

Curing of Fish

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The traditional methods of processing fish by salting, drying, smoking and pickling are collectively known as curing. It is the oldest method of fish preservation and is still widely practiced in developed and developing countries. Cured fish consumption is more in areas where the availability of fresh fish is comparatively limited, namely interior markets and hilly areas. This is also the cheapest method of preservation, since no expensive technology is used.

In India roughly 20% of the fish caught is preserved by curing. Considerable quantities of cured fish are also exported, mainly to Singapore, Sri Lanka and to the Middle East.

Simple sun drying was the widely practised traditional method of fish preservation. By this,

preservation was achieved by lowering of water content in the fish, thereby retarding the activity of bacteria and fungi. The heat was able to destroy the bacteria to a certain extent. Later on, a combination of salting and drying or salting, smoking and then drying were developed.

Drying

Dried and dehydrated foods are more concentrated, than any other preserved form of foodstuffs. They are less costly to produce, processing equipment is limited, storage area required is less and the distribution costs are minimum compared to other processing methods.

During drying the moisture content and water activity, is reduced and hence microorganisms

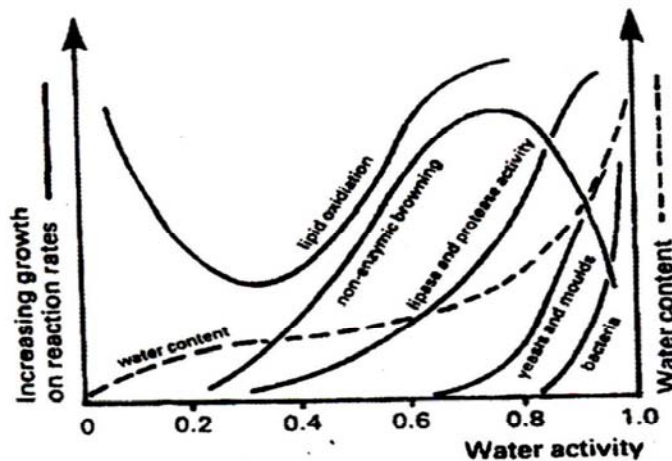


Fig.1. General water activity dependence of quality deterioration factors in foods.

cannot grow and multiply to spoil the fish. This will help in preserving the fish for a long time. Lowering the water activity will also influence the chemical and enzymatic changes in food. Fig. 1 summarizes the general water activity dependence that is observed over the whole water activity range with relation to different deteriorative reactions. From the figure it can be seen that microbiological growth is completely arrested below about 0.6 whereas certain other reactions that cause food spoilage continue. Lipid oxidation in fact increases at very low water activity.

Theory of drying

Three layers of water namely an adsorption layer, a diffusion layer and a free layer surround the surface of a colloidal particle. Water at the adsorption layer is tightly bound to the particle and is called bound water and it does not take part in any chemical reaction. The diffusion layer is less tightly bound to the adsorption layer and the further it is away from it, the more it behaves like free water. The third layer consists of free water which has all the properties of ordinary water and is able to support the growth of microorganisms and take part in chemical reactions. It is this water, which is important in the drying process. Water activity is the measure of water available to support microbial growth and chemical reactions.

Drying of fish is characterized by two different phases. Initially, drying is governed by evaporation from the near surface areas of the fish. Here drying continues at a constant rate equal to the rate of evaporation of free water surface. This phase is referred to as the constant rate drying period (Fig.2).

As the water evaporates from the surface of the fish, the water present in the interior of the muscles is transferred to the surface. This is mainly by diffusion of the water. This process is generally slower than the surface evaporation, and hence diffusion limits the drying rate. This period is

generally characterized by a slowly decreasing rate of drying, partially due to the fact that the drier the product is, the slower will be the diffusion of water to the surface. Thus this second phase is called the falling rate period.

Constant rate drying

Factors affecting the drying rate are air velocity, temperature, product surface area, relative humidity and product thickness.

Air velocity: The higher the air velocity, the greater is the drying rate. The moisture to be carried away should move through a stagnant surface layer of air by diffusion. Once through this layer, the moisture is transferred to the outer layer by convection. The higher the air velocity, the thinner is the surface layer, and greater will be the evaporation of moisture.

Relative Humidity : Humidity influences the drying rate by limiting the amount of water the air can absorb. If the air is saturated, then the fish cannot dry at all. If the RH is less than 100 % the air can absorb moisture and drying will take place until the air gets saturated.

Temperature: The amount of heat transferred to the product is proportional to the difference in temperature between the air and the product. High temperature differences increase heat transfer and drying rate. Warm air holds more moisture than cold air. If the temperature of the air is increased without the addition of water, the relative humidity falls. Lower RH favours more rapid evaporation and higher drying rates.

Surface area : The more the surface area, the greater is the surface available for drying. More area is exposed; faster will be the drying rate. Hence larger fishes are split open to increase the surface area.

Product thickness: Increased product thickness

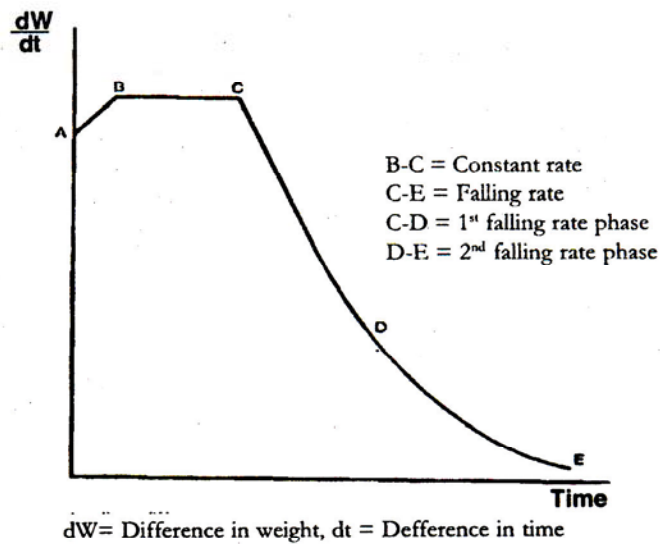


Fig. 2 Drying rate curve

result in longer drying periods. Evaporation rates are higher during the constant rate period, than in the falling rate period. Thinner fishes tend to dry faster than thicker ones mainly because of the increased surface area to volume ratio for thinner fishes.

Falling rate of drying

Since the surface moisture of the fish has been removed, further drying of the fish depends on the movement of moisture from the interior portion of the fish to the surface. Factors affecting the same are as follows.

Fat content of the fish: Fish with a high fat content tend to take a longer time to dry than lean ones.

Shape of the fish: The shape and thickness of the fish influence the rate of drying of the fish. Since, diffusion is a function of thickness, thicker products require a longer time for drying.

Temperature: Diffusion will increase with rise in temperature. Drying will therefore proceed more

rapidly with temperature increase.

Water content: As the water content is decreasing, the rate of diffusion of water to the surface layers is also reduced.

If the drying process is above ambient temperature, the constant rate period can be very fast. Here there is every possibility that the surface of the fish is dry, whereas the interior remains moist. Here diffusion from the interior to the surface will take place very slowly. The product will be dry on the surface and transfer of moisture from the interior will not take place. This is known as case hardening and this is mainly due to the deposits of soluble proteins and other solutes on the surface.

Methods of drying

There are basically two methods of drying fish. The common one is by utilizing the atmospheric conditions like temperature, humidity and airflow. This is traditional sun drying. The other is dehydration or artificial drying, by using artificial means like mechanical driers for removal of

moisture from the fish under controlled conditions.

Sun drying depends heavily on the natural weather conditions since the fish is dried by heat from the sun and the air current carries the water away. Here there is no control over the operations and many a time the losses cannot be substantiated. Hence it is necessary that the operations be controlled to get a product, which has an extended shelf life, but at the same time the texture, taste and flavour is maintained. It is here that artificial driers where processing parameters are controlled gain a lot of importance. Such processes are carried out in a controlled chamber or area. Such products have advantages over sun-dried products since they have better keeping quality and longer shelf life.

In mechanical driers, removal of water from the fish is achieved by an external input of thermal energy. This is an expensive method since there is need of fuel for heating and maintenance of the temperature. The drying chamber consists of a long tunnel in which the washed and cleaned fish is placed on trays or racks. A blast of hot air is passed over the material to be dried. After the required degree of drying the product is removed from the drier and packed.

Natural drying

In this type solar and wind energies are utilized as the energy source.

Drying on the ground

In sun drying fish is conventionally dried on sand. This sort of drying gives a product, which is contaminated with sand, filth and other foreign matters. To reduce the contamination fish can be dried on coir mats, cement platforms, bamboo mats and jute sacks. Fish dried on cement platform gets partially cooked due to the excessive heat. It also becomes necessary that the fish be turned over often to ensure a uniform dried material.

Rack drying

The most hygienic method for sun drying fish is drying them on racks. Here the fish is dried on raised racks above the ground. This can be made by tying old webbings to poles made of locally available materials, which are fixed at specific distances from each other. This ensures circulation of air from both top and bottom and contamination of the product with sand or dust is almost completely avoided and a quality product is assured. Here the rack can be sloping type where there is a drain of the water, or it can be a multi-deck rack that consists of two layers, or more.

Solar tent dryers

This is another form of dryer, using the solar energy. It is based on the principle that black surfaces absorb more sun energy than any light coloured one. Clear polythene sheets cover the four sides of the tent. The black PVC sheet covers the bottom of the dryer. The fish to be dried is placed inside the tent. The rack is made up of black plastic trays. There is a vent at the top and one at the bottom for the passage of air. The heated air passes through the fish and escapes through the vent at the top, while admitting fresh air through the vent at the bottom. The main disadvantage of this dryer is that temperatures cannot be controlled and may go very high.

Solar collector drier

Here the solar energy is first collected in the solar collector chamber. The heated air is then passed through the drying chamber, where the fresh fishes are kept for drying on plastic mesh/trays. The hot humid air will escape through the chimney. Clear polythene sheet covers upper side of dryer, where as the floor of the dryer is spread with black PVC sheet. The rack for fish spreading and drying is made up of black plastic mesh.

Solar cabinet dryer

This is a rectangular shaped dryer made up of plywood. The front side of the dryer is double walled. Inlet and outlet are provided for air to enter and escape from the chamber. A clear polythene sheet covers the upper portion of the drier. Two doors are present for loading and unloading the fish into the drier.

Artificial / mechanical dryers

These can be broadly classified into two types. In one type, the heat is transferred into the product through a hot gas, usually air. Eg. kiln dryers, cabinet dryers, tunnel dryers and fluidized bed dryers.

In the second type, the heat is transferred into the product through a solid surface, which may also be used as the cabinet for the product to be dried. eg drum dryer, vacuum dryer.

Hot air dryers

In these dryers the air is heated by steam / electrically. The hot air is blown over the product by the help of a fan or blower. The different parameters like temperature, air velocity, and humidity are controlled. Different types of dryers in this type are

- Cabinet dryer
- Tunnel dryer
- Multideck dryer
- Fluidised bed dryer

Cabinet dryer

This is a simple batch operated model used for relatively small-scale operations. A typical cabinet dryer consists of an insulated or non-insulated framed structure. Materials to be dried are spread uniformly on trays placed on permanent supports provided in the drier. A fan located inside the drier

will blow air through a heat source, which pass across or through the material loaded in trays.

Tunnel dryer

This type of dryer is most commonly used for drying fish. These are made in the form of long tunnels, 10-15 m long. Trolleys loaded with fish are moved at a predetermined schedule through the tunnel. Temperature and air velocity controls are provided. Hot air blown over the material is circulated with the help of fans. The movement of air is maintained in either direction in relation to the flow of the material. If the air movement is in the same direction as that of product movement, dryer is called a *parallel flow drying tunnel*. In such dryers the hottest air comes in contact with the wettest fish. Therefore higher temperatures can be used for drying. One serious disadvantage of the system is that the air towards the outlet side will become cool and highly humid, therefore the finished product may not be sufficiently dried.

If the movement of air is in the direction opposite to the movement of the product it is known as *counter flow drying tunnel*. Here, the hot dry air comes first in contact with the driest material, so that the finished product obtained will be sufficiently dry. However, the disadvantage is that in prolonged drying schedules the fish from one end of the tunnel may remain in humid air for long periods without getting sufficiently dry and result in spoilage.

Tunnel dryers should be designed based on the concept of hot air recirculation or by allowing part of the hot air passing over the fish to escape to the atmosphere. The recirculating air will become humid quickly and slow down the drying process, hence provision for dehumidification and humidity control should be provided.

Multi deck tunnel

In this type of dryer several tunnels are placed one above the other and air is blown in a zigzag manner

thrice after which it is exhausted. Here all the controls, heater, air blower and exhaust fans are placed on one side.

Fluidised bed dryer

The product is passed on a perforated conveyor bed and air is passed below, so that the product is partially lifted and dried. This is mainly used for fishmeal & fish powder

Contact Dryers

Vacuum dryers

Hollow shelves, through which the heating medium is circulated are fitted in the chamber. The material to be dried is placed inside the chamber in metal trays, which rests on the shelf. Vacuum will be drawn and drying will proceed under vacuum. This is an expensive method, but suitable for drying fatty fishes where fat oxidation and rancidity can be minimized.

Rotary dryers

These dryers are used mainly for fishmeal. The source of heat is hot air, which is circulated through the shell or it can be supplied from a steam heat jacket. Rotary drum dryer, Direct rotary dryer, Indirect rotary dryer and Steam dryer are some of the type of dryers used for drying purposes.

Drum dryers

Certain dryers like the single drum dryer, double drum drier, and twin drum dryer are used for drying fluid materials. Here the drum is heated by steam and the product to be dried is deposited as a thin film on the drum, which is scrapped off by a blade.

Salting

This is one of the oldest methods of preservation of fish. Salting is usually done as such or in

combination with drying or as a pretreatment to smoking. During salting osmotic transfer of water out of the fish and salt into the fish takes place, which effect fish preservation. It is based on different factors like diffusion and biochemical changes in various constituents of the fish.

Salting amounts to a process of salt penetration into the fish flesh. Penetration ends when the salt concentration of the fish equals that of the surrounding medium. Movement of salt molecules from the brine into the fish takes place through a layer of salt solution covering the fish but having a salt concentration below that of the brine. This layer is formed because the water diffuses out at a faster rate during the initial stages from the fish than the salt solutes, which enters the fish. As the period proceeds the thickness of this covering layer diminishes as its salt content grows. At this point diffusion of water from the fish ceases and the salt concentration in the layer equals to that of the salt concentration in the brine solution. Loss of water limits bacterial growth and enzyme activity, thus preserving the fish. The high salt content prevents the growth of normal spoilage microflora in the fish; but halophiles, which can survive 12-15% of salt, will survive.

Salt and its properties

Basically there are three main sources of salt.

Solar salt : Derived from the evaporation of sea water and salt lakes. Most commonly used source of salt in tropical countries.

Brine evaporated salts: Underground deposits, which are brought to the surface in liquid form and evaporated by heating.

Rock salt: Natural deposit of salt , which are ground to fineness before use.

The following factors of salt like chemical composition, microbiological purity and the

physical properties have to be taken into consideration before application to fish.

The main impurities of commercial salt are calcium and magnesium chlorides and sulphates, sodium sulphate and carbonate, and traces of copper and iron. Calcium and magnesium chlorides slows down the penetration of salt into the fish, thus increasing the spoilage rate. Magnesium chloride is hygroscopic in nature and tends to absorb water thus making the fish more difficult to dry. Excessive quantities of calcium and magnesium compounds, imparts a bitter taste to the fish and makes it brittle when dry. Traces of copper gives a brown appearance to the fish making it look spoiled.

Halophilic bacteria are present in most commercial salt. A particular group of halophiles called Red / Pink cause reddening of wet or partially dried salted fish. These do not grow in brine or in fully dried fish. Halophilic moulds on the other hand tend to grow on fully dry fish, causing dark patches. These are called "dun".

A mixture of large and small grain sizes is recommended for dry salting of fish. If fine grain is used directly on the fish, salt burn may occur due to the rapid removal of water from the surface and no penetration of salt to the interior of the fish.

Types of salting

Dry salting

This is the most widely used method of fish curing. All types of fishes except fatty fishes, big or small are cured by this method. Here, the fish is gutted, beheaded or ventrally split open and the viscera removed. The fish is then washed clean. Larger fishes are dorso-ventrally split open and cleaned thoroughly. Scores are made along the thick flesh portion for better penetration of salt. Salt is then applied in the ratio 1:3 to 1:10 (salt to fish) depending upon the size of the fish. The fish is

then stacked in clean cement tanks or other good containers. The bottom of the tank is covered with salt and a layer of fish is placed. Both fish and salt are alternately placed in the tank and wooden planks are put on the top and weighed down. The salt draws out the water in the fish and the weight placed keeps it under pressure. The fish is kept in this condition for 24-48 hours. After this the fish is taken out, washed in brine to remove adhering salt and drained. It is then hygienically dried in the sun preferably on clean racks. Yield of the product by this method is about 35-40%. This product has a shelf life of 6-10 weeks.

Wet salting

The initial stages of processing and salting are the same as for dry curing. Once the fish is put into the tank it is allowed to remain in the self-brine. The fish is not dried at all. The wet fish is then drained and packed in palmyrah leaf baskets or coconut leaf baskets and taken to the market. The fish is taken out only when there is demand. This method is particularly suitable for fatty fishes. This is mainly done for fishes like oil sardine, mackerel, ribbonfish etc. In such fishes the fat gets oxidized on exposure to air.

These products have moisture content of 50-55% and the salt content around 25%. They are most susceptible to fungal attacks, bacterial degradation and general putrefaction. They have a very short shelf life.

Kench salting

Here the salt is rubbed on to the surface of the fish and stacked in layers of salt and fish. The self-brine formed is allowed to drain away. This method is not recommended for use in tropical countries since the fish will be exposed to air and susceptible to insect infestation and spoilage. The fish tend to react with atmospheric oxygen producing rancid flavours and brownish discoloration.

Pickle salting

Here the fish and salt are packed in layers and kept in water tight containers. The self brine covers the fish and a lid is place to keep the fish immersed in the brine. If the self brine is not sufficient , saturated brine is added to immerse the fish.

Mona curing

Mainly done on medium to small size fishes. Here the curing is done without splitting the fish open. The intestine and entrails are removed by pulling out through the gill region. The fish is then salted and kept in tanks. The flesh is not exposed during salting thereby causing less contamination. The yield is about 70% and product has a shelf life of 50 days.

Pit curing

The fish is mixed with salt in the ratio 4 :1 and put in pits dug on the beaches. The pits may be lined with palymrah / coconut leaves. After 2-3 days the fish is taken out and packed in bamboo baskets and transported to markets without drying. The quality is poor and the fish is highly contaminated with sand and has a shelf life of about 20 days.

Colombo Curing

This was a specialty product made for Sri Lanka, and preservation is done by means of a pickling process. A piece of dried malabar tamarind (*Garginia cambogea* or Gorukkapulli) is put in the abdomen portion of the cleaned gutted fish. . These are stacked in wooden barrels and filled with brine, closed watertight and marketed. Fish has a shelf life for 6 months.

Conditions before salting

- The fish used for salting should be as fresh as possible. It should be borne in mind that fresher the fish the better will be the end product.

- The water used for washing and brining should be potable and should not be coloured or contaminated.
- Salt used should be of good quality and should not contain high amounts of Magnesium and Calcium chlorides. These being hygroscopic in nature will delay the drying process.
- While dressing the fish, care should be taken to clean and wash the same. The intestine should not be ruptured since this will contaminate the flesh
- All utensils and tanks used for drying and allied purposes should be cleaned properly and dried before use.
- Cement tanks should be scrubbed scrupulously and kept clean

Smoking

Smoke curing is another traditional method of 'preservation of fish. It is generally a combination of salting, and drying. Smoking is usually done in a specially designed kiln or a room. The source of smoke is wood, sawdust or coconut husk, depending on the particular flavour required. The fish that is salted and partially dried is used for smoking. Smoking can be done at temperatures below 35° C (cold smoking) or at higher temperature (hot smoking) . Liquid smoking by immersion in smoke liquor and electrostatic smoking is also practised in different countries.

Wood contains both combustible and non-combustible substances like moisture and ash. It is the combustible part made of organic compounds like cellulose, lignin, pentoses, phenols and other protein substances, which gives the particular flavour. The smoke produced is a typical aerosol and contains gases and hydrocarbons in addition to organic substances either in the liquid or gaseous state. The different types of products produced by the distillation of wood are :

- Gases like CO₂, CO, H₂ and hydrocarbons.
- Aqueous distillates like acids and their derivatives, alcohols, aldehydes; ketones; hydrocarbons, phenols and pyridines
- Tar distillates like valeric aldehyde, furans, phenols and their derivatives.

Types of smoking

Cold smoking

This is the conventional type of smoking using traditional chimney kilns. Here the temperature is never raised above 40 °C. The fish to be dried is hung on the top or kept in mesh trays. The wood is burned at the bottom of the kiln. The smoke travels upward and imparts the flavour to the fish. The fish does not get cooked. The RH is always maintained below 70 by allowing in a fresh draught of air when the percent RH goes beyond the required level. Duration of smoking extends from 36-72 hours. Cold smoked fish products are more stable and have a pleasant odour.

Hot smoking

Hot smoking is done in a mechanical kiln, which is of a tunnel type. The fish to be smoked is kept inside on trolleys and heat is supplied either directly or indirectly. Electric heaters are placed at different intervals through out the smoke path to maintain a uniform temperature throughout the chamber. Here the fish to be smoked is dried at 75- 80° C in order to cook the flesh. The fish is then smoked at a temperature around 100° C or above depending on the type of product specified. The flesh of hot smoked fish is delicate succulent and tasty, and has a longer keeping time.

Liquid smoking

Use of smoking liquid or concentrates are used in developing countries. The liquids are prepared by dry distillation of wood. The fish is salted, and given a dip in a smoke concentrate and then dried

in an ordinary kiln dryer. The liquid thickens and coats the fish thus imparting the particular flavour to the fish.

Electrostatic smoking

It is mainly used for smoking small fishes. Here the process of drying, smoking and packing of fishes is reduced to 12-18 min by means of using a high voltage current and infra – red heating. Here the salted fish is passed through a drying chamber heated by infra red lamps and then passed into a smoking oven by conveyor belts. Smoke is generated from the bottom and gets deposited on the fish. Then the fish passes through a baking oven where the fish is dried to the required moisture level.

Hot smoking is more popular in India. Hot smoked products are partially cooked due to the heat of smoke. The preserving effect of smoking on fishery products is attributed to a combination of surface drying, salting and deposition of phenolic and other anti microbial constituents of smoke on the fish. Small fishes are smoked whole whereas larger ones are smoked as fillets or chunks. Freshness of the fish is an important factor in determining quality of smoked product. Smoke imparts a characteristic attractive colour (as the golden yellow colour in the case in white fleshed fish like eel) and the special smoky flavour, relished by many. Smoked salmon is a highly priced delicacy in Europe. In India also the tribal population relishes this taste very much.

Preservative action of smoke

It is by the combined action of smoking, drying and deposition of natural chemicals produced by the destructive distillation of wood.

- Initial salting of the fish lowers the moisture content and inhibits the growth of many spoilage microorganisms and pathogens.

- Smoking results in surface drying of the fish and as a result there is a physical barrier to the aerobic microflora to proliferate. Hot smoking will destroy enzymes as well as bacteria.
- The phenolic constituents like guaiacol and its homologues will delay autoxidation of the highly unsaturated fish lipids.
- Antimicrobial agents like phenols, nitrites and formaldehyde will control microbial spoilage considerably.

Bactericidal property of smoke

Pure cultures of non-spore formers are affected by smoke, whereas those of spore formers are easily affected. Bactericidal effects of smoke is conditioned by the formaldehyde content of smoke as well as the organic acids, phenols and other organic compounds found in the tarry substances of the smoke. Smoking at lower temperatures does not have much bactericidal effect whereas there is greater reduction of microorganisms during hot smoking.

Physical properties of smoked products

The colour, taste and odour of smoked fish depends on the type of wood used and the compounds absorbed by the fish. Amount of phenolic compounds taken up by the flesh will give a better-smoked product. Cold smoked fish will contain guaiacol, phenol and cresols whereas hot smoked fish will contain methyl esters of pyrogallol in addition to phenols.

Marinades

Marinades are fish or shellfish preserved in a mixture of acetic acid and salt so as to get a product with extended shelf life and flavour. Acetic acid is responsible for producing the tenderness of marinades. This is affected by the action of certain proteolytic enzymes, which cause

a partial breakdown of the proteins with the release of some free amino acid. The salt removes the water and coagulates the protein. It also controls the hydrolytic action within the desired levels.

Types of marinades.

Cold marinades: Raw fish is preserved in a mixture of acetic acid and 10% salt at an optimum pH of 4.5. At no stage during the process the fish is heated. Bacterial and autolytic activities occur, and hence the shelf life is very limited at ambient temperatures.

Cooked Marinades: The fish is placed in a hot solution of 1-2 % acetic acid and salt at about 85°C. Here most of the bacteria are killed and the enzymes are inactivated or denatured. Shelf life is also of a longer duration.

Fried Marinades: Here the fish are fried for 15-20 minutes in fat before packing in brine containing 2-3.5 % acetic acid and 3-5 % salt . Frying kills most of the bacteria and denatures the enzymes.

Effect of curing on nutritional / textural properties.

Drying or dehydration removes the active water and stops the growth of microorganisms. It also reduces the rate of enzyme activity and chemical reactions. While drying, there is moisture loss, and the fish protein and other substances tend to be concentrated and the product becomes hard. Nutritional changes of dehydrated foods are less if the temperature is kept moderate and the food is adequately packed. High temperatures destroy heat labile nutrients, like vitamins and reduce the nutritional quality of proteins.

In salting of fish, the concentration of salt is higher on the outside than inside. As a result of osmosis most of the soluble cell proteins will get salted out. Even though the fish proteins are denatured by salt there is not much change in nutritive value.

High levels of salt induce protein denaturation and rapid moisture diffusion to the surface of the fish resulting in salt crystal formation and brittleness. The essential amino acids are also not affected by salting. However pepsin digestibility of protein decreases with increased salt concentration. Salt exhibits prooxidant activity in fish flesh and may increase losses of some vitamins and bring about undesirable oxidative changes of fat. Lipid oxidation, protein denaturation and Maillard reactions are the main causes for changes in nutritional quality of dried fish products. Salt used also be of good quality and optimally used so that there is no excess, which makes the product unfit for consumption.

In smoking, the preservative action of smoke is due to the combined influence of heating, drying, and chemical components of the smoke. Phenolic substances present in the smoke are mainly responsible for the antioxidative properties. The smoke particles in vapour phase exhibit much higher antioxidant properties than those in liquid phase. Since smoking follows salting, some proteins are lost and others changed in their nutritive value. Further, changes and losses occur by the action of heat and interaction of smoke components and proteins. Loss of water causes an increase in the concentration of salt, curing agents and smoke components as a result of which additional changes take place in the nutritive value. Colour of the smoked fish is due to the interaction of carbonyls and proteins similar to the Maillard reaction. Smoking brings about changes in the solubility of protein, pH and free sulfhydryl groups. Vitamin losses due to smoking are small. Dry curing followed by smoking is less destructive to thiamin as compared to smoking after salting.

Polycyclic aromatic hydrocarbons exhibit carcinogenic properties of which one of the best known groups is benzopyrene. The amount of PAH in smoked products is affected by factors like method of smoke generation, temperature of

combustion, air supply, length of smoke ducts, density and temperature of smoke. It is possible to eliminate PAH from smoke by applying sufficiently low temperature to thermal wood destruction and oxidation. Application of an electrostatic filter reduces the amount of benzopyrene

Preservatives used in cured fish

The traditional method of curing has not changed much over the years. However as part of the commercialization process, it is seen that consumers are quality conscious and seeking products that are hygienically prepared.

Preservatives are used in cured fish for extending shelf life and to minimize spoilage. Most commonly used preservatives are benzoic and sorbic acid. Benzoic acid is mainly used in high acid foods like pickles as a mould and yeast inhibitor. Sorbates and propionates are effective anti-mould agents and are widely used.

Nitrite is used in ppm levels in some cured products to stabilize colour and for flavour development. They also have an antimicrobial action on microbial cells and on bacterial enzymes. Antioxidants are used to prevent rancidity and oxidative flavour deterioration. Commonly used antioxidants are BHA, BHT, nordihydroguarctic acid (NDGA) and tertiary butyl hydroquinone (TBHQ). The synergistic activity of metal chelators like citric acid, phosphoric acid, ascorbic acid and EDTA has been well recognized.

Many spices have antimicrobial and antifungal properties and also contain antioxidants. However none of these are applicable on a commercial basis since a large quantity will have to be used, which may alter the characteristic odour, colour and flavour of the product.

Different methods have been reported for the application of preservatives to cured fish. CIFT

has developed the Calcium propionate treatment for the effective preservation of cured fish.

Direct dusting method: Calcium propionate powder (3g/100g cured fish) is taken in a coarse mesh cloth bag and dusted. This method is most effective against fungus, “red” discoloration and off smell.

Dip treatment in calcium propionate brine : Just after salting, the cured fish are kept immersed for 30 minutes in saturated brine containing 3% calcium propionate. The fish is then drained and dried. Fungal attack is prevented.

Calcium propionate mixture treatment : The cured samples are sprinkled with a mixture containing 3% calcium propionate in refined salt and intimately mixed. The appearance is affected because of excessive salt particles on the surface of the fish.

In these cases the extension of shelf life is extended from 2 months to 1 year in the case of dry cured products and upto 4 months in the case of wet cured products.

Spoilage of cured fish products

Moulds and fungi

Fungus usually grows well on unsalted and salted dried fish, which has high moisture content. Moulds usually grow at relative humidity above 75 %. The optimum temperature for growth is 30 –35 °C. In salted fish, brownish black or yellow brown spots are seen on the fleshy parts. This is mainly caused by the growth of halophilic mould called *Sporendonema epizoum*. This gives the fish a very bad appearance.

Rancidity

This is caused by the oxidation of fat. Rancidity is more pronounced in oil rich fishes like mackerel,

sardine etc. The unsaturated fat in the fish reacts with the oxygen in the atmosphere forming peroxides, which are further broken down into simple and odouriferous compounds like aldehydes, ketones and hydroxy acids, which impart the characteristic odours. At this stage the colour of the fish changes to brown. This is known as rust. This change results in an unpleasant flavour and odour to the product, leading to consumer rejection. Fatty fishes continue to become more and more rancid during storage. Certain impurities in salt and traces of copper accelerate this. Rancidity reduces the nutritive value and consumer acceptance and is a serious problem in cured fatty fishes.

Pink/red halophiles

This type of spoilage is mainly due to the presence of halophilic bacteria (*Halobacterium salinarum*, *H. cutirubum*, *Sarcina morrhuae* and *S. litoralis*) from the salt. It is commonly found in tropical countries like India. Spoilage appears on the surface as slimy pink patches. These bacteria are not harmful by nature. They are aerobic and proteolytic in nature, grows best at 42°C and at 10% salt concentration by decomposing protein and giving out an ammoniacal odour.

Use of good quality salt will avoid this defect to a great extent. This spoilage is usually found in heavily salted fish and is absent in unsalted fish.

Insect infestation

Spoilage due to insect infestation occurs

- During initial drying stages
- During storage of the dried samples.

The flies, which attack the fish during the initial drying stage, are mainly blowflies belonging to the family Calliphoridae and Sarcophagidae. *Chrysomya megacephala* is the major species, which causes

damage. These flies are attracted by the smell of decaying matter and spoiling fishes. During the glut season when the fish is in plenty and some are left to rot, these flies come and lay their eggs. The eggs develop into maggots, which bury within the gill region and sand for protection from extreme heat. They develop mainly when conditions are favorable with adequate moisture and intermittent rain. This results in loss of nutritive value of the fish and economic losses to the processor.

The most commonly found pests during storage are beetles belonging to the family Dermestidae. Beetles attack when the moisture content is low, especially when the storage time is long. The commonly found beetles are *Dermestes ater*, *D. frischii*, *D. maculatus*, *D. carnivorous* and *Necrobia rufipes*. The larva causes most of the damage by consuming dried flesh until the bones only remain.

Mites are important pests, found infesting dried and smoked products. They are very minute and bring about powdering of the product thereby giving it a white appearance. *Lardoglyphus konoi* is the commonly found mite in fish products.

Infestation can be reduced by

- Proper hygiene and sanitation
- Disposal of wastes and decaying matter
- Use of physical barriers like screens, covers for curing tanks etc
- Use of heat (45°C) to physically drive away the insects and kill them

Fragmentation

Denaturation and excess drying of fish results in breaking down of the fish during handling. Fish can become brittle and is liable to physical damage when handled roughly. It is necessary that fresh fish is to be used as raw material to ensure a good quality finished product.

Quality control and safety aspects of cured fish

The cured fish products are easily prone to spoilage and deterioration if they are not processed and stored well. The main problems affecting cured fish are, histamine, mycotoxins, 3,4 benzopyrene, spoilage due to oxidation, and halophilic bacteria and mould.

Histamine is a biogenic amine. It is an index of bacterial spoilage as well as a risk factor to the health of consumers. Maximum histamine of 20 mg/100 g fish has been fixed as the rejection level. It is mainly seen in scomberoid fishes.

Cured fish are easily prone to moulds and fungal attack. The product must be dried fully and must not be left uncovered in damp places. Lightly infected fish can be cleaned with brine solution and redried or smoked again. The main fungi isolated from dry fish were *Aspergillus*, *Mucor* and *Penicillium* species. Some of the species are pathogenic in nature and known to cause food spoilage and hence of significance in food safety. Care should be taken to see that highly infected fish is discarded because of the risk of mycotoxins, which are harmful to the consumers. Aflatoxin is a mycotoxin produced by the fungus *A.flavus*. It is a potential carcinogen.

Poly Aromatic Hydrocarbons (PAH) contain many highly carcinogenic substances. 3,4 benzopyrene is a carcinogen that has been detected in different smoked products.

Nitroso (N^o) substances in smoke imparts a pink color to the flesh of smoked fish. No substances are also capable of forming carcinogenic N-nitrosamines by reactions with the amines in the fish.

Specifications for dried fish products

The Indian government has laid down standards

for different dried fish products that are available in the market. These standards are prepared by the Fish and Fisheries Products Sectional Committee, which consists of experts in the field. Once the Food and Agricultural Division of the Council approves these standards, the Bureau of Indian Standards Institution adopts them. At present Indian standards for different dried fish products (Table 1) have been compiled into a single one, "Fish Dried and Dry-salted specification, Indian standard (1S14950- 2001)".

Packaging of dry fish

Conventionally dried fish is generally marketed in palmyrah leaf baskets, coconut leaf baskets and gunny bags. Since the packaging is permeable, the product absorbs moisture and gets soggy. It is seen that this fish is prone to attack by insects, rodents or other pests. The fish also arrive at the destination in an exposed condition. Hence these packaging

materials afforded least protection to the product. Plywood boxes and waxed corrugated cartons are also used for packing large quantities. Studies at the Institute have shown that high density polythene woven gusseted bags laminated with 100 gauge low density polythene is suitable for bulk packaging dried fish. HDPE is impervious to microbial and insect attack.

In the consumer market the fish is packed in low-density polythene or polypropylene. Packets of different sizes and weights ranging from 50g upto 2kg bulk packs are available. Cleaned and processed, ready to-cook condiment incorporated products are found in super markets. More costly packaging films like polyester polythene laminates and thermoform containers are used to pack dried prawns and value added dried products. Even though they are costly they provide added protection and consumer appeal.

Table 1. List of Indian Standard Specifications for dried and dry salted fish

Specification for dried and laminated Bombay duck	IS : 2884 -1979
Specification for dried prawns/ shrimps	IS : 2345-1985
Specification for dried shark fins	IS : 5471 -1969
Specification for dried white baits (stolephorus sp.)	IS : 2883 -1985
Specification for dry- salted leather jackets (chorinemus sp)	IS : 3852 -1985
Specification for dry- salted mackerel	IS : 4302-1985
Specification for dry-salted catfish	IS : 3851-1966
Specification for dry-salted dhoma	IS: 8836- 1985
Specification for dry-salted horse(caranx sp, mackerel	IS : 3853-1985
Specification for dry-salted seer fish	IS : 5198-1985
Specification for dry-salted shark	IS: 5199 - 1985
Specification for dry-salted surai (Tuna)	IS: 5736 -1985
Specification for dry-salted threadfin (DARA) and dry-salted jewfish (GHOL)	IS: 3850 -1973
Specification for fish maws	IS: 5472- 1985

Some commercially important dried products

Masmin

It is the main smoked dried fish product of the Lakshwadeep islands. It is prepared from skipjack tuna. The meat is boiled in seawater and alternately dried and smoked till the characteristic flavour and colour is got. The finished product is a hard-smoked and hard dried one with a shelf life of more than a year

Shark fins

Fresh shark fins are dried in the sun to a moisture level of 10%. The shark fins are further processed to obtain shark a fin ray, which is used in making exotic soups. The best rays are obtained from the dorsal and ventral fins of the shark

Fish maws

The air bladder of a certain fishes like eel, catfish, catla, rohu, kalawa are used for the preparation of fish maws. The air bladder is processed by removal of inner membrane, cleaned in water and dried in the sun to a moisture level of 15%. The maws are further processed to isinglass, which is used as a clarifying agent for wine, beer and vinegar.

Dried squid

Fresh squid is used for producing dried squid. The squid is whole cleaned, split open, dipped in salt solution and washed in clean water. It is dried on ropes, hung by the anterior side to a moisture level of 18%. The mantle is stretched and kept flat by passing through rollers.

Dried jelly fish

Both unsalted and salted dried jellyfish are produced for export. The salted jellyfish has final

moisture content of 60% and unsalted about 20%. They are graded based on the size of the umbrellas.

Dried laminated bombay duck

Fresh Bombay duck is gutted and washed thoroughly. The fish is then dried on a scaffold by interlocking the jaws of two fishes. The head and fins are removed and it is split open longitudinally. A dip treatment in 1% brine for 20 minutes is given and the fish is dried again on mesh trays to moisture content of about 16-17%. It is then flattened out in rollers and trimmed to required shape. The product is again dried until a moisture content of 10% is reached.

Status of Curing Industry in India

In a developing country like ours, cured fish products constitute a major portion of our staple diet. Curing is still a traditional industry based in the villages where the standards of hygiene and sanitation are rarely met with. Lack of potable water, poor quality of raw material, contamination, insect infestation and spoilage are the main problems encountered. In spite of all this, there is demand for cured fish products. In the past few years it is noticed that consumers are more hygiene conscious and product safety is also very much looked into. Quality products packed in consumer packs are in great demand. The conditions of dried fish in the wholesale markets have changed little, but the retail markets have improved considerably. New products like condiment incorporated and value added ready to cook/eat dried products are available in super markets and retail shops. Export statistics have also shown an increasing trend for dried products both in terms of quantity and value realized. With proper quality control and improved scientific management the fish curing industry will be able to grow and maintain an increasing demand in the future years