Chapter 8

Handling and chilled storage of fish

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Quality of fish raw material plays an important role for the quality of the end-product. Once the fish raw material freshness and nutrition value is lost, it cannot be recovered in the processing stages. Products that are processed from low quality raw material are not always a safety risk, but the quality (nutrition value) and shelf life is significantly decreased. The quality deterioration can start right away during fishing and it continues all the way to the final user. Time-temperature abuse should be avoided at all stages of handling till landed fish reaches the consumer or the processor. In tropical countries more care in handling is necessary as fishes thrive in high ambient temperature has high body temperature and hastens spoilage.

Fish is highly perishable because of their chemical composition. It has high content of soluble substances in the flesh (many of which contain nitrogen and triglycerides characterized by polyunsaturated fatty acids) and high level of autolytic enzyme. After the death of the fish, spoilage starts due to the action of microbes, enzyme and oxidation. It is therefore, necessary to preserve fish after harvest if not consumed or disposed immediately.

Influence of time and temperature on shelf life of fish

For fish, shelf life is defined as the time from when it is taken from the water until it is no longer fit to eat. The effect of time/temperature storage conditions on product shelf life has been shown to be cumulative. The shelf life at different storage temperatures (at t°C) in comparison to 0°C (melting ice) as been expressed by the relative rate of spoilage.

$r = (O.1\ t + 1)^2$, where r is the relative rate of spoilage and t is temperature (in °C).

For example,

When fish is well chilled and has a temperature of 0°C, then r is 1.

If the fish is at 4°C, Then, $r = (0.1 \times 4+1)^2 = 1.96$ (~2.0). Thus, spoilage is twice as fast at 4°C as it would at 0°C.

Hence, the temperature history of a fish can help to estimate the remaining days of shelf life of the fish (Table 1).

Table 1: Relative rate of spoilage and lost of equivalent days on ice for different temperatures and times (*Source*: Doyle, 1995)

Temperature (°C)	Relative rate of spoilage (r)	Equivalent days on ice with time							
		4 hr	8 hr	12 hr	18 hr	24 hr	36 hr	48 hr	72 hr
-2	0.64	0.11	0.21	0.32	0.48	0.64	0.96	1.28	1.92
0	1.00	0.16	0.33	0.50	0.75	1.00	1.50	2.00	3.00
2	1.44	0.24	0.48	0.72	1.08	1.44	2.16	2.88	4.32
4	1.96	0.33	0.65	0.98	1.47	1.96	2.94	3.92	5.88
6	2.56	0.43	0.85	1.28	1.92	2.56	3.84	5.12	7.68
8	3.24	0.54	1.08	1.62	2.43	3.24	4.86	6.48	9.72
10	4.00	0.66	1.33	2.00	3.00	4.00	6.00	8.00	12.00
12	4.84	0.81	1.61	2.42	3.63	4.84	7.26	9.68	14.52
15	6.25	1.04	2.08	3.12	4.69	6.25	9.38	12.50	18.75

Chilled storage

Chilling is a preservation technique which helps to extend the shelf life of the fish at low temperature. It should be practiced carefully and hygienically as soon as the fish is caught. It helps to reduce the spoilage rate by reducing the temperature without reaching freezing. The shelf life of the fish can be extended as more as it is kept at lower temperature by minimizing the bacterial and enzymatic activity.

The important chilling methods of fish and fish products are:

- Iced storage.
- Chilled seawater (CSW) storage.
- Chilled freshwater (CFW) storage.
- Mechanically Refrigerated seawater (RSW) storage.
- Air chilling

Iced Storage

Ice when used for chilling has the advantage of reducing the temperature in large quantity because the latent heat of fusion of ice is more and melting of this ice helps in maintaining the temperature at 0°C**.** However, ice is needed to maintain the temperature as well as to accommodate the heat from the environment. Hence in tropical conditions a 1:1 fish to ice ratio is ideal for ice storage. However, a theoretical weight of ice required to chill the fish as per the body temperature of the fish is given in Table 2: It is recommended that icing should be done immediately after the fish is being caught. It should be done in orderly manner so that there occurs a uniform chilling effect throughout the storage conditions. Usually small particles of ice (flake ice) are recommended rather than larger one, as larger one may cause damage to the flesh and will not give a uniform cooling effect. Smaller ice particles also provide a better contact between the ice and fish. Some general conclusions have been made based on the experimental work on several species of marine and freshwater fish.

- Non fatty fish keeps longer than fatty fish
- Freshwater fish keeps longer than marine fish.

Fish from tropical conditions keeps longer than those from temperate conditions

Table 2.Theoretical weight of ice needed to chill 10 kg of fish to 0°C from various ambient temperatures

Temperature of fish (°C)	**Weight of ice needed** (kg)
30	3.4
25	2.8
20	2.3
15	1.7
10	1.2
5	0.6

(*Source*: FAO, 1984)

Types of Ice:

Block Ice

Here the ice is manufactured in block form which are then crushed into smaller pieces before use. Crushing helps in reducing the size and helps in increasing the surface area of contact. Water in ice making cans are immersed in refrigerated sodium or calcium chloride solutions. Time of ice block formation can vary from few hours to 24 hours depending upon the ice plant. The ice formed are released from the can by hot gas defrost method.

Flake Ice

Flake ice is formed as smooth contours and as thin flakes of an area of 100-1000 mm^2 and a thickness of 2-3mm. Flake ice has a very high area per unit mass and can cover large quantity of fish for a given weight when compared to crushed block ice. Water is sprayed on the refrigerated drum to make the flake ice. The ice sheet is then scraped off in dry sub-cooled flakes. The temperature of the refrigerant is -20 to -25°C.

Plate Ice

Water is sprayed on vertical hollow plate through which refrigerant is passed. Flat sheet of ice is made on the surface of this plate and is separated from the plate by supplying hot gas once the ice sheet reaches the required thickness. The process of making plate ice is much faster and the thickness can be varied accordingly

Tube Ice

Ice is made as hollow cylinder. A series of hollow cylinders are arranged in which the ice is formed in the inner surface. The hollow cylinders will be surrounded by refrigerant. Hot gas is passed to defrost the ice from the cylinders. Tube ice will have to be crushed to the required size before icing and has all the advantages of the flake ice.

Liquid ice or Flow ice

Liquid ice or flow ice is having a jelly like appearence. It actually consists of amorphous ice micro particles suspended in a non-corrosive, non-toxic solution. It requires smaller flow rates for the same cooling capacity because of liquid ice cooling system. The liquid ice at about 50% ice concentration is pumped into the fish box. Hence it is liquid form it can make more contact with the fish surface to be cooled.

Soft Ice

Soft ice is made by freezing a weak brine or seawater in a drum provided with refrigerated walls. The crystals of fresh water ice forms slurry in the brine as temperature falls and it is pumped into a storage tank. Ice crystals are skimmed off from the tank to be used as soft ice slurry.

Chilled Sea Water (CSW)

Ice is introduced in water where it brings down the temperature of water. When sufficient temperature is reached (0°C) fish is introduced. In this case, the fish is surrounded with a mixture of ice and water. The water will remove the heat from the fish. The transfer of heat from fish to water and from water to ice will continue until the system is brought to a state of equilibrium. The surface contact of the fish and chilling medium will be maximum in CSW than in ice alone.

The cooling rate of the fish in CSW is higher than that of fish in ice. CSW can be adopted in fishing vessels as it has many advantages over ice storage. The main advantages of the CSW system are listed below:

- Faster cooling rate.
- Maintenance of a uniform temperature.
- Less damage to fish.
- Easy unloading of fish using pumps.

Refrigerated Sea Water (RSW)

Mechanical refrigeration system is adopted in RSW to cool the seawater. The advantage of RSW over CSW is that there is a reasonable control of temperature over a range, which is not possible in CSW. At 3.5% salt, the sea water has a freezing point of about -2°C and if refrigerated it is possible to reduce the temperature to -1°C where maximum storage life for chilled fish can be obtained. Although it is complicated in operation, it is much cheaper to adopt.

Air chilling

In air chilling, cold air is blown over the fish in a chill room. However, the use of cold air is less satisfactory. When cold air alone is used, as in a chillroom, the heat taken from the fish will rapidly warm the air. The warm air rises and is cooled by contact with the coils of the cooler and then moves by natural convection or fan circulation back to the fish. Thus, it is important to remember that for air cooling to be effective, a good circulation of cold air must be blown over the fish. However, even when a fan is fitted in a chillroom it is difficult to achieve the rapid cooling rates possible with ice and chilled sea water. Another disadvantage of air chilling is that, without the use of ice, the fish becomes dry. Continuous air movement evaporates water from the fish surface and deposits it as frost or condensate on the coils of the evaporator. In addition, the air in some parts of the chillroom will be colder than in others. For example fish close to the evaporator, may in time become partially frozen. Slow freezing of the fish can be detrimental, since appearance, flavour and texture of the fish may be affected. Air chilling however, can be used for prepackaged fish products.

Further reading

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