Extension Bulletin E-1323 (MICHU-SG-80-510) FILE: 23.511

Commercial Freezing of Freshwater Fish

Cooperative Extension Service • Michigan State University
Michigan Marine Advisory Service

By A. Estes Reynolds, Tom Rippen
and Cherie LeBlanc*

There is only one reason to freeze fresh fish and that is to preserve its quality. Fish is one of the most delicate and perishable of all foods. Therefore, freezing requires the utmost care from the time of catch to the time of freezing. The job is not completed at that point, but must be followed by proper packaging, -20°F cold storage and good management to market the product successfully.

The quality of frozen fish is affected by several factors—pre-freezing quality, handling during preparation and protection by packaging and antioxidants during freezing and storage. This bulletin covers each of these areas and offers suggestions for extending shelf life.

Economic Considerations

A fish processor thinking of freezing fish in order to even out the highs and lows of supply-and-demand curves must consider special aspects which do not normally apply to marketing fresh fish. The most obvious considerations are freezing capacity, storage space and related facilities. These capital investments must be considered in the total cost of the frozen product. Other elevated costs are related to equipment maintenance, vapor-proof packaging, labor, utilities and low-temperature transportation. Another consideration is market potential and competition for the consumer's dollar. In most cases, some food in the consumer's diet must be replaced by the fish product if it is to sell. If the consumer is already eating fish, a new product must offer an advantage over the competition.

When estimating the economic advantage of freezing, keep in mind that fish have a limited shelf life. Improperly protected whitefish can lose significant quality and value in less than one month of frozen storage.

Let's look briefly at the cost of processing and freezing 100 pounds of round fish and producing 100 pounds of frozen fillets:

	Pound	100 Pounds Round	100 Pounds Fillets
Cost of round fish	$.50	$50.00	$ 83.33
Cost of freezing	.015	.90	1.50
Antioxidant	.03	1.80	3.00
Packaging	.05	3.00	5.00
Storage	.005	.30	.50
Labor	.04	2.40	4.00
Investment 11% per year		3.21	5.35
		$61.61	$102.68
Overhead 20%		12.32	20.54
Product cost		$73.92	$123.22

This table does not include all costs, and it is based on estimates, not actual costs. Thus each processor should make up a similar list and determine his costs before entering the market.

Fresh Fish Quality

Only the finest quality fish should be frozen. Freezing does not upgrade or restore any quality which has been lost due to improper handling, high temperatures or poor sanitation. Freezing fresh, high-quality fish will guarantee a consistent, marketable product to repeat customers. Thus it is of utmost importance to freeze fish as soon after catch as possible.

Several quality factors deteriorate rapidly after fish die which affect their flavor and texture when

*Dr. Reynolds is former Extension specialist, Department of Food Science and Human Nutrition, now at the University of Georgia, Athens; Tom Rippen is an advisory agent in the Department of Food Science and Human Nutrition; and Cherie LeBlanc is former laboratory technician in the MSU Meat Laboratory.

1P-9:80-2.5M.JP

Price 20 cents

frozen and thawed. Tissue breakdown by enzymes as a result of poor handling and high temperature causes the connective tissue between muscle blocks to become soft and cause gaping. Gaping is the separation of muscle blocks which gives an open appearance to the fillet and allows the flesh to dry out and lose juices. The longer after catch before freezing, the greater this problem becomes (Figure 1).

Studies at Michigan State University agree with many other sources in confirming that even while holding in ice, fresh fish flavor is lost quickly—before off-flavors develop. In order to produce a high-quality, frozen product, fish should be rapidly chilled on board after catch, handled with care and processed as soon as possible under sanitary conditions. When these guidelines are followed, degradation due to microorganisms and enzyme activity is minimized.

Improper handling results in poor-textured and off-flavored fish which are as harmful to business as no fish at all.

Freezing—Effects on quality

Fish muscle starts to freeze at approximately 29°F and is essentially frozen at about 18°F. At this point, bacteria cease to grow; however, they are not killed, only frozen. As soon as fish is thawed, they continue to grow; thus it is imperative to keep bacteria numbers as low as possible. Always clean and sanitize filleting tables, knives and hands. Thoroughly wash dressed fish and fillets of slime, blood, kidney and viscera prior to freezing.

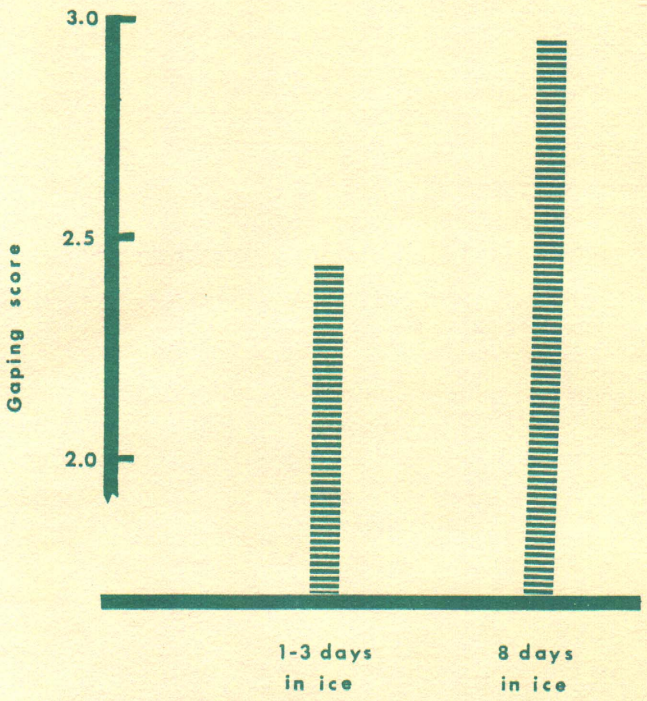

Figure 1 — Effect of time before freezing on gaping (occurrence of separated or torn flesh when thawed.) Source: R. M. Love and M. A. Haq, 1970. Journal of Food Technology. Vol. 5, No 3. Pages 249-260.

Freezing forms ice crystals in the flesh which tend to break down muscle texture. This breakdown releases juices and enzymes when fish is thawed and allows bacteria to grow at a faster rate due to the available food. The problem is greatly enhanced by slow freezing or fluctuating temperatures during storage.

During slow freezing, relatively large ice crystals form. Therefore freeze the product as rapidly as possible to retain texture and flavor. Remember that small objects freeze faster than large; freeze fillets individually or in thin boxes.

Fish oxidize during frozen storage, resulting in rancid off-flavor. To prevent this, fish must have protection. Antioxidants help to deter chemical reactions associated with oxidation, but proper packaging is the most effective means of control.

Dehydration or freezer burn will also occur if fish is not tightly packaged to prevent moisture loss during frozen storage. Dehydration and oxidation frequently occur simultaneously. Fish that are ice-glazed to protect against these problems must be reglazed when the ice layer evaporates or cracks.

Each lot of fish should be labeled and dated to insure that stock is turned over on a first-in, first-out basis.

Antioxidants

Antioxidants are chemicals which tie up oxygen or in other ways hinder the progression of chemical changes in fat. When fish are packaged and frozen without the benefit of an antioxidant, oxygen within the package oxidizes the fat to produce rancid and unpleasant off-flavors during frozen storage. Even storage below 0°F can only partially control product deterioration. The problem is especially acute with fatty fish such as whitefish. Oxidized fish have a severely limited market and are detrimental to the trade.

Using Antioxidants

Several antioxidants are effective when used according to manufacturers' recommendations. A brief soak in a 1% solution of ascorbic acid or

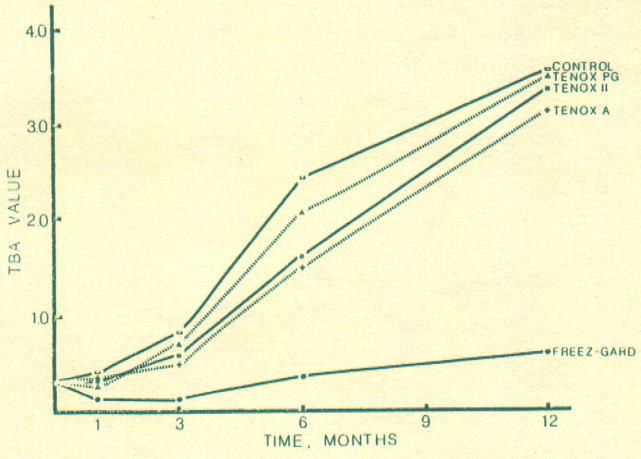

Figure 2 — TBA values of mechanically deboned suckers harvested in the summer, treated with and without antioxidants, and stored at -18°C for up to 12 months.

erythorbic acid (1½ ounce per gallon of water) will help to preserve properly packaged or glazed fish. The synthetic antioxidants BHA, BHT, TBHQ and PG can be used only at very low concentrations, which makes uniform application difficult. The adage "when a little is good, more is better" does not apply to antioxidants. Excess may actually encourage oxidation or violate state and federal regulations.

Many studies, including work conducted at Michigan State University, have shown the value of phosphates and salt as well as antioxidants for texture and flavor improvement of frozen-thawed fishery products.[1] *FREEZ-GARD*, a commercial combination of salt, phosphate and erythorbate, is a suitable product for pre-treating fish for freezing.

The recommendations listed in the next column apply to 1% ascorbic acid and erythorbic acid dips as well as to *FREEZ-GARD*.

Packaging

Fish must be properly protected during freezer storage to prevent excessive dehydration and fat oxidation, as well as to reduce the opportunity for further contamination. Several types of packaging materials are currently used for fish which vary in their ability to meet all of the desired characteristics. An effective package is strong, tight-fitting, impermeable to moisture and air, and relatively inexpensive.

[1] Salt acts to *increase* the rate of oxidation unless combined with an appropriate antioxidant.

Polyvinyl chloride (PVC), polyester, and aluminum foil all form excellent barriers, although foil is easily torn.

Polyethylene is durable but offers less protection against oxidation.

Wax paper and cartons, traditionally used by the fishery industry, suffer from looseness of fit and allow the passage of air and moisture. On the other hand, an ice glaze provides the closest, form-fitting package of all. A well sealed vacuum package is preferred by many, since not only are drying and oxidation minimized but storage space is conserved.

Several procedures for packaging frozen fish

FREEZ-GARD Procedures

1. Prepare a 12% *FREEZ-GARD* solution (1% by weight of fish):
   - —Mix one pound of *FREEZ-GARD* with one gallon of soft water to treat no more than 96 pounds of fish.
   - —This compound may be difficult to get into solution, so increasing the concentration is wasteful and usually unsuccessful.
   - —To aid mixing, add *FREEZ-GARD* to a small amount of warm water, stir for a few minutes, then add to remaining cold water.
   - —Make up fresh solution daily, or refrigerate unused portion for the following day.
2. Thoroughly wash fish to remove slime, blood and viscera.
3. Soak fish in solution 30 seconds to 5 minutes, depending on thickness. Less time is required for skinned fillets than for scaled, dressed fish.
4. Immediately drain and freeze rapidly.
5. Package in a barrier film, preferably under vacuum.
6. If fish are to be glazed, freeze them solid (4 to 12 hours) then briefly dip them 2 to 4 additional times in a solution of 2 ounces of *FREEZ-GARD* per gallon of soft water. After ice glaze has formed, quickly return fish to the freezer prior to cold storage.

are suitable. The best is to soak fillets or dressed fish in antioxidant, freeze, dip once for a light glaze and then vacuum package. Package them individually for consumer sales or in 25-pound bags if boxed for the restaurant trade. Freezing in this manner is recommended when a long storage time (up to 6 months) is anticipated.

For storage periods of 1 to 4 months, vacuum packaging may not be necessary. Prepare fish as above, then box pre-frozen pieces in a fiberboard box containing a heavy plastic liner. Separate layers of fish with additional sheeting to prevent sticking, press out the air, tie the liner shut and close the box. Consult your restaurant and institutional buyers regarding the package form and content weight they prefer.

The key to packaging is making certain that as much air as possible is excluded from the package and that it seals tightly.

Glazing

Glazing fish in ice provides a skin-tight, inexpensive package but also has several drawbacks when used without an overwrap. It is fragile, evaporates throughout storage, requiring periodic renewal, and is less acceptable to consumers due to excess melt water. However, this technique is especially useful when fish are held for further processing or delivered to the restaurant or institutional trade. Soft water is preferred for glazing, since hard water contains minerals that increase the rate of oxidation. For best results, glazing should be used in conjunction with an antioxidant and packaged as outlined above.

Storage

Compared with other foods, frozen fish have a relatively short storage life. It is best to market fish within 4 to 6 months after freezing, although this depends on species and packaging method. Frozen shelf life is decreased if ideal storage conditions are not provided. The length of time that fish are held prior to freezing as well as the manner in which they are handled will greatly influence their useful period of frozen storage.

Storage freezers should be well maintained and organized so that space needs are met without crowding stock. These rooms must be kept clean and free of odors. Each lot of fish should be labeled and dated to insure proper stock turnover.

Because fish are less stable than other frozen commodities, they require lower freezer temperatures. A storage temperature of -20°F or colder is strongly recommended. Never allow temperatures above -10°F. Storage life is extended with lower temperatures. When stored at 0°F, fish have only half the storage life possible at -20°F.

Cold room temperature should be closely controlled to avoid fluctuations greater than 4°F. It is advisable to monitor temperature continuously with a suitable recording thermometer.

Thawing

Frozen fish can be thawed in several ways. The methods act to either conduct heat away from a warm suface and into the flesh or generate heat uniformly throughout the flesh. Thawing in still air is commonly practiced in small operations but it is not recommended. Allow sufficient time to thaw under refrigeration (35 to 40°F) or submerse securely packaged fish in cold running water. For large processors, however, faster, more advanced options are possible. These include air-blast thawing, vacuum thawing, dielectric thawing, electrical resistance thawing and microwave thawing.

When a less modern method is chosen, a few simple principles should be heeded. Improperly thawed fish are subject to serious quality losses and may present a health hazard.

Thawing in still room air can result in very uneven rates of heat transfer. In some cases, the fish surface will warm, become soft and begin to spoil before the center thaws. Since size of the fish or fish block affects the rate of thawing, large blocks will take considerably longer to thaw and must be thawed under refrigeration.

Individually frozen, thin fillets may be thawed at 40°F to 60°F if held covered until nearly thawed and then moved to a chiller, below 40°F. When possible, thaw fish in their original package to minimize dehydration, contamination and high surface temperatures.

Thawing and refreezing should be avoided, as this causes severe textural breakdown. Water within the muscle is freed and large ice crystals form. The flesh becomes mushy, suffers excessive drip loss and is dry when cooked. Should surface thawing occur during the glazing or packaging operation, the product should be completely refrozen before final packaging is attempted.

Frozen fish should not be thawed until they are ready for use. Thawed fish deteriorate rapidly due to the release of enzymes and nutrients for bacterial growth.

Remember: Freezing only preserves quality at the time of freezing and then only when all of the proper methods are applied during frozen storage.