Low temperature preservation of fish and fish products

H. Mandakini Devi* and Elavarasan K.
*Scientist, Fish Processing Division,
ICAR - Central Institute of Fisheries Technology, Cochin - 682029

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 country 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.

Low temperature storage is one of the most effective and economic methods for preserving fish and fish products. In broad there are three categories of low temperature preservation: chilling, superchilling and freezing**.**

Chilling

The purpose of chilling is to prolong the shelf-life of fish, which it does by slowing the action of enzymes and bacteria, and the chemical and physical processes that can affect quality. Chilling is the process of cooling fish or fish products to a temperature approaching that of melting ice. Thus, during chilling the temperature is reduced to that of melting ice, 0 °C. The most common means of chilling is by the use of ice. Other means are chilled water, ice slurries (of both seawater and freshwater), and refrigerated seawater (RSW). For the full benefits of chilling to be realized, it is essential to maintain chill temperatures throughout the different fish-handling operations. Bulk storage of fish on board just after catching may be made by RSW or CSW. RSW is generally used when a mechanical refrigeration unit cools the water and CSW is more often used when ice is added for cooling.

Superchilling

Superchilling has been defined as the lowering of the temperature of the flesh to within the range from -3 ° to -1°C. Brine is use as refrigerant in superchilling. The storage time of fishes should not exceed 12 days. Above this days ice formation is increased and makes the fish unsuitable for filleting or smoking.

Freezing

Fish is largely water, normally 60-80 percent depending on the species, and the freezing process converts most of this water into ice. Freezing requires the removal of heat, and fish from which heat is removed falls in 3 stages of temperature. During the first stage of cooling, the temperature falls fairly rapidly to just below 0°C, the freezing point of water. As more heat requires to be extracted during the second stage, in order to turn the bulk of the water to ice, the temperature changes by a few degrees and this stage is known as the period of "thermal arrest". When about 55% of the water is turned to ice, the temperature again begins to fall rapidly and during this third stage most of the remaining water freezes. A comparatively small amount of heat has to be removed during this third stage. As the temperature of fish muscle is lowered to -1°C, -2 °C, -3 °C and -4 °C the percent of water frozen is 19, 55, 70, and 76, respectively. At first, the rate of freezing of the water in fish is relatively rapid; and by the time the temperature is lowered to only -6°C, about 80 percent of the water is frozen and the flesh is rigid, even though the remaining 20 percent of the water is not frozen. At this point, the rate of freezing is sharply reduced, and a further decrease of about 20°C will freeze only about an additional 8 percent of the water leaving about 12 percent of the water in the system still in the liquid state. It is not until the temperature is lowered to about -55°C that all of the water will appear to be frozen.

The rate at which foods are frozen is just as important as the temperature at which frozen foods are held and the range of fluctuation of the storage temperature. When foods are allowed to freeze slowly, water molecules, even though they are slow moving, have time to migrate to seed-crystals resulting in the formation of large ice crystals. When foods are made to freeze rapidly, the sluggish water molecules do not have enough time to migrate to ice crystals but instead are "frozen in their tracks. Rapid freezing may be effected by a variety of methods which include the use of liquid and gaseous refrigerants, cold-air blast, and cold-plate contact.

Liquid Refrigerants

Freezing is most rapid when the food is brought into direct contact with refrigerants (i.e., where the foods are immersed directly in a liquid refrigerant, sprayed with liquid refrigerants, or exposed to cold gases emanating from liquid refrigerants). This is because the removal of heat is proportional to the temperature differential at the food surface, and the direct contact between food and refrigerant tends to maintain the temperature differential at the highest possible value for the particular system. Brine is the most commonly used liquid refrigerant. Brine may be defined as a salt solution. salt solutions have lower freezing points than pure water, and brine can be made cold enough to freeze foods which are immersed in it while the brine itself remains fluid. The freezing point of brine is determined by the concentration of the salt. When the concentration of the salt reaches a value of 23.3 percent by weight, the limit of the trend is reached at a temperature of (-21.2°C). Other liquid refrigerants which may be used in direct contact with foods in place of brines include liquid nitrogen at -196°C, liquid carbon dioxide at (-78°C, and Freon-12 (dichlorodiflouromethane) at -29°C.

Mechanical Systems Using Liquid Refrigerants

A mechanical refrigeration system consists of an insulated area or room (the refrigerator) and a continuous, closed system consisting of a refrigerant, expansion pipes or radiator type evaporator located in the refrigerator, a pump or compressor, and a condenser. The compressor and condenser are located outside the refrigerator. The refrigerant flows into the expansion pipes as a liquid. Here it evaporates to a vapor and in changing from the liquid to the vapor phase it absorbs heat through the evaporator. The vapor is pulled into the compressor by the suction action of the pump and is then compressed into a smaller volume of hot gas. The latter action causes the gas to heat up and this heat must be taken out. This is done by passing the compressed gas through a system of pipes or radiators usually cooled by water, or sometimes by forced air. Cooling the compressed gas liquefies it, whereupon it is then returned to the evaporator in the refrigerator. The conversion of the gas to a liquid also produces heat which is transferred to the water or air of the condenser. There are a number of ways in which refrigeration may be applied to the insulated area which is to be cooled.

Plate Freezing

In plate freezing, layers of the packaged product are sandwiched between metal plates. The refrigerant is allowed to expand within the plates to provide temperatures of -33.3°C or below, and the plates are brought closer together mechanically so that full contact is made with the packaged product. In this manner the temperature of all parts of the product is brought to -17.8 0c or below within a period of 1.5-4 hours (depending upon the thickness of the product).

Refrigerated Air

Although air is fundamentally a poor conductor of heat, the fact that its density changes as its temperature changes permits its use as a contact refrigerant. Refrigerated air is commonly used in cold storage, air blast freezer and fluidized bed freezers. In case of cold storage, air inside the cold store is made cold by the evaporator (or expansion pipes) and have fan to circulate the cold air inside the room. Food inside the cold store is cooled down by conduction. The International Institute of Refrigeration recommends a storage temperature of -18°C for lean fish and -24°C for fatty species. The code also recommends that for lean fish intended to be kept in cold storage for over a year, the storage temperature should be -30°C.

Blast freezers are generally rooms or tunnels in which cold air is circulated by one or more fans through an evaporator and around the product to be frozen. Air blast freezers are generally preferred when unwrapped products of irregular size are involved. Fluidized bed freezers are used for food products of small uniform size. When particles of fairly uniform shape and size are subjected to an upward air stream, they are said to become fluidized. Depending on the characteristics of the product particles and the air velocity, they will float in the air stream each one separated from the other, surrounded by air and free to move.

Further studies

FAO (1994). Freezing and refrigerated storage in fisheries. FAO Fisheries Technical Paper – 340.

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