Fish, Frozen

Revised 2008

Types of Quality Loss Found in Frozen Fish

Frozen fish can be stored for a considerable amount of time under frozen conditions, provided proper freezing and packaging conditions were observed. However, over time the overall quality of the frozen fish can deteriorate. Some of the common types of quality degradation are listed below:

1. Off-odors and flavors due to bacterial action prior to freezing.
2. Loss of normal tissue structure, development of toughness, and tendency to drip during thawing resulting from being held too long prior to freezing, being held too long in the freezer, or being held at too high freezer temperatures, or held at fluctuating freezer temperatures.
3. Rancid off-odors and flavors and rusting due to poor packaging or glazing and being held at too high freezer temperatures or for too long a time for the species. Fatty fish are most subject to rancidity.
4. Drying out and becoming tough because of inadequate packaging or glazing. Commonly called freezer burn, desiccation, or dehydration.
5. Color change. Light or white flesh fish can darken whereas carotenoid pigmented fish, including but not limited to ocean perch and salmon can undergo a fading of the red color.

Factors Influencing Quality Loss in Frozen Fish

The following factors are important in influencing quality degradation in frozen fish products:

1. Intrinsic Factors:
   a. The condition of the fish at the time of freezing as it relates to the nutritional status or the stage of spawning can affect both appearance and texture of frozen fish.
   b. The ultimate pH of the flesh post-mortem, which can be influenced by the fishing method and the degree of struggling induced during the fish capture. Low pH or acidic cod muscle has been shown to become tough during frozen storage.
   c. The stage of rigor mortis at the time of freezing, which can affect the appearance and texture of the fish. If the fish were frozen pre-rigor or during the onset of rigor the frozen product may distort or gape during the thawing or cooking process. The onset of rigor, which may have been arrested by freezing, will continue during thawing.
2. Holding Procedures prior to Freezing:
   a. In order to maintain quality, fish should be held for as short a time as possible, and at temperatures near 32°F (0°C) prior to freezing. A study showed that headed and eviscerated Whiting held for 2 days in ice (32°F = 0°C) had a good quality frozen storage

life at 0°F (-18°C) of 12 months. In contrast, Whiting held in ice for 4 days prior to freezing had a storage life of only 6 months.

3. Packaging Material or Glaze:

   a. Frozen whole fish and fish products should be protected from moisture loss by use of a glaze, packaging material, or combination of both. Fish and fish products not adequately protected from moisture loss in the freezer become dull in color, the surface dries out and the flesh becomes tough and stringy. Although several types of glazes have been proposed, including alginate, pectinate films or waxes, a plain ice glaze is simple to apply and effective. Addition of a water-soluble antioxidant, such as ascorbic acid, to the glazing solution has been shown to increase the effectiveness of an ice glaze.

4. Freezing Rate:

   a. When fish muscle is placed at a sub-freezing temperature, the muscle temperature drops steadily until it reaches about 28-30°F (-2.2 to -1.1°C), the freezing range for fish muscle. At this point, ice crystals start to form within the tissues and the temperature remains relatively constant. When most of the cellular water has been frozen, the muscle temperature drops rapidly again until it eventually equilibrates with the temperature of the environment. If the rate of freezing is fast, the ice crystals that form within the tissue cells will be numerous in number but small in size, resulting in little damage to the tissues. On the other hand, if the freezing rate is slow, a few ice crystals will form, but these will be large in size and they can damage tissue cells. This damage will be in the form of denaturation of proteins with loss of water holding capacity, impairment of cell membrane permeability, and disruption of cellular components with release of enzymes previously contained. This will all be manifested as drip loss during thawing and possible flavor changes.

5. Thawing Method:

   a. The procedure employed for thawing frozen fish can affect quality of the thawed product. The defrost time should not be too long; otherwise, bacterial growth or surface dehydration might occur. The product temperature should not remain in the critical zone (32-33°F) (0 to 0.6°C) too long, else protein damage with loss of water holding capacity might result. Conversely, the product thawing method should not be too fast, or high temperatures will rapidly thaw the outside of the product while the inside remains frozen. This rapid thaw will force ice crystals in the cells to rupture cell membranes, resulting in a rapid loss of nutrients, moisture and flavor.

6. Freezer Temperatures:

   a. Fish, like fruits and vegetables, continue chemical changes in their flesh after freezing. These deteriorative changes are accelerated by high storage temperatures and are retarded by lower storage temperatures.

The following are a few examples of how storage temperature affects high quality storage life:

Number of Weeks before a Product was First Found Significantly Different from a Control Sample*				
Product	**Weeks of Storage at**			**Determinant Attribute**
	-18°C 0°F	**-23°C -10°F**	**-29°C -20°F**	
Cod fillets, cello wrapped in 5 lb. packs	15	35	77	o texture at 0°F o flavor at -10 & -20°F
Salmon, whole dressed, glazed	37	42	70	o flavor and color
Shrimp, green headless, glazed in 5 lb. cartons	55	55	76	o flavor
Alaska Pollack Surimi, blocks	5	10	26	o strain value
Temperatures can never be held absolutely constant during storage because of the cyclical operation of refrigeration equipment and product movement to and from storage. Storage temperature fluctuations should, however, be controlled as much as possible in order to minimize the normal loss of moisture from glazed and packaged fish. This control will help realize the maximum storage shelf life potential of the product.				

* Source: WFLO Project #110C "The Effects of Cold Storage Temperature on the High Quality Shelf Life of Selected Frozen Seafood."

7. Species Variation:

   a. Fish are classified, for frozen storage purposes, as fat or lean types. The fatty types have oil or fat in their flesh that can become rancid, commonly called oxidative rancidity. Lean fish may have some oil or fat in their flesh, but the quantities are so small that rancidity is not a serious problem. Various types of packaging materials, antioxidant dips, glazes, etc. are used to control rancidity. There are medium fatty species that could be classified either as fat or lean, but they are usually called fatty, to be on the safe side, when planning prolonged storage periods. The oils of some species are less susceptible to rancidity than others, but high oil or fat content is usually a criterion for expecting a shorter good quality storage life.

A summary of the expected storage life of fish is as follows:

Storage Life of Frozen Fish at 0°F (-18°C) or Below*		
	Packaged Whole or Headed and Gutted	**Pieces and Fillets**
Moderately fatty and fatty fish, glazed	6-10 months	4-8 months
Lean fish, glazed	10-12 months	8-10 months

WFLO Project #110C shows that the high quality storage life can be almost doubled by storage at -10°F (-23°C) or below.

Species of Fish, by Category			
FATTY	Alewives Atlantic Halibut Barracuda Bass, striped Bluefish Bonito Butterfish Catfish Carp Eel Herring Jack mackerel King mackerel Mackerel Mullet Sable fish Salmon Sardines Scup (porgies) Shad Shark (dogfish) Sheepshead Smelt Snapper, red Sturgeon Sucker Swordfish Tuna Weakfish (sea trout) Whitefish	LEAN	Bass, sea Blackfish Cod Croaker Cusk Dru Flounder Fluke Grouper Grunt Haddock Hake m, red Marlin Ocean Perch Pacific Halibut Perch, yellow Pickerel Pike Pollack Pompano Skate Sole Whiting
Note: Lean fish are fish with less than 2% fat; levels 2% or higher are classified as moderately fatty or fatty, the exact fat level varies depending on species, area of catch and time of year when caught, and section of fish. Belly or tail meat usually more fatty than other sections, dark meat more fatty than white meat.			

Frozen Prepared Fish Products

Frozen breaded fish sticks, both uncooked and cooked, and other prepared fish products are made from so many different raw materials that predictions of their expected good quality storage life are impossible to make with any degree of accuracy. For best retention of quality, products should be stored at below 0°F (-18°C). High quality packaging materials should be used, and temperature fluctuation during storage should be kept to a minimum.

Minced fish is becoming more available as deboning technology is improving. Because of the additional handling, increase in surface exposed to oxidation, etc., shelf life of minced fish is usually reduced substantially, unless antioxidants and exceptionally good packaging are used. In general, it may be assumed that minced fillets will have a shelf life about one third that of the fillets, and one third of that if the minced fish is recovered from frames during deboning. Thus, for example, if frozen fish fillets have a shelf life of 9 months, the minced fillet shelf life will be reduced to about 3 months, and that recovered from boning, little more than 1 month. Additional information about this topic is located elsewhere in this manual under **Fish, Comminuted, Deboned and Minced**.

Surimi, from which a variety of structured seafood or seafood analogs, such as lobster tails and crab legs are being manufactured, is essentially minced fish which has been washed thoroughly to leach out blood and water soluble matter and remove much of the oil. The washed mince is dewatered and blended with cryoprotectants (sugars, polyphosphates) to inhibit protein denaturation and preserve gel strength during frozen storage. With most of the water-soluble constituents and oil removed during washing, Surimi products are less prone to oxidative rancidity compared to minced fish. It is recommended that Surimi be stored at 0°F (-18°C) or lower.

A summary of the expected storage life of Alaska Pollack Surimi is as follows:

Temperature	Storage Time in Weeks
0°F (-18°C)	5
-10°F (-23°C)	10
-20°F (-29°C)	26

* Source: WFLO Project #110C "The Effects of Cold Storage Temperature on the High Quality Shelf Life of Selected Frozen Seafood."

Effects of Freezing and Thawing on Quality of Fish

Investigation:	The effects of storage in ice and various ways of freezing were investigated. Thawing and storage conditions were kept constant.
Result:	Storage in ice resulted in no or very small effect on the membrane. After an added freeze-thaw cycle, significantly higher levels of the enzymes were detected than after only ice storage, irrespective of the length of ice storage. The fastest freezing resulted in the smallest membrane disintegration.
Conclusion:	Fast freezing is recommended.

Investigation:	The effects of frozen storage time and temperature, in combination with different thawing methods were investigated.
Result:	The most important factor during frozen storage is the temperature. A lower storage temperature (-40°C/-40°F) did not affect the membrane structure as much as a higher storage temperature (-18°C/0°F) did. The sensory evaluation also showed a

	significant difference between high and low-temperature storage. Different storage time and temperature in combination with different thawing treatments showed that fast thawing was of greater importance both to sensory quality and biochemical measured effects in fish stored at lower temperature. In general, faster thawing resulted in less membrane disintegration than slower thawing, regardless of storage time.
Conclusion:	To result in a high quality frozen fish product, a low and constant storage temperature (about -30°C/-22°F) is recommended. A good frozen stored fish (as described above) must be thawed fast to achieve the best eating quality.

Investigation:	The effect of the unavoidable temperature increase in fish during glazing was investigated. An estimation and comparison of the effect on liquid loss during thawing after a fast and a slow refreezing to frozen storage temperature after glazing was done.
Result:	The faster the temperature was lowered to the desired storage level after glazing, the less amount of thaw drip and the lower the leakage of marker enzymes were measured. Fish from the two groups could significantly be differentiated in a sensory test.
Conclusion:	A active refreezing after glazing in the process line can strongly be recommended.

Investigation:	Four different industrial freezing and handling were compared, focusing on sensory and biochemical changes in the fish. The influences from the following parameters were studied: individual or block-frozen fish, both as round fish and as fillet; refreezing, with or without storage.
Result:	Refreezing seemed to be the most important factor before frozen storage. Refreezing was the only factor that could be differentiated in sensory evaluation of texture properties, and a significant higher released enzyme activity was determined after refreezing than after first freezing. After storage, clear differences could be seen in enzyme leakage between fish first frozen individually and in blocks, where the individually frozen fish released fewer enzymes. In the sensory evaluation a preference for the individually frozen fish also was seen. This indicates that storage after refreezing amplifies the effects caused by differences in handling during the first freezing on the fish quality.
Conclusion:	If possible, avoid refreezing. If not, notice that first freezing is done as optimal as possible; that is for fish, individually as whole gutted fish.

* Source: Katarina Nilsson, PhD in Food Science, Frigoscandia

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