INTRODUCTION

Fish preservation is a very important aspect of the fisheries. Normally the fish farms or other fish capturing sites are located far off from the market place and there is chance of fish decomposition and the uncertainties of their sale in market. When the fishes are caught in numbers, greater than the amount of consumption, their preservation becomes a necessity for their future use. Preservation and processing, therefore become a very important part of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of flavour, taste, odour, nutritive value and the digestibility of their flesh.

Freshness of fish
Freshness is usually judged in the trade entirely by appearance, odour and texture of the raw fish. Since assessment depends upon the senses, these factors are known as sensory or organoleptic. The most important things to look for the freshness of fish are:

- The general appearance of the fish including that of the eyes, gills, surface slime and scales and the firmness or softness of the flesh.
- The odour of the gills and belly cavity;
- The appearance, particularly the presence and absence of discoloration along the underside, of the backbone.
- The presence or absence of rigor mortis or death stiffening;
- The appearance of the belly walls.

Causes of spoilage of fishes

In the cooler regions of the world the fish preservation is not required for a few days after their capture. This is because, the temperature is low enough to discourage the bacterial growth and so the spoilage of fishes is minimized. In tropical regions such as India, the hot climate favours rapid growth of bacteria and so the spoilage of fish flesh becomes inevitable. Landed fishes may ordinarily remain fresh for not more than 8 hours and begin to decompose rapidly after that. The decomposition or spoilage of fish flesh occur mainly due to various chemical, microbial and the enzymatic action.

Chemical action

The chemical action involves oxidation of fat, contained within the fatty tissues of the fish. It is more pronounced in fat fishes (e.g. oil sardine, mackerels, catla, trout, grass carp etc.) which as a
result become decolourised. The oil starts getting oxidized as soon as it comes in contact with the atmospheric air, which is known as rancidity. The colour of the fat and its viscosity changes and

![Image](image1.jpg)

**Fig – 9.4**

the fish becomes strong tasted. Methods employed to prevent rancidity include application of antioxidants like polyphenols or other viscous fluid and minimizing exposure of fish to atmospheric air.

**Microbial action**

![Image](image2.jpg)

**Fig – 9.5**

Microbial action involves bacterial decomposition of the fish flesh. The bacteria are found in the lower part of the gastrointestinal tract and on the general body surface of the fish. They may also
be contributed from the surrounding insanitary a most suitable place for their growth and multiplication. Proteins, constituting 70 - 90 % are degraded by proteolytic organisms such as Pseudomonas, Proteus, Chromobacterium, Halobacterium, and Micrococcus, etc. The Carbohydrates, present in small amount in the fish flesh are spoiled by carbohydrate fermenting organisms like Streptococcus, Leuconostoc, Micrococcus, etc. Fats constituting 3 - 5 % of the flesh are digested by relatively few gram negative bacteria. Degradation process occurs through the processes as follows:

Enzymatic action

Enzymatic action is due to action of various enzymes found in the body tissues / cells of fishes. They spoil the tissue by the process of autolysis and make the fish susceptible to bacterial attack. Proteinase for example can digest muscle proteins of the fish, catalyse the gill spoilage and ATPase brings about a complete disappearance of ATP, from muscle tissue in 6 to 8 hours. Autolysis of protein results in formation of amino acids and other nitrogenous products, which on further decomposition produces ammonia, carbon dioxide, volatile basic compounds like various amines and fatty acids, and foul smelling products like indole, skatole, etc.

Methods of preservation

Preservation can be done, both for short and long duration:

Preservation for short duration

Fig – 9.6
Chilling

This is obtained by covering the fish with layers of ice. However, ice alone is not effective for long preservation, because melting water brings about a sort of leaching of valuable flesh contents which are responsible for the flavour. But ice is effective for short term preservation such as is needed to transport landed fish to nearby markets or to canning factories, etc. Here autolytic enzymic activities are checked by lowering the temperature.

Preservation for long time

When the preservation is required for a long period of time, the fishes are passed through the cleaning, gutting and conservation and storage.

Cleaning:

During cleaning, the caught first are fish washed thoroughly in cold, clean water to remove bacteria, slime, blood, faeces, and mud, etc. from the body surface of the fish. It is being done under proper sanitary conditions.

Gutting:

After cleaning, the fishes are cut along their mid ventral side, and their visceral organs are removed. By removing viscera, the bacteria in the gastro intestinal tract and enzymes of visceral organs are removed along with it to prevent bacterial decomposition and enzymic autolysis respectively.

Conservation and storage:

Conservation is necessary to keep the dead fish in fresh condition for quite a long time. This is achieved by employing any one of the methods like freezing, drying, salting, smoking and canning.

Freezing
Freezing means removal of heat from the body. To check the enzymal, bacterial action and putrefaction it is preferred to store the fish under lower temperatures. The fishes are chilled in ice when they are to be stored for a few days. Ice is put inside the body cavity in large fishes. The fishes are arranged in tiers in shelves or boxes and stacked, and should not be dumped in heaps in cold storage. It is preferred to store at a temperature below 6.6°C to prevent microbial spoilage of fish. The formation of ice to some extent causes damage to the biological material, like growth of crystals of ice ruptures the structural components, releasing the enzymes and precipitation of liquid water and thereby causing precipitation of proteins effecting the change of pH making it more or less dry. The ice formation is initiated when the temperature of fish is lowered to about 1°C with a change in the concentration of inorganic and organic compounds. Freezing continues to fall with the lowering of temperature. At -50°C to -60°C the entire water in the fish is frozen. The maximum freezing of water is between 1°C and 5°C with different sized crystal formation of ice.

Ice formation occurs at a place where heat is extracted and then spread to warmer areas from where heat is conducted to refrigerating medium. The size of the crystals depends upon the nature of freezing in slow or quick freezing. Large crystals formed in slow freezing, rupture the tissues more since it penetrates the cell wall easily and forms the drip. Drip is the flow of tissue fluids from the frozen fish or muscle during freezing of the fish or muscle. This drip is due to the cell damage caused in freezing. This drip leaches along with soluble protein, vitamins and minerals and gives an undesirable appearance. The formation of drip affects the appearance of the product and results in the loss of weight. Hence, drip is considered as one of the criteria for judging the quality of the frozen products.

**Uses of ice:**

- Fish preservation time can be extended by using ice.
- Ice reduces fish body temperature and keeps the body cool for more time.
- Water, formed due to ice melting, cleans the mucous, and other material of the fish body.
- Ice is useful as good preservative due to its melting point 0°C and latent heat 80 cal./gr.
- Due to high relative humidity of ice, it is very good for preservation.
- Ice is cheap and very effective preservative.

**Deep or quick freezing**

When fish is intended to be stored for a long period, quick freezing is preferred which inhibits bacterial action. During quick freezing every part of the product comes within the range of 0°C to -5°C. Properly frozen fish at -20°C retains its physical properties and nutritive values for a year or more and is almost as good as fresh fish. Smaller sized crystals, shorter time taken for freezing less time allowed for diffusion of salts and evaporation of water and prevention of decomposition are some of the advantages in quick freezing. There are three ways effecting quick freezing:

a) Direct immersion of fish in the refrigerating medium
b) Indirect contact with the refrigerant through plates
c) Forced convection of refrigerated air directed at heat transfer surfaces.

There are several methods of quick freezing. Among the various types of quick freezing plants installed in India the carrier air blast type is widely used. Preserving of fish in cold storage is practised on a small scale in India. Cold storage preservation of fish is practised at the places where storage facilities are available. The fishes are preserved overnight in cold storage and marketed the next day. With the increase in availability of ice, fish is transported in ice by different modes of transport like rail, trucks, motor launches, etc. The west coast has a large number of freezing plants at places like Bombay, Mangalore, Cochin, and Trivandrum where freezing of prawns, lobsters and frog legs are undertaken. At Bombay fishes like pomfrets, jew fishes, etc., are frozen and stored for several months.

Oil sardines, mackerel and seer are the three commercial important food fishes used in the application of refrigerated sea water for preservation. These fishes were stored in artificial sea waters prepared by dissolving common salt to give a sodium chloride content 3.5% at a temperature of -1.1 to 0°C. In general the fishes stored in refrigerated sea water had firmer texture and better appearance than ice-stored ones. The oil sardines stored upto 2 days did not show any difference compared to ice samples. Further storing resulted inferior quality of the fish. Similarly mackerel and seer could be stored for 4 to 6 days and 12 to 14 days respectively.

In general different methods of freezing are adapted through sharp freezer, air blast freezer, contact plate freezer, vertical plate freezer, immersion freezing, liquid freon freezing, liquid nitrogen freezing, fluidized bed freezer, cryogenic freezing, sub freezing, etc. All the methods of freezing shall help in absorption of heat and in preserving the initial qualities of fish. Among the various methods of freezing the blast freezer is mostly in use in India.

Freeze drying

This is modified deep freezing, completely eliminating all chances of denaturation. The deep frozen fish at -20°C is then dried by direct sublimation of ice to water vapour with any melting into liquid water. This is achieved by exposing the frozen fish to 140°C in a vacuum chamber. The fish is then packed or canned in dried condition. Any loss of flesh contents by way leaching during melting of ice is thus avoided. The product is quite fresh looking in appearance, flavour, colour and quality.

Filleting and freezing of fish

The processing industry also adopted freezing of fish in the form of fillets at times when prawns are not available. Fillets are nothing but the strips of flesh cut parallel to the backbone of the fish. Fishes like milk fish, cat fish, perches, mullets, carps, eel, etc., are suitable for filleting and freezing. Filleting can be done by hand which is economical or by using a filleting machine. Fillets may be with or without skin and it fetches a much higher price in the luxury market.

Fillets are dripped in brine to enhance their appearance and to reduce the amount of drip and it also gives a salty flavour. The freezing of fillets can be an individual quick freezing of block
freezing. After dropping in brine, the fillets wrapped in polythene sheet are frozen in contact plate freezer at $-35^\circ C$ to $40^\circ C$.

In block freezing the fillets in known weight 500grm, 1Kg, 2Kg. are packed in polythene bags lined with wax and sufficient quantity of glazed water is poured to cover the fillets. The fillets are put in a freezer at $-35$ to $40^\circ C$ and stored at $-23^\circ C$.

**Drying**

Drying involves dehydration i.e. the removal of moisture contents of fish, so that the bacterial decomposition or enzymic autolysis does not occur. When moisture contents reduce upto 10%, the fishes are not spoiled provided they are stored in dry conditions. Fish drying is achieved either naturally or by artificial means.

**Natural drying**

In natural drying the fishes after being caught are washed and dried in the sunshine. They are suspended or laid out flat on the open ground. The process, however, has a number of disadvantages. It is slow and results in much loss, through putrefaction. It can be carried out only in dry, well aerated climate receiving sunshine which is not too hot. It, thus depends upon the environmental factors and availability of space. Lastly only the thin fishes can be preserved by this method, because the fat fishes have much flesh allowing bacterial decomposition to continue in deeper parts of their body. An additional disadvantage is that dried fishes require a long soaking period to restore water and that the sun dried fishes are not usually relished.

**Artificial drying**

In artificial drying the killed fishes are cleaned, gutted and have their heads removed. They are then cut lengthwise to remove large parts of their spinal column, followed by washing and drying them mechanically.

**Salting**

Salting is a process where the common salt, sodium chloride, is used as a preservative which penetrates the tissues, thus checks the bacterial growth and inactivates the enzymes. Salting commences as soon as the fish surface of the fish comes in contact with common salt and the end product shall have the required salinity with taste and odour. Some of the factors involved in salting of fish which play an important role are purity of salt, quantity of salt used, method of salting and weather conditions like temperature, etc.

During the process the small fishes are directly salted without being cleaned. In the medium and large sized fish the head and viscera are removed and longitudinal cuts are made with the help of knives in the fleshy area of the body. Then the fish is washed and filled with salt for uniform penetration through flesh. Large fishes like sharks are cut into convenient sized pieces. Generally, sardines, mackerels, seer fishes, cat fishes, sharks and prawns are used for salting.
The salt used should be pure common salt so as to keep the quality of the fresh fish. Traces of calcium and magnesium caused whitening and stiffening of the flesh and gives bitter or acid flavor to the product. In addition it does not allow the easy penetration of common salt. Dry salting, wet salting and mixed salting are the three methods employed in salting of fish.

**Dry salting**

In this process the fish is first rubbed in salt and packed in layers in the tubs and cemented tanks. The salt is applied in between the layers of fishes in the proportion of 1:3 to 1:8 salt to fish. The proportion of salt to fish varies with the fish since the oily fish require more salt. At the end of 10 - 24 hours the fishes are removed from the tubs and washed in salt brine and dried in the sun for 2 or 3 days. Large fish lose about one third and small fish about one half of their dressed weights.

**Wet salting**

The cleaned fish are put in the previously prepared salt solution. It is stirred daily till it is properly picked. In some fishes like seer, black pomfret, Indian salmon etc., the gut is removed and filled with salt in 1 : 3 proportion. First the salt is filled in the gut region of the fish and stacked, on the following day further addition of salt is done since the salt settles down at the bottom. Finally the process is repeated to ensure the proper filling up of salt and left undisturbed for 7 - 10 days allowing the liquor to flow off. This method is mostly followed in eastern parts of our country. In western parts the gut is removed and the salt is applied in one lot and they are arranged in bamboo baskets. The fishes preserve in wet salting process are to be consumed before the rain sets in and the fishes are marketed without drying.

**Mixed salting**

In this process, simultaneous use of salt and brine is followed. The salting process is continued till the concentration of salt in the surrounding medium equalizes with the concentration of salt in the fish tissue. The salting process may affect the shape, structure and the mechanical features of muscle tissue.

**Pit curing**

It is another process employed in south and south east of our country. In this process the fish treated with salt are buried in pits lined with leaves. After 2-3 days they are removed and marketed directly.

**Smoking**

In this method, landed fish is cleaned and brined. It is then exposed to cold or hot smoke treatment. In cold smoking, first a temperature of 38°C is raised from a smokeless fire. After this heating, cold smoke at a temperature below 28°C is allowed to circulate past the fish. In case of hot smoking, first a strong fire produces a temperature around 130°C. This is followed by smoking at a temperature of 40°C. The smoke has to be wet and dense. Good controls are
necessary over density, temperature, humidity, speed of circulation, pattern of circulation and time of contact with fish of the smoke. The phenol content of the smoke acts as an antiseptic and it also imparts a characteristic colour and flavour. Some condensation of tars and resins also adds to the taste. Strict hygienic conditions are maintained throughout this operation.

![Image of smoking fish](image)

**Fig – 9.8 - Smoking**

Courtesy: www.wedlinydomowe.com/smoking-meat.htm

For best results, fishes are hanged on special structures in special installations called smoke houses. Some are produced by burning wood in the smoke house itself or are conducted to it through pipes from fire produced at a distance. For making fire and smoke, only hard wood (Conifer wood, Saw dust etc.) are used. Smoke house has a chimney at the top for exit of smoke. It also has a number of galleries for hanging fishes. The smoke house is made of fire proof material and is very well insulated to retain heat.

**Canning**

Canning is a method of preservation in which spoilage can be averted by killing micro-organisms through heat. It is generally well known that food carries micro-organisms which cause spoilage if left unchecked. These micro-organisms are to be eliminated and the entry of other is restricted. The canning process involves pre-treatment of fish, preparation of can, filling and closure of the can, technique of heating the filled cans to kill micro-organisms without damage to fish, finally cooling, cleaning and storage of the product. The raw material should be processed properly since it contains most dangerous *Clostridium botulinium* which should be destroyed. This is found in protein rich food such as fish which has pH 6-7 and is nonacidic. There are some other heat resistant bacteria like *Clostridium sporogenes* which can be eliminated at a temperature of 5
- 6 times more than *Clostridium botulinum*. It needs a temperature of 120°C for 4 minutes or at 115°C for 10 minutes to kill them in large numbers.

**Methods of canning**

**Filling:**

Empty cans should be packed carefully by employing the manual labour or through mechanical device. While packing, care should be taken to see that no air pockets are left which cannot be removed by exhausting. At the same time too tight packing should be avoided. It is always better to leave some space at the top for accommodating gas released while processing. Fatty fishes (salmon, herring, mackerel, etc.) results in acceptable products when salt is added. Non-fatty
fishes call for special additives to improve flavour and texture. Brine is used when fish is not salted properly as an additive for enhancing flavour. Monosodium glutamate is used as additive for canned fish at a concentration of 1.6 gm / Kg fish. Vegetable oil and olive oils are also used for filling the cans.

**Exhausting:**

The air and gas from the can should be removed before its sealing process. This can be done by using exhausting which minimizes the strain on the can through expansion of air during heat processing. Removal of oxygen to avoid internal corrosion and creation of vacuum when the can is cooled are indication of sound packing since it protects colour and flavour of products and retains vitamins, etc. Further it checks the growth of organisms which requires air for growth. Later sealing is done to obtain air tight seal between the cover and the body of container so that the spoilage agents cannot enter the sealed container after the canned fish has been sterilised.

**Processing:**

Removal of air as completely as possible is an important factor in steam processing. The container along with the contents fish is heated in a retort at a temperature which is sufficient to kill the potential inactive spoilage agents without any damage to the fish inside. The retort systems can be operated continuously or in batches. In the recent times open boilers are being tried. Thus pressure processing either by steam or by water is delayed in this processing. The majority of retorts, may be horizontal or vertical still, or rotating, are fed by steam. The retort shall have an inlet at the top through which steam enters. The weight of the steam that entered the retort and the incoming steam both put together drives the air out from the bottom without mixing. Air pockets if present in a retort may give rise to uneven processing and lead to under processing while interfering between pressure and temperature. The processing time and temperature required for each food depends on various factors like types of pack, size of cans retort system, etc. By adopting the above heating process the majority of the spoilage agents or bacteria are killed. If any bacteria remains unkiller they can be eliminated by subjecting it to rapid cooling immediately after processing. The can should be cooled to a temperature of 35°C which is sufficient for rapid drying of the can surface. It protects against rusting.

Chlorinated water of 5 ppm can be used for cooling purpose. Even after careful regulation of pressure during and after processing, the cans are sometimes exposed to temporary leaks. Through these leakages the bacteria may enter-after processing. Hence, to minimise this, chlorinated water is used for cooling. The canned product should not be transported immediately since the salt pellets and others additives used may take some days for equal distribution throughout the can contents. It is advised to store for 3 months before final quality control. During this period all cases of leak contamination would show up.

**Microbial spoilage:**

Sometimes the canned fish show signs of microbial spoilage which may be due to insufficient pre-treatment especially inadequate cooling or improper preservation of raw material. It exhibits
signs of spoilage accompanied by the presence of dead bacteria. These bacteria may at times withstand the processing during cooling and storage.

Insufficient processing leaves back a number of heat resistant spores forming bacteria in the canned product. The commonly observed spore formers are mesophilic anaerobes (Clostridium sporogenes, C. putrificum). They produce putrid swells, mesophilic aerobes (Bacillus sp) produces flavour and changes colour and softens the contents. Thermophilic bacilli produce flat sours which are rare. The bacteria has got ability to produce gas and to interact with the material inside the can. The gas accumulated at the head region in the can helps in determining the kind and cause of spoilage. The swelling of cans may also be due to CO2 and hydrogen formed due to microbial spoilage. Finally the canned product is thoroughly examined by various methods like examining the product organoleptically, chemically and microbiologically for the quality of final product. Then it is properly labelled which should exhibit the name of the product, meat contents and any specific information if required. The processed cans can be stored at a room temperature which should be just above the freezing point of canned products.

**Demerits of fish preservation**

Although the preservation and processing constitute a very important aspect of the fish industry, it has certain drawbackss, as well, particularly with respect to retaining quality of fish flesh these are discussed briefly.

- Chilling brings about denaturation of flesh. This is because of ice crystals formed during chilling and causing mechanical damage to the muscles. Cell walls burst, structure gets deformed and the flesh loses much of flavour and taste. The flesh also becomes dehydrated and losses texture.
- If proper hygienic measures are not taken during the processes like washing, guttation and evisceration, etc. more harm would be done to the preserved material, owing to increase in the bacteria population.
- Incomplete or poor preservation leads to decarboxylation of histidine of fish flesh into histamine. The latter some other related substances, collectively called saurine, are common causes of food poisoning.
- Drying reduces weight, nutritive value and the digestibility of the flesh.
- Excess salting allows growth of salt tolerant bacteria, causing pink eye spoilage of fish flesh.
- Salting combined with smoking results in loss of protein, about 1 to 5 % due to salting and 8 to 30 % due to smoking.
- Smoking also accelerates rancidity of fat and so reduces digestibility of fat products.
- Canning leads to much loss of vitamin B1, panthotenic acid, vitamin-C and pteroylglutamic acid.