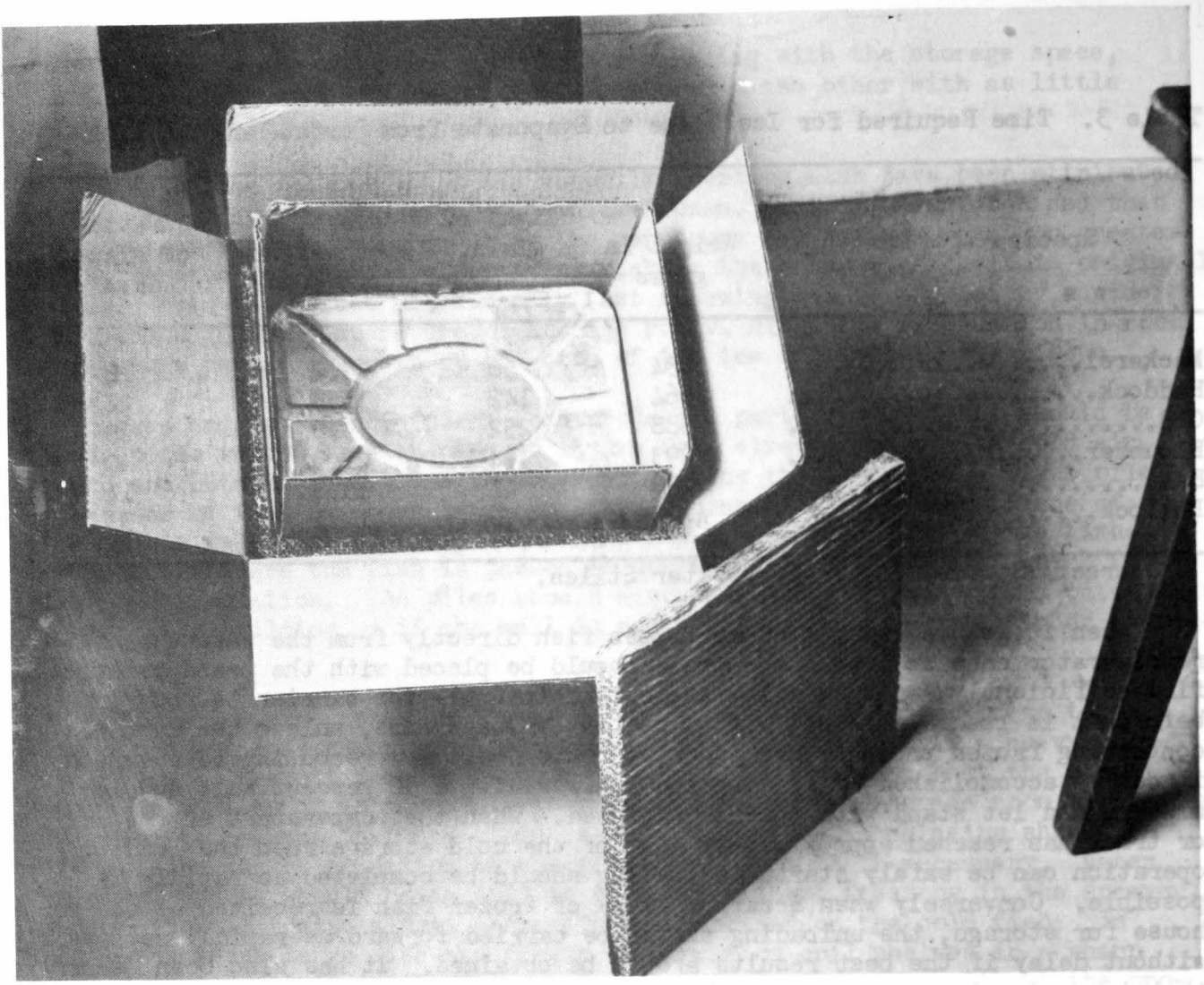

Fig. 2 Insulated container coming into common use.

Those operators of cold storage warehouses who are not keeping informed of the general recommendations for handling fish are not only increasing the sales resistance to fish, but to all other frozen food products as well, since all frozen foods are in a class by themselves. Since the scientific progress in the study of food freezing is so rapid, it is imperative for the warehouse operator to keep abreast of the new advances as they are reported.