Low Temperature Fish Preservation

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- **Chilling (5 to 0°C)**

- **Freezing (-18 to - 40°C)**

Chilling

- Chilling is an **effective way of reducing spoilage** in fish if it is **done quickly** and if the fish are **kept chilled** and **handled carefully** and **hygienically**.
- **Immediate chilling** of fish ensures **high quality** products. For every **10 C reduction** in temperature, the **rate of deterioration decreases** by a **factor of 2-3**.
- The **objective** of chilling is to **cool the fish** as **quickly** as possible to as low a temperature as possible without freezing. Chilling **cannot prevent** the **spoilage** together but in general, the **colder the fish**, the greater the reduction **in bacterial** and **enzyme activity**.

This lowering of temperature brings about

1. Arrest of almost all **enzymatic changes**,

2. Killing of about **50-60% of the mesophilic bacteria** and

3. **Slowing** down of the **activities** and **growth** of all other bacteria, which are cold-loving (psychrophilic) and cold-tolerant (psychrotrophic).

Chilling methods

The important chilling methods of fish and fish products at non-freezing temperature are:

- **Iced storage**.
- Chilled seawater (CSW) storage.
- Chilled freshwater (CFW) storage.
- Mechanically Refrigerated seawater (RSW) storage.
- Cold air storage.

The most common means of chilling is by the **use of ice.**

- Ice is available in **several forms** such as blocks, plates, tubes, shells, soft and flakes.
- Of these, **flake ice** is the most popular form for industrial use because of its **cooling efficiency.**
- It is also relatively dry and **will not stick** together to **form clumps** when stored.
- **Cooling capacity** is **more** for flake ice due to a **large surface area** for heat exchange.
- It also causes **minimum damage** to the flesh.
- To **ensure maximum contact** of ice with the fish, **proper selection** of the size of ice particles and good storage practices are needed.

Advantages of chilling of fish with ice

i) Temperature reduction

It reduces the temperature to **about 0 C**. The **growth** of **spoilage** and **pathogenic** micro-organisms is **reduced**, thus reducing the **spoilage rate**.

ii) Melting ice keeps fish moist.

This action mainly **prevents surface dehydration** and reduces weight losses. Melting water also increases the heat transport between fish and ice surfaces (water conducts heat better than air).

iii) Advantageous physical properties.

Ice has some advantages when compared with other cooling methods, **including refrigeration by air.** The properties can be listed as follows:

a) Ice has a **large cooling capacity and** comparatively small amount of ice will be needed to cool 1 kg of fish.

Advantages of chilling of fish with ice

iv) Convenience. Ice has a number of practical properties that makes its use advantageous. They are:

a) It is a **potable** cooling method. It can be **easily stored**, **transported** and used. Depending on the type of ice, it can be **distributed uniformly** around fish.

b) **Raw material to produce ice** is widely available. Although **clean, pure water** is becoming increasingly difficult to find, it is still **possible** to consider it a widely available raw material and it should be properly treated, e.g., **chlorination.**

c) Ice can be a **relatively cheap** method of preserving fish. This is particularly true if ice is properly produced, stored and utilized properly.

v) Extended shelf life.

The overall reason for icing fish is to **extend shelf life fresh** fish of in a relatively simple way as compared to storage of un-iced fish at ambient temperatures above 0oC. Extension of shelf life means producing safe fresh fish of acceptable quality.

Disadvantages of chilling of fish with ice

- Icing in the conventional method using **crushed ice can bruise the flesh** which results in **leaching of flavor compounds** and **water soluble proteins**.
- **Prolonged ice storage** can cause **changes in the texture** of the muscle, particularly the reduction in **breaking strength and hardness of fillets**.
- **Muscle proteases** including **cathepsin D and cathepsin L**, **calcium activated proteases** (calpains), **trypsin**, **chymotrypsin**, **alkaline proteases** and **collaginases** are involved in softening of fish tissue during storage
- Ice storage has been found to **adversely influence protein stability** and **water holding capacity** in salmon and cod fillets.
- Icing **cannot completely arrest** the **activities** of **psychrotrophic** organisms in fish, which is a **quality problem** in refrigerated food.

Chilling Rate

The rate of chilling is governed by:

- The size, shape and thickness of fish;
- The method of storage;
- Adequate mixing of ice, water and fish (in ice slurries);
- Adequate contact of ice with the fish;
- The size of the ice particles

Chilling

Advantages of Chilling

- — Chilled foods **taste closer to fresh foods** than frozen, canned or dried foods.
- — There is **little loss** of flavor, color, texture, shape or nutritional value.
- — Allows consumers to have **good quality**, ready prepared food without having to shop every day.

Disadvantages of Chilling:

- —Only a **temporary**, **short term** method of preservation.
- —Specialist **storage equipment** is needed – a fridge kept at below 5°C. Commercial stores must be below 2°C.

Freezing

Freezing (-18 to -40°C): Freezing is a process of preservation in which the temperature of fish & fishery product is learned **at -40°C or below** with most of the **water inside** of **tissue turning into ice**.

- Freezing fish is the **simplest and the most natural** way of preserving fish. Freezing is very **easy and safe** to do.
- Freezing **can't stop chemical reaction** but **slows it down**.

Purpose of Freezing

- To **slow down** fish spoilage
- To **increase** the shelf life of fish
- To **prevent** growth of microorganisms by – Killing some bacteria (little effect)
- **Reducing** water activity
- To lower temperature enough to **slow down chemical reactions** (every 10°C decrease in temperature that lead to half the reaction rate).

Principle of Freezing

- —The **temperature falls** fairly **rapidly**, at a more or less constant rate, to just **below 0 Centigrade** while the specific **heat being remove**.
- —The temperature remains fairly constant at about **-1 Centigrade to -5 Centigrade** while the **latent heat is being removed** and the liquid water is **Changing to ice**; This is known as **Thermal Arrest Period** (TAP).
- The **temperature drops rapidly again** while the specific heat of ice is being removed and most of the **remaining water freezes**.

Freezing systems

- There are three basic methods for freezing fish. These are:
- **Air blast freezing:** Where a continuous **stream of cold air** is passed over the product.
- **Plate or contact freezing:** where the product is placed in **direct contact** with hollow, metal, freezer plates, through which a **cold fluid** is passed.
- **Spray or Immersion freezing:** where the product is placed in **direct contact** with **fluid refrigerant.**

Air blast freezing

- **Circulating cold air** at **high speed** enables freezing to proceed at a **moderately rapid rate** and this method is referred to as **air-blast freezing**.
- Air-blast freezing is usually accomplished by **placing the products** on a **mesh belt** and **passing it** slowly through an **insulated tunnel** containing air **at-18 to -34°C** or lower, moving counter current to the product at a speed of **1 to 20 meter/sec.**
- **Air at -29°C** and at a speed of **10-12 meter/sec**, is often satisfactory, although lower temperatures are preferred.

Air blast freezing

- Air blast freezing is **economical** and is capable of **accommodating products of different sizes and shapes**.
- One of the biggest benefits of blast freezers is that they have the **ability to freeze several tons** of produce in as little as 24 hours.
- This **super-fast process** ensures that **bacteria has minimal time** to develop and keeps produce fresh in bulk.

Contact Plate Freezing

- Fish products can be frozen by **placing them in contact** with a **metal surface** cooled by expanding refrigerants.
- **Double contact plate freezers** are commonly used for freezing fish/prawn blocks. This equipment consists of a **stack of horizontal cold plates** with **intervening spaces** to accommodate **single layers of packaged product**.
- The filled unit appears like a **multi layered sandwich** containing **cold plates and products** in alternating layers.
- **When closed**, the **plates make firm contact** with the **two major surfaces** of the **packages**, thereby **facilitating heat transfer**,

Contact Plate Freezing

- Contact plate freezing is an **economical method** that **minimizes problems** of product **dehydration and defrosting of equipment**
- In this method the **packages** must be of **uniform thickness**. A packaged product of **3 to 4 cm thickness** can be **frozen** in **1 to 1.5 hour** when cooled by plates at **-35°C.**
- Freezing times are extended considerably when the package contains a significant volume of void spaces.

Liquid Immersion Freezing

- Liquid immersion freezing or **direct immersion freezing** is accomplished when a product is frozen **by immersing** or **by spraying** with a **freezant that remains liquid** throughout the process.
- This technique is **occasionally used** for fish and prawns. Liquid immersion freezing can result in **moderately rapid freezing**.
- Freezants used for liquid immersion freezing should be **non-toxic, inexpensive, stable**, **reasonably inert,** and should have a **low viscosity, low vapour pressure and freezing point** and reasonably **high values for thermal conductivity**.
- Freezants should have a low tendency to penetrate the product, **little or no undesirable effects on organoleptic properties.**
- Aqueous solutions of **propylene glycol**, **glycerol, sodium chloride, calcium chloride** and **mixtures of sugars and salt** have been used as freezant.

Liquid Immersion Freezer

Freezing

Advantages of Freezing

- —**Long term method** of preservation (weeks & months rather than days)
- —**Little change** in flavor or structure compared to canned or dried food
- Very **little nutritional loss** – most vitamin B and C is retained.

Disadvantages of Freezing

- —**Quick & controlled** freezing is needed **or large ice crystals** will form and **break the cell walls** of some foods.
- **Specialist storage equipment** is needed – a freezer kept at below -18° C.
- **Cell damage** can occur in **soft fruits** such as **strawberries** and the colloidal structure of some food products, such as sauces, can collapse when frozen.

Chilling and Freezing steps

1. **Select fresh fish** for freezing
2. If the fish is **small** like Dilis, **wash and freeze right away**.
3. If the fish is **large** like Ruhi, **remove scales**, and **trim fins and tails** and **wash**.
4. Wr**ap fish in plastic wrap** or put in a container **packed tightly** to eliminate air
5. **Label wrapped** fish or container with **name and date**.
6. **Chill/Freeze** immediately

Methods of freezing

A) **Slow Freezing.** (Large crystal, -15 to -29 C)

- The temperature is usually -25 centigrade or lower but may vary from -15 Centigrade to -29 Centigrade & freezing may take **3 to 72 hours.**

B) **Quick Freezing**. (Small crystal, -18 to -40 C)

- This is a sudden decrease in the temperature of fish up to freezing. The temperature usually -40 Centigrade & freezing time is **30 min to 1 hour**

The main advantages of Quick Freezing over Slow freezing

- **Small ice crystals** formed as a result **less damage to the cell structure** or **texture** of the food.

- The **freezing period** being much **shorter**, **less time** is allowed for the diffusion of salts and the **separation of water in the form of ice**.

- The product is **quickly cooled** below the temperature, at which **bacterial, mould, and yeast growth occur**, thus **preventing decomposition** of foods during freezing.

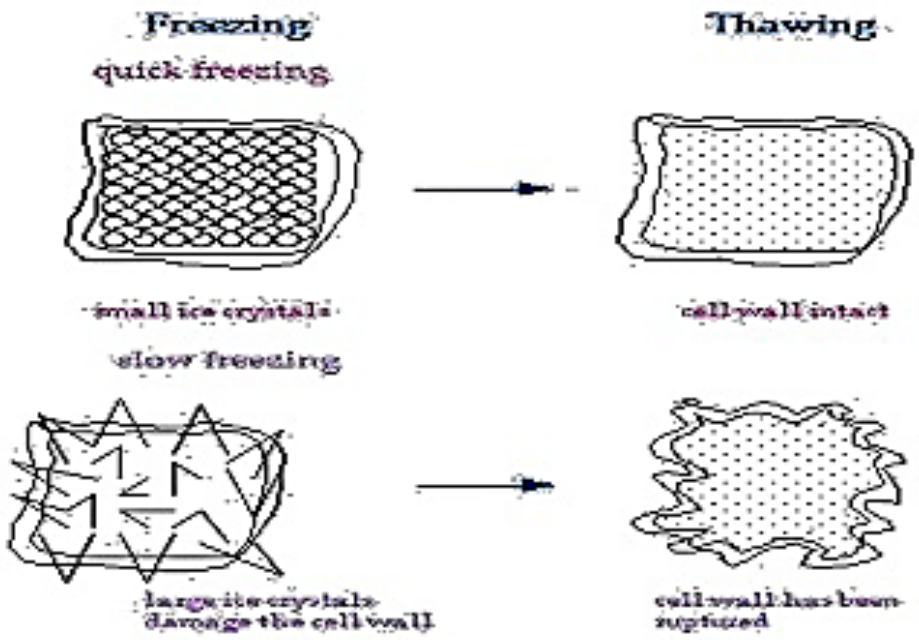
- The fourth and very practical reason in favor of quick freezing over 'slow-freezing', is the **inherent speed and greater output** and hence, **higher capacity for commercial freezing** plants with the resultant **cost reduction.**

Chilling versus freezing of fish

Chilling	Freezing
Short-term storage (up to **one month** maximum for some species, only a few days for others)	**Long-term storage** (**a year** or more for some species
Storage temperature **0 -5 °C**	Storage temperature well below zero, e.g. **-18 to -40 °C**
Relatively c**heap**	Relatively **costly**
Product rese**mbles fresh fish**	If poorly done can **badly affect quality**
Relatively **low-tech**	Relatively **high tech**
Low skills required	**High skills** required
Portable refrigeration	Generally **static** operations

The main advantages of Quick Freezing over slow freezing

SLOW & FAST FREEZING

- 

Thawing

- Thawing is the process of **changing a product from frozen to unfrozen**. It involves **transferring heat** to a frozen product **to melt the ice** that was formed within the flesh during the freezing process.
- The point at which **ice crystals are converted back to water occurs** completely when the **temperature** throughout the seafood **reaches -1 C**. The **time required** to **melt** all the ice in the frozen seafood is the **thawing time**.

Thawing process

1. Tempering phase:

- **Temperature** is **increased** until melting of ice is accelerated
- — Short phase due to **low specific heat capacity** and **high thermal conductivity**

2. Latent zone phase:

- — The **temperature** of the product is **almost constant**
- — Majority of the supplied **energy is used to melt the ice**

3. Heating phase:

- — Product's **thermal capacity** is comparatively **low**
- — **Temperature increases** rapidly as a result of further energy supply

Methods of thawing

Conventional methods of thawing

- — Refrigerator Thawing
- — Cold Water Thawing
- — Microwave Thawing
- — Thawing at room temperature

Novel methods of thawing

- — High pressure thawing
- — Ohmic thawing
- — Acoustic thawing

Thawing of fish

—Merits

- **— *Less cooking time***

Properly thawed fish is properly cooked; post processing become easy

- **— *Tenderness***

Increases with freezing and thawing; **breakdown of muscle fibers** by enzymatic action during proteolysis; formation of **large, extracellular ice crystals disrupts** the physical structure, largely breaking myofibrils apart and resulting in tenderization

- **— *Textural quality***

Texture is close to that of fresh and unfrozen food; may be changed by the freezing process and yet result in acceptable product

- ***Feasible processing operation***

Thawed fish makes the **processing operations feasible**; Cutting, grounding, slicing, filleting, canning, etc. become easy if the fish is thawed.

Thawing of fish

Demerits

- ***Weight loss***

Ice crystal melts into water and leeches out; Thus, effect the weight certainly lower than the original fish

- — ***Water holding capacity***

WHC is **reduced**; important factor considering the juiciness and taste of fresh food and for drip loss related to thawing; reduced ability to absorb water is linked to hydration of proteins and **destruction of ultra structure of the cells**

- — ***Drip loss***

Form of moisture migration; **soluble nutrients are lost**; water is removed from its original location in the product and collected elsewhere in the form of ice crystals, this water may or may not be reabsorbed into its original location; **If not reabsorbed** it **leaches out** of in the form of drip loss

Thawing of fish

- ***Color changes***

Non-enzymatic and enzymatic browning; mainly caused by a strong increase in lightness and decrease for both redness and yellowness;

- — ***Lipid oxidation***

Since chemical reactions can occur during frozen storage that **initiate primary lipid oxidation** (peroxidation) in the meat; This lead to radical **secondary** lipid oxidation upon thawing

- — ***Thaw rigor***

Rigor after thawing; Seafood frozen pre-rigor enters a **very strong rigor mortis** when thawed at high temperatures, **resulting in gaping** (breaking of connective tissue between the muscle segments) and **loss of drip**.

Precautions to prevent thaw rigor

• **Extend** the cold storage time; least **eight weeks** at a temperature of -28^{0}C or lower; thawed slowly at room temperature

Consequences of inadequate thawing

Consequences of over thawing	· Flesh **may soften** affecting the texture of the seafood. · Flesh can become **discolored**. · Loss of **flavor**. · **Economic losses** through reduced processing yield and drip loss. · Possible **growth of bacteria** that may accelerate spoilage, reducing the product shelf-life · Possible increase in **enzymatic spoilage** · Waste of resources e.g. water if using water thaw method
Consequences of under thawing	· Fish may be difficult or dangerous to fillet · Poor filleting will result in a lower yield