FACT SHEET

SEPTEMBER 2022 | ©Perennia 2022

FREEZING AND THAWING OF SEAFOOD PRODUCTS

Purpose:

To provide guidance and education to producers and buyers of frozen seafood products on best practices associated with freezing and thawing of seafood products.

Target Audience:

Anyone directly involved in production of seafood products.

What is freezing and why is it important?

Freezing is the process of converting water to ice. Freezing is distinct from cold storage, which is the act of maintaining the frozen state for an extended period.

The freezing point of fish is ~ -1.5 °C, and when fish and seafood products are chilled below this, the liquid water progressively becomes converted into ice. Lowering product temperatures below their freezing point is effective at stopping microbial growth and slowing other mechanisms of spoilage.

Freezing of fish and seafood products is a preservation method that extends shelf life, and enables access to products outside of their regular fishing seasons.

For more information, read the Seafood Spoilage fact sheet

What happens during the freezing process?

The water content of seafood products ranges from 60 – 80%. Freezing promotes the removal of heat energy, and because of the high water content in fish and seafoods, the bulk of energy during freezing goes into converting liquid water into ice (Figure 1). Freezing should proceed until the internal temperature of the product reaches the target cold storage temperature. Ice formation does not occur all at once, whereby the internal temperature lags the surface temperature of the product (Figure 2).

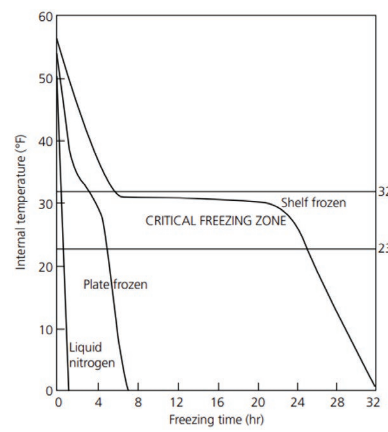

Figure 1. Comparison freezing methods on freezing time

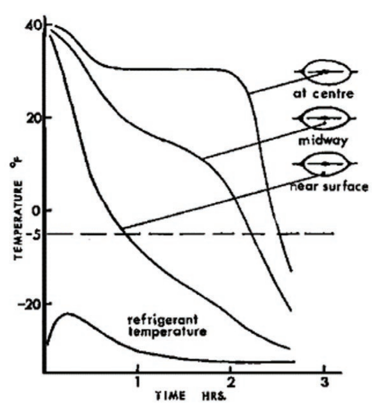

Figure 2. Temperature differences within product freezing

At temperatures from 0 °C to -18 °C, a proportion (> 15%) of water in fish and seafood products remains unfrozen. In this semi-frozen state, chemical compounds can become concentrated in the fluid water which can accelerate enzymatic spoilage in the product. Therefore, freezing processes for fish and seafood products should minimize dwell time within the critical freezing zone (temperatures from 0 °C to -5 °C) to avoid mechanisms that lower quality (Figure 1).

What is thawing and why is it important?

Thawing is the reverse process to freezing, whereby heat energy is absorbed and the water ice gets converted to liquid water. Due to the lower water contents, fatty fish require less energy than lean fish.

Thawing of fish and seafood is necessary by secondary seafood processors, restaurants, and consumers of frozen seafoods, and controlled processes should be adopted to avoid promoting spoilage within the product. An ideal process would ensure that the freshness level of the product is not different than prior to when it was frozen.

When frozen fish and seafoods are surrounded by either air or water at temperatures higher than the internal product temperature, heat gets absorbed by the product causing its temperature to rise. Heat transfer through thawed tissues is less effective than through ice, indicating thawing becomes less efficient over time. Adequate thawing is necessary to ensure clean cuts and good yields during filleting, and that brining, smoking, and/or cooking processes are evenly applied throughout the product.

Best Practices in Freezing and Thawing of Seafood Products

The high-quality characteristics of frozen fish and seafood products can be retained by adopting the following best practices:

Raw Material

The freshness of fish and seafoods products cannot be improved by freezing. Freshness of fish and seafoods can begin to deteriorate between processing and freezing, and while under frozen storage due to the progression of enzymatic activity and lipid oxidation in this state. Care taken during the handling and preparation of seafood products intended for freezing are critical to preserve the freshness of the raw materials. Products must be always adequately chilled due to the difficulty in cooling large amounts of fresh product in a short time.

Freezing Method

The optimal freezing method is directly influenced by the product intended to be frozen, and any packaging directly associated with the product. Air-blast, brine, and contact freezers each have benefits and drawbacks as freezing methods for freezing different fish and seafood products.

Each freezing method utilizes a refrigerant, whose operating temperatures defines the temperature gradient between the product and freezer. When a larger temperature gradient and product surface area are exposed to either freezing or thawing refrigerants, maximum heat transfer can be achieved. Optimal freezing methods try to maximize this temperature gradient and expose a large surface area to the refrigerant. For instance, immersion freezing in liquid nitrogen will be more effective than air-blast freezing at the same temperature.

Individually Quick Frozen (IQF) processes allow pieces of fish and seafood to be frozen such that products leaving the freezing are maintained as distinct pieces that do not clump.

Thawing Method

Thawing of fish and seafood can be achieved by conduction (with air or water) that warm products from the outside in, or supported by mechanical methods (vacuum, dielectric, electrical resistance, microwave) that heat products evenly throughout.

Thawing at chilled temperatures are most common for fish and seafoods, although mechanical methods have been utilized in commercial settings with success.

Thawing in recirculated chilled water maximizes heat transfer from the product to the water, and helps to wash away any dirt and debris from the product that may harbour bacterial growth. While rapid thawing is desirable, using elevated temperatures for long periods risk overheating smaller fish while larger fish remain frozen, or the overheating the product surface while the interior remains frozen. Temperatures > 15 °C should be avoided to slow bacterial growth, and water should remain in constant flow to prevent for formation of ice around the surface of the product.

Freezing and Thawing Time

Freezing and thawing times are strongly influenced by the unique circumstances of the plant. Therefore, freezing and thawing performance should be directly measured to ensure practices are effective at achieving the target internal temperature for all products and product formats. Inadequate freezing can accelerate spoilage whereas excessive freezing promotes dehydration and unnecessary energy consumption. Table 1 indicates freezing times for various products and different freezing methods.

Factors affecting the freezing rate include:

- type of freezer
- operating temperature
- initial product temperature
- product thickness
- shape and density
- species
- method of packaging

Table 1. Freezing times for different fish and seafood products in various formats (Kolbe and Kramer, 2007).

				Freezing time	
Product	**Freezing method**	**Product initial temp °C**	**Operating temperature °C**	**hr**	**min**
Whole cod, block 100 mm thick	vertical plate	5	-40	3	20
Whole round fish, 125 mm thick e.g., cod, salmon, frozen singly	air blast 5 m/s	5	-35	5	00
Whole herring, block 100 mm thick	vertical plate	5	-35	3	20
Whole herring, 50 mm thick on metal tray	air blast 4 m/s	5	-35	1	40
Cod fillets, laminated block, 57 mm thick in waxed carton	horizontal plate	6	-40	1	20
Haddock fillets, 50 mm thick on metal tray	air blast 4 m/s	5	-35	2	05
Haddock fillets, laminated block 37 mm thick in waxed carton	horizontal plate	5	-40	1	02
Kippers in pairs, interleaved pack 57 mm thick in cardboard carton	horizontal plate	5	-40	2	15
Whole lobster, 500 g	horizontal plate	8	-40	3	00
Whole lobster, 500 g	liquid nitrogen spray	8	-80	0	12
Scampi meats, 18 mm thick	air blast 3 m/s	5	-35	0	26
Shrimp meats	liquid nitrogen spray	6	-80	0	5

Packaging

The addition of a barrier between the product and its environment will slow down the freezing time. Packaging helps to protect against dehydration and fat oxidation, as such fatty fish are more susceptible to degradation under cold storage. Air acts as an insulator preventing heat transfer, so packaging should be fit tightly to the products to make freezing/thawing more efficient, but also to protect against oxidation, dehydration, and the build-up of frost. Glazing is also highly effective at limiting these degradative processes.

Cold Storage

Unfrozen seafoods should never be placed into cold storage without first performing a deliberate freezing step. The cold storage temperature has the greatest impact on the overall quality of frozen seafood products. This temperature, not the freezing time or temperature, has a greatest overall impact on the freshness of the product when thawed after long-term storage. Temperatures < -30 °C should be adopted for long-term storage and for fatty fish to maximize freshness for the end consumer.

Key Take Aways

1. Ensure fish and seafood products are effectively chilled prior to freezing.
2. Always verify the effectiveness of freezing and thawing processes for each product.
3. Ensure products are adequately protected during and after freezing to prevent mechanisms that lower quality.

References

Kolbe, E. and Kramer, D. 2007. Planning for Seafood Freezing. **https://agsci.oregonstate.edu/sites/agscid7/files/snic/planning-for-seafood-freezing.pdf**

Nicholson, J. 2001. The Freezing Time of Fish. Torry Advisory Note No. 62. **https://www.fao.org/3/x5936e/x5936e00.htm**

Jason, A.C. 2001. Thawing Frozen Fish. Torry Advisory Note No. 25. **https://www.fao.org/3/x5904e/x5904e00.htm**

Quick Freezing of Fish. Torry Advisory Note No. 27. **https://www.fao.org/3/x5906e/x5906e00.htm**

Johnston, W.A., Nicholson, F.J., Roger, A., and Strough, G.D. 1994. Freezing and refrigerated storage in fisheries. FAO Fisheries Technical Paper. No. 340. **https://www.fao.org/3/v3630e/V3630E00.htm**

Keay, J.N. 2001. Cook-Freeze Fish Products. Torry Advisory Note No. 69. **https://www.fao.org/3/x5941e/x5941e00.htm**