

## *Hygienic drying and packing of fish*



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*Training manual*

# ***Hygienic drying and packing of fish***

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## **Fish spoilage**

Fish is a highly perishable commodity, which requires proper handling, processing, packaging and distribution, if it is to be utilized in a cost effective and efficient way. The aim of preservation is to maintain food quality and nutritional value over a long period of time by preventing spoilage.

### **What causes fish spoilage?**

Spoilage is brought about by 3 destructive processes:

- enzymic decomposition,
- bacterial action, and
- oxidation

### **Enzymic decomposition**

- ❖ Enzymes are powerful biological chemicals that occur in the tissue of all living animals. They perform important functions, either by breaking down large food compounds into smaller ones in the stomach and gut, as in digestion, or, by helping to make new compounds for building new body tissue or for producing energy.
- ❖ In the living animal, the body keeps a close control on what enzymes do. However, when the animal dies, this control is lost. The enzymes will start attacking the flesh of the body, breaking large compounds down to smaller ones, just like the process of digestion.
- ❖ Enzymes can only operate in the presence of water. They are also sensitive to temperature. The preferred temperature is the ambient temperature, that is, they like it warm.

### **Bacterial action**

Bacteria are tiny living organisms that are found everywhere in nature. They are so small that millions can exist in an area of the size of a pin head. Most people associate bacteria with harmful diseases and sicknesses. But, they are not all bad. They are, however, a problem in the handling of food. Bacteria not only do spoil food, but they can cause food poisoning.

It is important to know that harmful, food poisoning bacteria are not found on fish in their natural home in the water. It is when they come into contact with dirty, un-cleaned surfaces

and are poorly handled that they can pick up the potentially dangerous, food poisoning bacteria.

Fish carry millions of bacteria on their external surfaces (skin and gills) and in their intestines. A healthy living fish uses its natural defence mechanism to protect it against the harmful effects of bacteria. However, when the fish dies, the defence mechanism stops working. This allows the bacteria the opportunity to feed on the flesh, multiply in millions, and eventually spoil the fish.

Conditions which allow bacteria to multiply are:

- ambient temperature,
- presence of water,
- source of food.

Bacteria will enter the flesh easily, if the fish has been damaged through improper handling and storage (e.g. if the skin of the fish is damaged, or the gut of the fish is not fully removed).

### **Oxidation**

- **Rancidity** is a more widely used term for oxidation. It occurs when oxygen in the air reacts with oil or fat in the flesh of the fish. This leads to a sour or stale, unpleasant smell or taste..
- Fatty pelagic fishes like skipjack tuna and sardines store fat in their flesh and can turn rancid quickly, if not handled and stored properly.
- White fleshed demersal fish store fat in their livers, so these must be removed during gutting.
- When frozen fatty fish are stored improperly, they can still spoil through oxidation, even though the temperature is too low for bacteria to grow or enzymes to work effectively.

### **Curing**

Bacteria and enzymes like ambient temperatures and need to operate in the presence of water. They do not like low temperatures or very high temperatures. They do not like to work in dry conditions. Many processing procedures in fact create the conditions that bacteria and enzymes do not like.

Curing is a traditional method, which has been used for centuries for preserving fish. The traditional methods of processing fish by salting, drying, smoking, pickling or combination of these methods are collectively known as 'Curing'. These methods are still widely practiced in developed and developing countries as it is the least expensive method of fish preservation. Fish curing industry is less organized compared to the freezing industry and is still carried on as a cottage industry. Removing water from the food by drying it in some way is an effective method of stopping bacteria and enzymes from spoiling food. Salting helps the drying process too, as it binds the water, making it unavailable to bacteria.

## **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 pre-treatment to smoking.

### **How does salt preserve fish?**

Salt is a valuable agent, which helps to prevent spoilage. Salt preserves by extracting water. This happens because water from inside the fish is drawn out into the strong salt solution outside the fish. As the water moves out, the salt moves in, penetrating deep into the flesh of the fish. Water is essential for bacteria to grow, so if the water is removed, bacteria cannot grow. Furthermore, the spoilage bacteria do not like salty conditions. The more salt in the fish, the more they dislike it.

Loss of water limits bacterial growth and enzyme activity, thus preserving the fish. By salting, the moisture content of fish is reduced to around 38 % and bacterial growth is prevented. When the moisture content is reduced to 25 %, autolytic activity is greatly reduced.

Dirty salt should not be used and if the salt is wet, it must first be dried. There are some special bacteria that like to live in salt-- these are called the salt-loving bacteria or halophiles. 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. They require salty conditions to grow and can easily be identified in salt because of their pink or red colour. These specialised bacteria can spoil fish, producing unpleasant smells.

### **How should fish be prepared for salting?**

- ✚ The raw material used should be of best quality to make the best products. Stale or spoiled fish cannot be improved by any form of processing, and that includes salting.

- ✚ The thickness of flesh of the fish must not be more than 25 to 30 mm (about 1 inch)
- ✚ Medium-sized fish should be split through the back, then gilled and gutted
- ✚ Large fish can either be filleted, with the skin left on or split and the flesh scored deeply at 25mm (1 inch) intervals
- ✚ Very large fish must be filleted and the flesh cut into 25 mm (1 inch) strips
- ✚ It is best to scale the fish, because the removal of water and penetration of salt will be easier

### **Salting methods**

There are two common methods of salting fish-- wet salting and dry salting.

#### **Dry salting**

- Dry curing is the most common method of fish curing
- To ensure that fish dries well, dry salting is recommended for *lean fish*, not fatty fish.
- 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 over put down 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.

#### **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 (pickle) formed is allowed to drain away.

#### **Wet salting**

- ✚ 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 are most susceptible to fungal attacks, bacterial degradation and general putrefaction. They have a very short shelf life.

**Brining and pickle curing** are the two methods used for wet salting.

- **Brining** requires water saturated with salt. Keep adding salt to the water, until no more salt will dissolve.
- Large fish must be cut open, and it is preferable to take out the backbone. Fish which are covered in a heavy coating of scales must be scaled. In places where the flesh is thick, scores must be made so that the salted brine can penetrate the flesh. Very large fish should be cut into thin fillets.
- After the fish has been prepared according to its size, it must be cleaned and put in the brine. Place a clean piece of wood weighed down with clean stones on top of the fish to keep the fish below the surface. Fish for drying, smoking and canning are usually brined prior to processing.

### **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.
- In pickle curing, the fish are laid alternately with dry salt in a water-tight container, using a fish-to-salt ratio of 1 part fish to 0.3 or 0.4 parts salt by weight. If less salt is used, then the fish will spoil.
- Place a layer of gutted, opened and washed fish pieces flat on the salt, flesh side down. In other words, flesh to flesh and skin to skin.
- After each layer of fish sprinkle on a thin layer of salt. Keep placing a layer of fish then a thin layer of salt until all the fish and all the weighed salt is finished. Make sure you finish with a layer of fish, skin upwards, and a final layer of salt.
- Water from the fish will quickly start to form. The surrounding salt will dissolve in this water. This is called the ***pickle***. It is retained inside the container and will eventually cover all the fish. Place a clean piece of wood weighed down with clean stones on the top of the fish until salting is completed.



## Colombo Curing

- ✓ This is a specialty product made for Sri Lanka, and preservation is 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.

## Sources of salt

Commercial salt can be classified into three main groups depending on the source and the method of manufacture:

- (i) **Solar salt** - prepared by the evaporation of sea or salt lake waters by the action of sun and wind. Most commonly used source of salt in tropical countries.
- (ii) **Brine evaporated salt** - underground salt deposits are brought to the surface in solution (brine) and this is evaporated, usually by heating.
- (iii) **Rock salt** - natural deposits of salt are ground to varying degrees of fineness without any purification.

## Chemical composition of salt

- ✚ Commercial salts vary widely in their composition; high quality salt may contain 99.9 per cent sodium chloride, whereas low quality salt may only contain 80 per cent sodium chloride.
- ✚ Apart from contaminants such as dust, sand and water, the main chemical impurities of commercial salts are calcium and magnesium chlorides and sulphates, sodium sulphate and carbonate, and traces of copper and iron.
- ✚ Solar salts tend to be less pure than mine evaporated salts.
- ✚ Calcium and magnesium chlorides, even when present in small quantities, tend to slow down the penetration of salt into the flesh; the presence of these salts may also increase the rate of spoilage.
- ✚ Magnesium chloride is hygroscopic and tends to absorb water, making the fish more difficult to dry and to keep dry.
- ✚ Fish salted in pure sodium chloride may be soft and yellow in colour. Calcium and magnesium salts give a whiter colour, but tend to impart a bitter taste. Very often the

consumer demands a whitish colour in salted fish products and small quantities of calcium and magnesium compounds in the salt are usually considered desirable. Excessive quantities, however, lead to a bitter flavour and the dried product tends to be brittle which can cause problems during packaging and distribution.

- ✚ Trace quantities of copper can cause the surface of salted fish to turn brown; this does not reduce the eating quality, but it does make the fish look like a spoiled or poor quality product.

### **Physical properties**

In dry salting, the size of salt crystals is important. A mixture of large and small grain sizes is recommended for dry salting of fish. Fine crystals tend to dissolve too quickly whereas large crystals dissolve very slowly and there is a risk of deterioration. 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.

### **Microbial contamination of salt and their effect on salted products**

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”.

### **Cooking of salted fish**

The concentration of salt is so high in salted fish products that it is necessary to remove much of the salt before the fish is cooked. This can be done by putting salted fish in clean, fresh water. The water will need to be changed about 3-4 times to encourage the removal of salt.

## **Pickling**

Pickling with salt, vinegar, sugar and spices is also widely employed for fish curing. A variety of fish products prepared with vinegar and spices enjoy wide popularity in Germany and other North European countries. Pickling is also practiced in China, Japan and Philippines. Although pickled products are of semi perishable nature, since the concentrations

of salt and vinegar employed are limited by considerations of palatability, they possess a greater appeal to consumers than salted and dried fish.

## **Smoking**

Smoking is one of the oldest methods of preservation of fish and it combines the effects of salting, drying, heating and smoke components. The preservative action is mainly by lowering the water activity and by the deposition of the smoke components produced by the thermal degradation of sawdust or wood. A wide variety of organic constituents such as phenolic, carbonyl and organic acids are present in the smoke. These compounds, along with the low water activity and applied heat inactivate autolytic enzymes and retard the growth of spoilage microorganisms.

## **Drying**

Drying is the oldest known and cheapest method of fish preservation. In India, around 25 % of the fish landed is used for drying. There is a huge demand for dry fish in the domestic and foreign markets.

### **Basic principle of fish drying**

The preservation by drying depends on reducing the moisture content to a level where microorganisms and most intrinsic enzymes become inactive. Generally, moisture content of not more than 15-20 % is aimed at, this being the upper limit below which moulds do not grow. During drying, the moisture content and water activity, is reduced and hence microorganisms cannot multiply and grow 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. The microbiological growth is completely arrested, when water activity is below about 0.6.

### **Water activity**

The water activity ( $a_w$ ) in a fish is defined as the ratio of the water vapour pressure in the flesh of the fish to the vapour pressure of pure water at the same temperature and pressure. It ranges between 0 and 1, and is a parameter that measures how available the water is in the flesh of the fish. Available water is necessary for the microbial and enzymatic reactions involved in spoilage.

### **Advantages of drying**

- Drying helps to achieve a shelf life of 4-6 months for fishes
- Dried fish products are less costly to produce
- Drying helps to retain more nutrients in fish compared to many other processing methods
- Dried and dehydrated foods are more concentrated than any other preserved form of foodstuffs
- Drying doesn't involve any costly equipments
- Processing equipments involved in drying are limited
- Storage area required for dried products is less
- The distribution costs are minimum compared to other processing methods

## **Different types of drying techniques**

### **Natural and artificial drying**

Drying is usually done in two ways. The first one is by utilizing the atmospheric conditions like temperature, humidity and airflow. This is traditional sun drying. Open sun drying (Naturally drying fish under the sun using solar energy) is the widely practiced method for drying fish. If air is used to carry away the water vapour formed, the process is called air drying. The basic principle of drying is that the activity of the muscle enzyme and microorganism is reduced to a minimum through removal of the water content of the fish. The other one is dehydration or artificial drying. Artificial drying is done by mechanical driers for removal of moisture from fish under controlled conditions.

### **Traditional method of open sun drying/Natural drying**

- In this type solar and wind energies are utilized as the energy source. Fish is dried by heat from the sun and the air current carries the water away.
- Initially drying takes place by the removal of moisture from the skin surface and later from the interior of the fish.
- Depending on the relative humidity, temperature and air velocity, the removal of moisture takes place continuously.
- This is the simplest method of drying fish.

- Usually small, lean fishes are dried under this method.
- Sun drying depends heavily on the natural weather conditions and there is no control over the operations.

### **Drying on the ground**

- The fisher women engaged in drying still follow the traditional method of open sun drying, which is usually practiced in unhygienic conditions resulting in poor quality.
- Drying is normally done on the beaches/sand, which results in contamination of the fish with sand, filth and other foreign matters.
- Apart from this, cheap, un-purified salt is used coupled with seawater rather than fresh water for rinsing dried fish.
- Fishes are laid out to dry on the beach with no protection from the crows, dogs, cats and birds, which are common in these areas. As a result, not only does the final product lack quality, but it is also sold at the lowest price in the market.

### **Drying rate**

The factors, which affect the rate of drying, are:

1. Size of the material: Larger fish takes a longer time to dry compared to smaller ones
2. Surface area: Large surface area will increase the rate of drying
3. Temperature: The higher the temperature, the faster will be the rate of drying
4. Relative humidity: The lower the relative humidity, the faster will be the drying
5. Air velocity: The greater the speed of the air, the faster the drying
6. Fat Content: Fatty fishes will take a longer time to dry than lean fishes
7. Water content: The higher the water content, the faster is the drying

### **Drying the fish on coir mats, raised platforms, bamboo mats and jute sacks**

- Drying the fish on coir mats, raised platforms, bamboo mats and jute sacks will help to reduce the contamination to a certain limit.
- Main disadvantage of this type of drying is that dried fishes can be contaminated with sand and foreign matters.
- The fish dried on cement platform gets partially dried due to the excessive heat.
- It becomes necessary that the fish is turned over often to ensure a uniform dried material.

## **Rack drying**

- Keeping the fish on racks kept above ground level is a hygienic method for sun drying the fish.
- Racks 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 both under and over the fish and contamination of the product with sand and dust also will be minimized.
- In addition to that, sloping type of racks can allow easy draining of any surplus water present on the fish surface.

## **Solar dryer**

In recent years, there is a considerable interest in the development of solar powered driers. This is a method by which the sun's heat is converged and utilized for drying. The energy of the sun is collected and concentrated to produce elevated temperatures and an increased rate of drying. A black surface is used for converging the solar heat. Raising the air temperature increases the amount of water the air can hold, thus the relative humidity will be reduced and the air will be able to absorb additional water vapour. Solar tent driers and cabinet driers are working on this principle.

## **Artificial/Mechanical dryers**

In mechanical driers, for removal of water from fish, an external input of thermal energy is required. This is brought about by the aid of burning fuel or electrical heater. This is an expensive method, since there is need for fuel or electricity for heating and maintenance of the temperature. Products are kept in trays and racks and kept inside the tunnel for heating. Hot air is passed over the material to be dried and the product is removed from the drier after sufficient drying.

These can be broadly classified into two types. In one type, the heat is transferred into the product through a hot gas, usually air. E.g. *Kiln dryer, cabinet dryer, tunnel dryer and fluidized bed dryer*. Tunnel dryer is most commonly used for drying fish. In fluidised bed dryer, 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.

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. E.g. *Drum dryer, rotary dryer and vacuum dryer*. Rotary dryers are used mainly for fishmeal.

### **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 oxidation and rancidity of fat can be minimized.

### **Freeze drying**

- ❖ Evaporation of moisture from fish placed in a vacuum quickly cools the fish due to the transfer of heat energy. The fish freeze after about 15 per cent of the water has evaporated. If the fish are allowed to freeze during drying, they do not shrink and will dry with an open porous structure. They will rapidly reconstitute to look very similar to fresh fish although the water will not be as tightly bound as in fresh fish.
- ❖ If heat is applied to the fish in a vacuum drier and they are not allowed to freeze, shrinkage similar to that found in normal air dried fish occurs.
- ❖ For rapid freeze drying, some heat must be supplied to the fish, if evaporation is to proceed at a rapid rate. Moisture must also be removed from the vacuum chamber, otherwise it will become saturated and no further drying will be possible.
- ❖ Freeze drying requires a high energy input and is only feasible for very high value products.
- ❖ Freeze dried products have the advantage that they can be stored under ambient conditions as long as the packaging is impervious to water.

## **Preparation of fish and shrimp for drying**

- Fish selected for drying must be as fresh as possible.
- The freshly caught fish/shrimp should be placed on ice until it is processed.
- If no ice is available, clean the fish with fresh or sea water, place it in a clean box and cover it with a wet cloth or mat to protect it from sunlight, dust and flies. However, without ice, the fish will need to be processed as soon as possible.

- The fish most suitable for drying are lean fish and fish with a low fat content, such as shark and most of the white fleshed fishes.
- It is advisable to wash table, knives etc., which are using for fish processing, in 10 ppm chlorinated water.
- Wash the fish/shrimp samples in clean water immediately after procurement.
- The sample has to be dressed after washing. Fish must always be gutted before drying. Depending on the size of the fish, it can be prepared in several ways. De-scaling has to be done for fishes like sardine. Small fishes can be salted directly after cleaning it well. Large fishes should be cut into butterfly style. Large fish, like shark, should be cut into strips or small rectangles to ensure adequate drying;

### **Drying of shrimp**

- Wash and clean the shrimp sample
- Weigh the sample
- Take water (water and shrimp in 1:1 ratio) and heat it to 80 °C
- Add 3 % salt to it
- Give a dip in the water until the sample colour changes to pink
- Dip the sample in 0.1 % citric acid
- Drain the water and keep it for drying

### **Drying of fish (small size)**

- Wash and clean the sample
- Weigh the sample
- Add salt in 6:1 ratio (fish: salt)
- Give a through mixing
- Take water (water and shrimp in 1:1 ratio) added with 3 % salt
- Give a dip treatment for 30 sec to 1 min
- Drain the water and keep it for drying

### **Drying of fish (large size)**

- Wash and clean the sample
- Cut the fish in butterfly style



- Remove the gills and entrails
- Take the weight of the fish
- Add salt in the ratio of 3:1 (fish: salt)
- Keep the sample for 12-24 h
- Wash away the excess salt in 3 % salt solution (1:1 ratio of water and fish)
- Drain the water and keep it for drying

### **Cooking of dried fish**

- Dried fish can be used in the same way as fresh fish if it is soaked for 2 - 3 hours before cooking. A properly dried fish can contain up to 80 per cent of its weight in protein. There are very few foods with this characteristic.

## **Quality problems in dried fish**

### **1. Spoilage by Fungi (Dun)**

- Fungus usually grows well on unsalted and salted fish with high moisture content. Fungus attack causes changes in the colour and flavour of fish. In salted fish, brownish black/chocolate or yellow brown spots are seen on the fleshy parts, caused mainly by the growth of halophilic mould, *Sporendonema epizoum*. Halophilic moulds tend to grow on fully dry fish, causing dark patches. These are called “dun”. Growth of fungus also leads to breakdown of fat and protein besides production of mycotoxins.

### **2. Spoilage by Bacteria (Pink/Red halophiles)**

- A particular group of halophiles called red/pink causes reddening of wet or partially dried salted fish. These do not grow in brine or in fully dried fish. Spoilage is caused by halophilic bacteria (*Halobacterium salinarum*, *H. cutirubum*, *Sarcina morrhuae*, *S. Litoralis* and *Halococcus spp.*) from the salt, which appears as slimy pink patches on the surface of fish. They are aerobic and proteolytic in nature and non-harmful.
- This kind of spoilage is usually seen in highly salted fish and is absent in unsalted fish. Halophilic bacteria are present in most of the commercial salt. Using of good quality salt will solve this problem to a great extent.

### **3. Rancidity/Rust**

- Rancidity is caused by oxidation of fat and fatty fishes are more prone to it. The colour of the fish changes to brown, which is known as rust. Rancidity also leads to reduction in the nutritive value, development of unpleasant flavour and odour in the product, affecting consumer acceptance. Certain impurities in salt and traces of copper accelerate this.

### **4. Case hardening**

- The fish has a chalk-white appearance, and is hard and brittle. This is caused by over-rapid drying, which leads to drying out of the outside of the fish while the inside is still moist.

### **5. Insect infestation**

- Insect infestation occurs during initial drying stage of fish and storage of dried product. Blowflies attack the fish during initial stage of drying, which are attracted by the smell of decaying matter and spoiling fishes.
- During storage, beetles especially *Dermestes spp.* attack dried fish, which consumes the product until the bones only remain.
- Mites are important pests, found infesting dried products. They are very minute and bring about powdering of the product thereby giving it a white appearance. *Lardoglyphus konoii* is the commonly found mite in fish products.
- Insect infestation can be reduced by maintaining proper hygiene and sanitation, disposal of waste and decaying matter and use of physical barriers and heat to physically drive away the insects and kill them.

### **6. 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.

### **7. Sand content**

- The best way to avoid the presence of high sand content is to dry the fish without having contact with sand. In the existing conditions, a mechanized fish cleaner can be used for removing sand from the conventionally dried fish products.

### **8. Losses in nutritional value**

- There is no evidence that the temperatures typically reached during sun drying cause any appreciable loss of nutritional value of the protein.
- But, excessive heat treatment is known to impair the nutritional value of the proteins, as a result of a variety of chemical reactions. It is reported that drying at 75 °C lowers lysine availability and net protein utilization. Oxidized fat is known to react with proteins and damage the nutritional value of protein.
- The nutritional value of oxidized fat is appreciably lower than that of the fat in natural form. Lipid peroxides, an intermediate product of oxidation, reportedly destroy Vitamins A and E.

### **Preventing spoilage of dried fish**

In order to prevent spoilage, care and attention must be used during:

#### **1. Processing**

The fish used must be fresh, prepared correctly according to size, and dried under the required climatic conditions. Using drying racks above the ground will protect against pests. Fishes can be hygienically dried in solar dryer even during unfavourable weather conditions without spoilage and maintaining its nutritional values.

#### **2. Transport**

When the fish has dried, it can be packaged into clean plastic bags, or any other dry and clean suitable material and transported. If the fish is to be sold in the local market, it can be displayed inside rat-and-insect-proof boxes, covered with mosquito netting and placed on a table. In this way, the product can be viewed by customers, without being handled.

#### **3. Storage**

The dried fish must be stored in a place that is free of insects and rodents. The best type of store house is raised on stilts above the ground, in a well-ventilated, shady spot.

### **Preservatives in salted/dried fish**

- Sodium sorbate/Calcium sorbate/Potassium sorbate (200 mg/kg maximum singly or in combination expressed as sorbic acid) is in the list of permitted preservative/food

additive, which can be used in salted fish in the Food Safety and Standards Authority of India (FSSAI) regulation.

- Treatment with sodium chloride and 0.1 % citric acid prior to drying has shown to improve the quality of sun dried prawns.
- Many spices and plant derived products have proven antibacterial, antifungal and antioxidant properties. Betel leaf extract can be used as a good substitute to chemical antioxidants in fish. Addition of 5 % turmeric in curing salt has been reported to improve the quality of dried white baits. But, these are not used on commercial basis, since the large quantity required to get the desired results may alter the characteristic odour, flavour and colour of the product.

### **Drying using solar dryer**

Energy is the major component in the operational expenditure of the fishing sector. Mechanical dryers using electricity or fossil fuels such as diesel oil and furnace oil, as the energy sources are available, but they are very energy intensive and also emit CO<sub>2</sub>. Alternative energy sources are coming into sharp focus in an era of escalating fuel prices. It is against this background that solar energy is gaining attention as a potential source for drying. When the sun shines so brightly for a good part of the year in a tropical country like India, tapping this energy is the best option for conserving conventional sources of energy. Solar heating system is the most viable option as it is cost effective and eco-friendly. The black heat collection units can be connected to a drying chamber to supply a flow of warm air and it is not then necessary to expose the fish to the direct rays of the sun, which can cause problems with case hardening and cooking of the fish, if the temperature is not adequately controlled.

#### **Solar tent dryer**

It is based on the principle that black surfaces absorb more sun energy than any light coloured one. In solar tent dryers, 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 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.

### **Hybrid solar dryer designed by ICAR-CIFT**

Designs of solar dryer vary from very simple direct dryers to more complex hybrid ones. ICAR-CIFT has introduced a hybrid solar drying system for hygienic production of dry fish by using environment friendly abundantly and freely available renewable solar energy. Continuous drying of fish is possible in this system with the help of LPG, biogas, biomass or electricity as alternate back up heating source, where the fish can be hygienically dried in unfavourable weather conditions without spoilage and maintaining its nutritional values.

### **Advantages of hybrid solar dryer**

- Eco-friendly
- Cost effective
- Hygienic drying conditions
- Protection against sand, dust, insects, rodents and birds
- Drying is possible even during adverse weather conditions
- Drying under controlled conditions of temperature and humidity
- Improved product quality
- Reduction in the drying time
- Preservation of nutritional quality

### **Hybrid solar dryer with electricity as alternate back up energy source**

One of the hybrid solar dryers developed has electricity as alternate back up heating source for continuous drying of fish even under unfavourable climatic conditions. Solar energy is effectively harnessed using specially designed solar air heating panels and proper circulation of the hot air across the stainless steel trays loaded with fish with the help of blowers makes the drying process faster.

- ☀ In short, solar dryers will help to prepare good quality dried fish products with longer shelf life and better nutritional properties with reduced drying time. Moreover, the fishes

dried hygienically using solar dryers will definitely find a place in the market as branded products meeting approved quality standards.

## **Packaging of dried fish**

Packaging materials and products liable to enter into contact with fishery products should:

- not impair the organoleptic characteristics of the fishery products;
- not be capable of transmitting to the fishery products substances harmful to human health;
- be strong enough to protect the fishery products adequately.

### **Packaging materials for dried fish**

- ✓ Commonly used packaging materials for dried fish are *palmyrah leaf baskets, coconut leaf baskets, bamboo baskets, newspaper baskets and gunny bags*. None of them is an efficient packaging material. 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.
- ✓ For exports, dried fish is bulk packed in *hessian sacks*. Such packages do not provide protection from moisture absorption, oxygen or insects.
- ✓ *Plywood boxes and waxed corrugated cartons* are also used for packing large quantities.
- ✓ Dried fish should be packed in a sturdy container such as a *wooden or cardboard box fitted with a lid* in order to totally enclose the product. Open boxes, although protecting the fish from physical damage, are not effective against high humidity and insect attack.
- ✓ Properly sealed *cartons, made from waxed or plastic coated board*, should be sufficiently moisture proof and rigid enough to withstand rough handling.
- ✓ Dried fish, being highly sensitive product, needs to be packed in modern **plastic based films/laminates** and the possibility of **vacuum packing/gas flushing** of products also has been examined.

- ✓ Currently *lamine films of polyester/polyethylene* are mostly used for packaging of dried fish. Polyester films have good strength properties and reverse colour printing can also be done. Polythene is heat sealable and has good food contact application.
- ✓ Studies at ICAR-CIFT have shown that *high density polythene (HDPE) woven gusseted bags laminated with 100 gauge low density polythene* are suitable for bulk packaging of dried fish. **HDPE** is impervious to microbial and insect attack. HDPE is a material, which will not spoil even if it gets wet.
- ✓ In the consumer market, the fish is packed in *low density polythene (LDPE) or polypropylene (PP)*. Packets of different sizes and weights ranging from 50 g upto 2 kg bulk packs are available.
- ✓ In the studies carried out at ICAR-CIFT, **PP** of 100 gauge and **LDPE** of 100-700 gauges were found suitable for storing dry fish. The advantages of LDPE are clarity, low water vapour transmission rate, heat sealing capacity, good bursting and tearing strength.
- ✓ Dry fish remained in good condition for long, when stored in films of high gauge. This is mainly because of the low water vapour transmission rate and oxygen transmission rate, which decrease with increase in thickness.
- ✓ **PP pouches** of 300 gauge are found good for salted fish products with more than 35 % moisture for obtaining a shelf life of 6 months.
- ✓ A common packaging practice adopted in India for export of laminated Bombay duck is *LDPE bags* and further packed in *7 ply CFB boxes/gunny bags*.
- ✓ Dry shell-on prawns are packed mostly in *duplex cartons or polystyrene trays* and then covered with a laminate film.
- ✓ Nowadays, *monolayer and multilayer films, combination and co-extruded films* are used for bulk packing and consumer packaging of dry fish.
- ✓ 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.

### **Problems in packaging dried fish**

- Dried fish is hygroscopic in nature and absorbs moisture when the climate is humid and become susceptible to spoilage by moulds and bacteria.

- When it comes in contact with air or oxygen the deterioration due to oxidation is rapid.
- They may also be attacked by insects, rats and mice, as well as domestic animals.
- Dried fish are sometimes brittle and easily damaged if not handled correctly.
- Packaging methods such as *hessian sacks, wooden boxes and baskets* are generally inadequate in protecting dried fish from these causes of damage.
- Care should be taken not to leave plastic or polythene bags containing dried fish in direct sunlight or in hot places since the increased temperature causes '*sweating*' (i.e. the removal of water still present in the dried fish). This water condenses on the inside of the polythene bag and will wet the dried fish and make them susceptible to mould attack.
- A further disadvantage is that some dried fish have sharp, hard points and edges, which puncture and rip the plastic or polythene bags, thus allowing air moisture, dust, and insects to spoil the fish. Packaging of cured fish poses a problem because of the irregular shape and sharp protrusions.

### **Reduced Oxygen Packaging (ROP) for dried fish**

Reduced Oxygen Packaging (ROP) means removing, displacing, replacing or controlling the oxygen content in a package below the 21 % normal oxygen concentration. ROP is defined as the reduction of the amount of oxygen in a package by removing oxygen; displacing oxygen and replacing it with another gas or combination of gases. Reduced oxygen packaging techniques such as vacuum packaging and modified atmosphere packaging can be used for storing dry fish over a long period of time.

#### **Vacuum packaging (VP)**

In vacuum packaging, air is removed from the package and the package is hermetically sealed so that vacuum is maintained inside the package. Vacuum packaging is one of the best methods for effectively delaying fat oxidation as it limits the availability of oxygen molecule for oxidation. The product kept under a lower O<sub>2</sub> atmosphere, with less than 1 %, inhibits the growth of aerobic spoilage microorganisms, compared with the normal atmospheric packaging.



### **Modified atmosphere packaging (MAP)**

In modified atmosphere packaging, the atmosphere of a packed food is modified so that its composition is different from air. However, the atmosphere may change over time due to the permeability of the packaging material or the respiration of the food. It is well documented that the shelf life of marine products can be extended by MAP. But the extension in the keeping quality of fish depends on the raw material quality, temperature, gas mixtures and packaging materials. Various atmospheres have been studied in fish packaging. Nitrogen (N<sub>2</sub>), oxygen (O<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>) are the main gases used commercially in seafood, although trace gases, such as carbon monoxide, nitrous oxide, sulphur dioxide, argon, and xenon are commented as possible gases. MAP technology can be applied to any fish varieties. However, the gas combinations have to be optimised for better results. The correct MAP gas mixture maintains high quality by retaining the original taste, texture and appearance of the foodstuff.

### **Fish drying in Gujarat**

Fishes such as Bombay duck, ribbon fish, lizard fish, croakers, cat fishes, horse mackerel, and sharks, fish maws and small sized prawns are dried in the sun all along the Gujarat coast (Veraval, Porbandar, Mangrol, Nava Bandar, Jafrabad, Okha etc.). Dried fish from Gujarat is sold in both domestic and international markets. Local consumption of dried fish is very less and limited to some places in the state. A major part of the dried fish is transported out of the state to Mumbai, from where it is dispatched to various centres, even to the North Eastern States and Southern States of the country.

Dried Bombay duck is an important item. Due to high moisture content, the only processing method adopted for Bombay duck is drying. For the preparation of commercially dried Bombay duck, the fresh fish, just after landing, is washed in sea water and hung in pairs from a scaffold by interlocking the jaws for drying. Less than 10 % of the dried Bombay duck is exported to countries like Sri Lanka, Mauritius, Bangladesh, UAE and Seychelles. A small quantity is converted into laminated Bombay duck, which has found a good market in the UK and West European countries.

Beach drying is the one of the oldest methods for preserving large catches of small sized shrimps and fishes in Gujarat. The catch is sometimes simply spread on the beach in a thin layer for drying. Fishes are also dried on coir mats/raised platforms/bamboo mats/jute

sacks/racks. Efficient sun drying of fish is impossible in the tropical coastal region because of the very moist, though hot, air. While the exterior of the fish dries easily when exposed to the sun, the inside remains moist and warm. The products are dried depending upon the weather. They often get contaminated with sand, bacteria, rodents, insects etc., thereby yielding low grade products. Salt used is of inferior quality containing fair amount of impurities. Salt is primarily responsible for 'reddening' the cured fish, due to halophilic bacteria. Further, due to the build up of high humidity on storage, dried fish is easily susceptible to mould growth. When fish is dried by conventional air drying, the most obvious phenomenon is shrinkage and change of shape as water is withdrawn from cellular structure. Case hardening is a common feature in sun dried fish. Rehydration property is very poor, because denaturation of proteins and migration of fat makes the internal structures of dried fish less hydrophilic. Packaging of the cured fish is also very unsatisfactory. The processing and packaging therefore need to be oriented on modern lines.

## **Indian standard specifications for salted fish/dried salted fish**

### **Bureau of Indian Standards (BIS)**

Bureau of Indian Standards (BIS) is the National Standards body functioning under the aegis of Ministry of Consumer Affairs, Food and Public Distribution, Govt. of India. Presently, BIS has 14 Division Councils which are formulating Indian Standards covering all areas other than those mentioned in Agricultural Produce (Grading and Marking) Act, 1937 and the Drugs and Cosmetics Act, 1940.

### **Indian Standard (IS 14950:2001) fish-dried and dry-salted-specification**

This standard prescribes the requirements and the methods of sampling and test for various types of dried and dry-salted fish.

### **Preparation of dry-salted fish**

In the preparation of dry-salted fish (mackerel, leather jacket, seer fish, surai, shark, cat fish, threadfin, jew fish, horse mackerel and dhoma), the fresh fish is split open by a cut from dorsal side along the vertebral column and the entrails and gills are removed. The knife is passed deep along the vertebral column and the fish is flattened out. Scores are made on the thick fleshy parts by passing the knife lengthwise. After washing the fish, salt shall be

smear in proportion of not less than 1:4 by mass on the cut surface of the fish and the fish is kept under cure for not less than 24 h. Salt used for curing shall conform to IS 594. The salted fish is washed slightly to remove excess of un-dissolved salt and dirt. The fish is dried in sun spread over drying racks for a period of 10 to 18 h over two to three days. During drying, the fish is turned upside down occasionally to facilitate quicker and even drying. The fish while drying shall be protected against contamination from dirt, sand, flies and insects. In the case of large size fish, it may be cut longitudinally into pieces of suitable size.

### **Preparation of dried Bombay duck**

In the preparation of dried Bombay duck, the fresh fish as soon as it is landed is washed with clean water to remove all adhering impurities and hung in pairs on ropes between vertical poles, the jaws being used for locking in pairs. The fish is dried in the sun. It may also be dried in artificial dryers.

### **Preparation of laminated Bombay duck**

In the preparation of laminated Bombay duck, the fresh fish is thoroughly washed in clean water. The guts are removed and then washed well again. The gutted fish are suspended from a scaffold for surface drying for about 2 h. At this stage, remove the head, tail and fins using a sharp knife or scissors and split longitudinally along the belly portion. Bones can be removed if required. Dip the fish thus laminated in sufficient quantity of 1 percent brine (prepared from refined salt) for 20 min. Drain the fish and spread on drying racks to a moisture level of 16-17 percent. Flatten the product by means of a roller press. Trim the sides to get pieces of uniform size. Dry the product again for 1-2 h so that the final moisture content is about 15 percent. It is always advantageous to use a tunnel drier for drying the product to improve the quality of the finished product.

**Quality standards for dried fish products as recommended by Bureau of  
Indian Standards (BIS)**

<b>Sl. No.</b>	<b>Product</b>	<b>Moisture, percent by mass, Max</b>	<b>Sodium chloride (on moisture free basis), percent by mass</b>	<b>Acid insoluble ash (on moisture free basis), percent by mass, Max</b>
1.	Dry-Salted Cat Fish	35	25 (min)	1.5
2.	Dry-Salted Dhoma	35	10-15	2
3.	Dry-Salted Horse Mackerel	35	25-30	1.5
4.	Dry-Salted Threadfin (Dara)	40	25 (min)	1.5
5.	Dry-Salted Leather Jacket	35	25-30	1.5
6.	Dry-Salted Mackerel	30	25-30	1.5
7.	Dry-Salted Jew Fish (Ghol)	40	25 (min)	1.5
8.	Dry-Salted Seer Fish	35	25-30	1.5
9.	Dry-Salted Shark	35	25-30	1.5
10.	Dry-Salted Surai (Tuna)	35	20-25	1.5
<b>Dried products</b>				
11.	Dried Bombay Duck	15	7.5 (max)	1.0
12.	Laminated Bombay Duck	15	6 (max)	1.0
13.	Dried Fish Maws	8	-	1.5
14.	Dried Prawns	20	5 (max)	1.0
15.	Dried Shark Fins	10	-	1.5
16.	Dried White Baits	15	2.5 (max)	1.5

## **Food Safety and Standards Authority of India (FSSAI)**

The Food Safety and Standards Authority of India has been established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption.

In its notification dated 11 January 2016, the FSSAI has amended the standards for salted fish/dried salted fish. These new regulations will be called Food Safety and Standards (Food Products Standards and Food Additives) Amendment Regulations, 2016.

1. Dried/ salted and dried fishery products means products prepared from fresh or wholesome fish after drying with or without addition of salt.
2. The fish shall be bled, gutted, beheaded, split or filleted and washed prior to salting and drying.
3. Salt used to produce salted fish shall be clean, free from foreign matter, show no visible signs of contamination with dirt, oil, bilge or other extraneous materials.
4. The product shall be free from foreign matter, objectionable odour and flavour.
5. The product may contain food additive permitted in Appendix A.
6. The product shall conform to the microbiological and chemical requirement as laid down in the regulations

<b>Sl. No.</b>	<b>Characteristics</b>	<b>Requirements</b>
1.	Water activity ( $a_w$ ) at 25 °C	Less than 0.78
2.	Salt content (percent Sodium Chloride)	Not less than 12 %
3.	Histamine content, max.	200 mg/Kg
4.	Acid Insoluble Ash on dry basis	Not more than 1 %

**Food additives for use in salted fish (Appendix A: List of Food Additives)** in Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2016: Sodium sorbate/Calcium sorbate/Potassium sorbate (200 mg/kg maximum singly or in combination expressed as sorbic acid)

**APPENDIX B: Microbiological Requirements for Salted fish/dried salted fish**

Total plate count	Not more than five lakhs / gm
<i>E. Coli</i>	Not more than 20 / gm
<i>Staphylococcus aureus</i>	Not more than 100 / gm
<i>Salmonella &amp; Shigella</i>	Absent in 25 gm
<i>Vibro cholerae</i>	Absent in 25 gm
<i>Vibro parahaemolyticus</i>	Absent in 25 gm