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CURED FISHERY PRODUCTS

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Fish preservation by means of traditional methods is still being used widely to keep the fish edible for longer time. The term “Curing” includes the method of drying, salting, smoking, marination and fermentation. These are the oldest and cheapest methods used alone or in combination to preserve the fish. As fish is highly perishable in nature efficient post harvest handling and preservation is critical to retain its freshness until it reaches the consumer. Proper handling and quicker preservation will help to reduce the physical and quality loss of fish.

Advantages of fish curing

The method of curing is simple, cheap and can be easily adopted

It enhances the shelf life of products

Helps to preserve fish when available in glut for lean period

Source of protein for areas where fresh fish is not available

Less capital intensive

Less energy requirement for storage of end products

Disadvantages of fish curing

Usually, secondary quality fish is used for curing

Poor quality final product due to unhygienic handling and production

Use of low quality inputs such as salt further degrades the quality of the products

Presence of physical contaminants such dirt and sand in the final products

Dried fish products

Drying is one of the oldest and widely used methods of fish preservation in which the moisture content of fish is removed by evaporation to arrest microbial and enzymatic spoilage. In general, the term 'drying' implies the removal of water by evaporation. In fish, water constitutes about 70-80% and since water is essential for the activity of all living organisms its removal will facilitate retardation of microbial and autolytic activity as well as oxidative changes and hence can be used as a method of preservation. Fish drying can be done by natural and artificial means. In any process of drying, the removal of water requires an input of thermal energy. The thermal energy required to drive off the water can be obtained from a variety of sources, e.g.,

the sun or the controlled burning of oil, gas or wood. The thermal energy can also be supplied directly to the fish tissue by microwave electromagnetic radiation or ultrasonic heating.

During air drying, water is removed from the surface of the fish and water moves from the deeper layers to the surface. Drying takes place in two distinct phases. In the first phase, whilst the surface of the fish is wet, the rate of drying depends on the condition (velocity, relative humidity etc.) of the air around the fish. If the surrounding air conditions remain constant, the rate of drying will remain constant; this phase is called the 'constant rate period'. Once all the surface moisture has been carried away, the second phase of drying begins and this depends on the rate at which moisture can be brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower; this phase is called the 'falling rate period'.

Constant rate drying phase

During this period the rate of drying is dependent on several factors:

Relative humidity of the air: The lower the relative humidity of air surrounding the drying area, the greater the ability to absorb water and the faster the rate of drying.

Air velocity: Air velocity has a positive relation with rate of drying. Better the speed of the air over the fish, the greater will be the drying rate. The air around fish consists of an immediate stationary layer above the fish, a slowly moving middle layer and an outer turbulent layer. On saturation of the immediate stationary air layer, the moisture passes into the slowly moving middle layer. The higher the air speed in the outer layer, the thinner the slow moving layer, allowing more rapid movement of water away from the fish.

Air temperature: the evaporation of water produces a cooling effect. At the beginning of drying, the temperature of the fish is reduced below ambient; after a short while it reaches a steady value. At this steady value, the heat energy required for evaporation is balanced by the heat supplied by the surrounding air. Warm air can provide more heat energy and, provided that the air speed and relative humidity will allow a high rate of water movement, the rate of drying will be increased.

Surface area of the fish: the larger the surface area, the faster the rate of drying. By scoring and splitting the fish, the surface area increases relative to the weight/thickness; the rate of drying will, therefore, be faster.

Falling rate drying phase

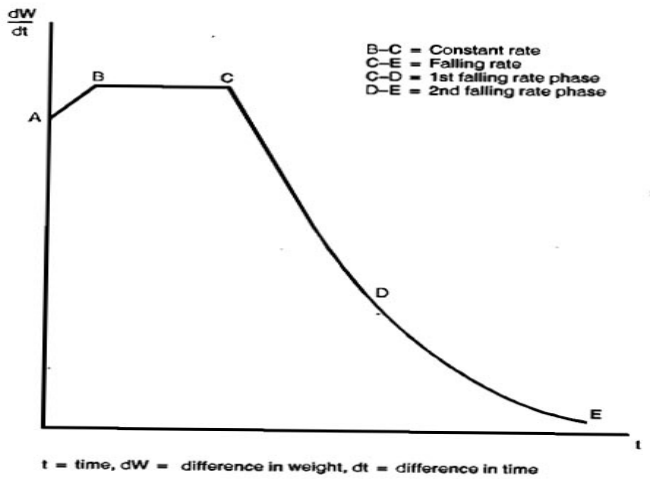
Once the free surface moisture has been removed, the rate of drying depends on the movement of moisture from interior to the surface of the fish. Several factors influence the rate of drying:

Nature of the fish: a high fat content in the fish retards the rate of drying.

Thickness of the fish: the thicker the fish, the further the water in the middle layers has to travel to reach the surface.

Temperature of the fish: diffusion of water from the deeper layers to the surface is greater at higher temperatures.

Water content: as the water content falls, the rate of movement to the surface layers is reduced.



Drying rate curve.

Source: Redrawn from *FAO Fisheries Report*, No. 279. Food and Agriculture Organization of the United Nations, Rome. 1983.

Methods of Drying

There are basically two methods of drying fish. The common and traditional method being sun drying which is done by utilizing the atmospheric conditions viz., temperature, humidity and airflow. In recent times, the controlled artificial dehydration of fish has been developed so that fish drying can be carried out under controlled conditions, regardless of weather conditions.

Natural drying or sun drying is the process in which fishes are dried under sunlight. Here solar and wind energies are utilized as the energy sources used to evaporate the water in fish. Generally fishes are suspended in bamboo poles or any other support or laid out flat on the open ground. Different methods include:

Drying on the ground

Rack Drying

Solar tent dryers

Solar cabinet dryer

Artificial drying or dehydration the fish is dried mechanically in an enclosed atmosphere under a controlled condition unlike natural drying where we have no control over the environmental condition. Cleaned, gutted and beheaded fishes are dried in dryers where temperature, humidity and air velocity is controlled.

Artificial / Mechanical Dryers

Hot air dryers

- *Cabinet dryer*
- *Tunnel dryer*
- *Multi deck tunnel*

Contact Dryers

- *Vacuum dryers*
- *Rotary dryers*
- *Drum dryers*
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Fish can be dried with or without the addition of salt. Dry fish products with and without salt is available in the markets. Small fishes like anchovy, sole, pony fish etc. can be dried directly after thorough washing or they can be dried after giving a drip treatment in brine. Dip such small fishes in 5-10% brine for 5-10 min depending on size of fish and dry to moisture content less than 15%. It is better to use fine salt that dissolves faster. Small shrimps like *Metapenaeus dobsoni* can be dried after giving dip in boiling water containing salt and citric acid to get an attractive pink color to dried shrimp. The shrimp need to be dried to moisture content 10-15%. Layer salting is preferred for medium and bigger-sized sized fishes before drying. The salt is applied in a salt: fish ratio of 1:3 (bigger fish) to 1:7 (smaller fish) depending upon the size of the fish. The salting should be carried out for a period of 16-18 hours, preferably overnight. The salted fishes should be dried to moisture content less than 30% after giving a wash to remove excess salt in the surface layers using potable water (preferably saturated brine solution). Crystal salt alone or fine and large crystal salt in combination can be used for salting. Mechanical drying of fish should be carried out at a temperature of 45-55°C (Ideal). It is better to avoid use of temperature above 60°C to reduce the cooking effect and case hardening. Mechanical drying usually requires 7-10.30 hours depending on the size and kind of the raw material to reduce the moisture content to safe levels.

Salted fish products

Salting 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. The presence of sufficient quantities of common salt (sodium chloride) in fish can prevent, or drastically reduce, bacterial action. Salting amounts to a process of salt penetration into the fish flesh when fish are placed in a strong solution of salt (brine) which is stronger than the solution of salt in the fish tissue. Penetration ends when the salt concentration of the fish equals that of the surrounding medium. This phenomenon is known as osmosis. It is based on different factors like diffusion and biochemical changes in various constituents of the fish. This process facilitates preservation of fish by reducing the water activity. A concentration of between 6 – 10% salt in the tissue will prevent the activity of most spoilage bacteria; the removal of some water from the tissue during the salting process will also reduce the activity of the spoilage bacteria. If fish are salted before drying, less water needs to be removed to achieve preservation. A water content of 35 – 45%, depending on the amount of salt present, will often prevent, or drastically reduce, the action of bacteria.

Salt: Source and properties

Common salt, in its purest form consists of sodium chloride (NaCl). However almost all commercial salts contain varying levels of impurities depending on the source and method of production.

Based on the source as well as method of manufacture, common salt can be grouped as:

Solar salt: prepared by the evaporation of sea or salt lake waters by the action of sun and wind.

Brine evaporated salts: produced from underground salt deposits which are brought to the surface in solution form and is heat evaporated.

Rock salt: obtained as natural deposits from interior rock mines which are ground to varying degrees of fineness without any purification.

Chemical composition

Commercial salts vary widely in their composition with best quality salt containing up to 99.9 % sodium chloride, whereas low quality salt may only contain 80% sodium chloride. The main chemical impurities of commercial salts include calcium and magnesium chlorides and sulphates, sodium sulphate and carbonate, and traces of copper and iron. Apart from these, contaminants such as dust, sand and water may also be present in salt. Presence of calcium and magnesium chlorides even in small quantities tends to slow down the penetration of salt into the flesh and hence their presence may lead to increase the rate of spoilage. Further magnesium chloride is hygroscopic and tends to absorb water, making the fish more difficult to dry and to keep dry. 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 in salt can cause the surface of salted fish to turn brown affecting the appeal of dried fish.

Microbiological purity

Many commercial salts, particularly solar salts, contain large numbers of salt tolerant bacteria (halophiles) and counts of up to 105/g have been recorded. One group of halophiles, the red or pink bacteria, can be a problem in commercial fish curing operations as they cause a reddening of wet or partly dried salt fish. They do not grow when the fish are fully immersed in brine or when they are fully dried. Halophilic moulds can grow on fully dried fish and cause the formation of dark patches, which is called 'dun'. Halophilic moulds tend to occur more frequently in rock salt.

Physical properties

Fine grain salt dissolves more rapidly in water and is preferred for making brines. If fine grain salt is used directly on a fish, it may cause a rapid removal of water from the surface which becomes hard and prevents the penetration of salt to the inside of the fish, a condition referred to as 'salt burn'. For dry salting, a mixture of large and small grain sizes is recommended.

Types of Salting

Dry salting: This is the most widely used method of fish curing. Dry salting is advisable for fishes of any size, except fatty fishes. The fish is gutted, beheaded or ventrally split open and the viscera removed followed by washing. Scoring is also practiced if the flesh portion is thick for facilitating better salt penetration. 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 layered with salt and weight is applied from top for better salt penetration. The fish is kept in this condition for 24-48 hours. After salting period, the fish is taken out, washed in brine to remove adhering salt and drained. It is then hygienically dried to a moisture content of about 25%. Yield of the product by this method is about 35-40% with a storage stability of up to three months under ambient conditions.

Wet salting: The initial stages of processing and salting are the same as for dry curing. However the fish kept in tank is allowed to remain in self-brine till marketing without further drying. For marketing, as per the demand the wet salted fish is drained and packed in palmyrah leaf baskets or coconut leaf baskets. This method is particularly suitable for fatty fishes like oil sardine, mackerel etc. Wet salted fishes have a short stability with a moisture content of 50-55% and a salt content of around 25%.

Pickle salting: Pickle curing is a type of wet salting where the fish is layered by granular salt which, dissolves in the surface moisture of the fish forming solution which penetrates into the fish removing moisture from the fish. The fish is allowed to remain in this self-brine. If the self-brine is not sufficient, saturated brine is added to immerse the fish.

Kench salting: In this method, 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 cannot be recommended for general use in the tropics as the fish are not covered by the brine or pickle and are, therefore, more susceptible to spoilage and insect attack. Exposure to the air and the presence of salt also encourages the rate of fat oxidation which gives rise to discoloration and the characteristic rancid flavours.

Mona curing: Mona curing is mainly adopted for medium to small size fishes. Before salting, the intestine and entrails are removed by pulling out through the gill region without split opening the fish. The flesh is not exposed during salt thereby causing less contamination with a shelf stability of about two months. The yield obtained by this method is about 70%.

Pit curing: In this method, fish is mixed with salt (4:1) and placed in pits dug on beaches. The pits may be lined with palymrah / coconut leaves. After 2-3 days of maturation, the fish is taken out for marketing in wet condition. These are packed in bamboo baskets and transported to markets without drying. The quality of fish cured by this technique is poor with a shelf stability of up to three weeks only.

Colombo Curing: Colombo curing is similar to pickling process which is widely practiced in Sri Lanka. A piece of dried Malabar tamarind (*Garginia cambogea*) is kept in the abdomen portion of the cleaned gutted fish which is further stacked in airtight wooden barrels filled with brine. Fishes cured by this method has a shelf life for up to 6 months.

Quality issues in dried and salted fish

Pink/Red: Salt content prevents the growth of normal spoilage microflora in the fish; but halophiles, which can survive 12-15% of salt, will survive. Halophilic bacteria are present in most of the 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. This type of spoilage is mainly due to the presence of halophilic bacteria. The source of such bacteria 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 36ºC by decomposing protein and giving out an ammoniacal odour. Usage of good quality salt will avoid this. This spoilage is mostly found in heavily salted fish and absent in unsalted fish.

Dun: Halophilic moulds tend to grow on fully dry fish, causing dark patches. These are called "dun". 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 degree C. In salted fish, brownish black or yellow brown spots are seen on the fleshy parts. This is mainly caused by growth of halophilic mould called *Sporendonema epizoum*. This gives the fish a very bad appearance. During the initial stages of appearance of moulds on the fish, it is possible to remove them manually. In advanced stages when it has penetrated the flesh nothing can be done. To avoid the mould growth it is necessary that the fish be dried properly to pack the fish in required type of packaging material and keep it in a cool and dry place from moisture. Chemical method of prevention includes dipping the fish in a 5% solution of Calcium propionate in saturated brine for 3-5 minutes depending upon the size of the fish.

Salt Burn: 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.

Case hardening: Under certain conditions, where the constant rate drying has been very rapid, the surface of the fish can become 'case hardened' and the movement of moisture from the deeper layers to the surface is prevented. This can result in a fish that is dry on the surface and looks, to all intents and purposes, fully dry but the centre will be wet and spoiled.

Rancidity: This is caused by the oxidation of fat, which is present in the fishes. 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 odoriferous compounds like aldehydes, ketones and hydroxy acids, which impart the characteristic odors. At this stage the colour of the fish changes from yellowish to brown this is known as rust. This change results in an unpleasant flavour and odour to the product, thus leading to consumer rejection. Though a certain degree of rancidity can be accepted, it is seen that the nutritional value of these fishes are much lower than non-oxidized ones. These fatty fishes continue to become rancid during storage. Certain impurities in salt and traces of copper accelerate this.

Insect Infestation: Spoilage due to insect infestation occurs during initial drying stages as well as 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*. These flies are attracted by the smell of decaying matter and odours emitted from the deteriorating fishes. During the glut season when the fish is in plenty and some are left to rot, these flies come and lay their eggs. These 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 both economic and nutritive loss to the fish processor. The most commonly found pests during storage are beetles belonging to the family *Dermestidae*. Beetles attack when the moisture content is low and especially when the storage is for a long time. The commonly found beetles are *Dermestes ater*, *D. frischii*, *D. maculates*, *D. carnivorous* and *Necrobia rufipes*. The larva does most of the damage by consuming dried flesh until the bones only remain. Mites are also an important pest, which are 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., and use of heat to physically drive away the insects and kill them at 45ºC.

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

Smoked fish products

Smoking is a popular method of fish preservation especially in North-eastern states of India. Smoked fishes are known for its unique aroma, texture and its golden yellow colour imparted by wood smoke. Heavily salted fishes were used to smoke for a longer period of time to get ‘Hard cures’. This method combines salting, drying and preservation by smoke components produced during the thermal breakdown of wood. Smoking of fish is known as an intermediate step in fish canning.

Marinated fish products

Value of fresh, frozen, salted, and dried fishes can be increased by the process of marinating it with spices, sugar solutions, oil, plant extracts, acids like vinegar, fruit juice, and wine to enhance the flavour, tenderness, juiciness, and also to extend the shelf life. Seafood such as squid, mussel, shrimp, sea snail, cuttlefish, and octopus etc. are also used for marination. These products are attracting customers because of their typical flavour, and textural properties. Tenderizing agents like acetic acid is added for texture modification and for better absorption of masala into the fish. The masala used can be theme based, for example mint based, fruit and vegetable based etc. After marinating with the masala, garnishing agents like dry mango, onion etc. can be used to make the product appealing. Selected extracts can be further used for augmenting the taste.

Marinated fish products serve as a good additive in the diet as these products are rich in essential nutrients required. Marinated products are rich source of essential amino acids which are also responsible for flavour and taste. They also contain significant amount of n-3 long chain polyunsaturated fatty acids such as eicosapentaenoic acid and docosahexaenoic acid.

Traditionally, marinades are products with typical flavour prepared from fish by treating it with edible acid and salt and these can be put in a medium such as brine, sauce or oil. The process of marination involves an increase in ionic strength and a decrease in pH which brings desirable change in taste, texture, flavour of marinades. Along with preservative effect acid gives characteristics succulence and tenderness to the marinated fish. Addition of salt aids in extraction of salt out from the fish tissues, helps in coagulation of protein and proteolysis happens in a desired level.

As most of the marinated products contain acid, it should be done in a glass, ceramic or stainless steel container. Aluminium containers should be avoided. Further, the products should be properly covered and refrigerated.

Flavour enhancers used in marination

Other than acid and salt, different flavour enhancers are used in these semi preserves to augment the palatability and shelf life. Different kinds of sauces are among the major flavour enhancers used in the marinated products. Tomato sauce, pomegranate sauce and olive lemon juice sauce are suitable for the marinated products. Sauces with spices, salt, condiments and sugar further increases the quality of the marinated products. As discussed, additives such as spice, sauce, cream, oil, mayonnaise, parsley and dill is found to have essential effects on quality of marinades. Other than this, different vegetables and sauces like garlic, pasteurized hot pepper etc. are also suitable for the purpose. Commercial lemon pepper and eugenol extract are also used as flavour enhancers. Another category of additives are oils. Oils such as sunflower oil, corn oil, essential oil, and vegetable oil are also suitable for the marinated products. Use of plant extracts like myrtle, rosemary, and nettle extracts with brine have preservative effects when added in the marinated products.

Marination of fish has greater scope as these products have huge demand in the market due to its typical taste, texture, and flavour properties. New flavours can be added to attract the modern customers in domestic and overseas markets.

Fermented fish products

Fermentation is an age old process in which complex protein molecules in the fish are broken down by the action of organic catalysts, enzymes or ferments into simpler molecules which are stable at normal temperatures of storage. This is suitable for both freshwater and marine fishes. However in India this technology is confined to north-eastern states where there is high demand for fermented fish products because of its unique aroma. Fermented products have a meaty flavour and they are rich in nutrients. Protein breakdown can be done by both exogenous and endogenous enzymes. Endogenous enzymes present in the guts and intestines of fish. In some processes salt is added to control the extent of fermentation and here a partial breakdown of protein takes place. Microorganisms like lactic acid bacteria are also involved in the process.

Fermented products are of three distinct types:

1. Products in which fish retains its original form eg. cured fish
2. Products in the form of paste- Fish is minced and partially dried
3. Products in the form of liquid that is fish sauce

Fermented products are categorized into three based on the usage of salt

1. High salted products: 20% or more salt eg. fish sauce, cured fish and fish paste
2. Low salted products: 6-18% eg. lactic acid fermentation and acid pickling
3. No-salt: eg. Alkaline fermentation

Endogenous enzymes in fish are active at or near neural pH. In some products various cereals and plants are added to boost the fermentation reaction as the digestive enzymes from these sources also aids in the reaction. In products were salt is used the degree of fermentation depends on the proportion of salt used, fat content of the fish, dressing of the fish like complete or partial removal of gut, nature of additives used and the temperature maintained.

Three types of products obtained when salt is used in a concentration more than 20%. If the fermentation is complete that means all the protein compounds are converted into water soluble compounds, the resultant liquid is called fish sauce. If it is partial then the fish substantially retains its original form, the final product is called cured fish. This cured fish can be minced and partially dried to get fish paste. In the products where salt is less than 20%, there is higher chance for microbial attack. So any other means of preservation other than salt is required in such kind of products. In such instance lactic acid fermentation along with added source of carbohydrate like rice, milk, sugar is used to achieve fermentation. In another method, low salted fermented fish is added with vinegar known as acid pickling at low temperature. Fermentation without salt is not a common practice. Examples are alkali

fermentation and fermentation by propagation of mould on dried fish. Leafy plants ash as a source of alkali is used to ferment the half spoiled fishes.

Another classification of fermented fish is based on the technique employed. One is process involving hydrolysis by enzymes and the other one is product preserved by microbial fermentation. Proteolytic and lipolytic enzymes from the surviving microflora in the fermentation media can boost up the reaction. They also contribute to the characteristic aroma and flavour. Examples for traditional fermented fish products of Northeast India are Sheedal, Hentak, Ngari, Tungtap etc.

Conclusion

Curing is one of the oldest and traditional methods of fish preservation. These are cost effective technologies, which can be opted for a wide range of communities, with minimum investment. However a major drawback in this traditional processing is the lack of standard operating procedures being followed which affects the quality of cured products. Moreover, there is a general a conception that drying/salting is a secondary method for preserving low value varieties and quality compromised materials. Efforts towards effective and hygienic handling practices in the process chain, popularization of improved drying and packaging practices, and adequate extension services can facilitate better adoption of cured fishery products in the seafood sector.

Suggested readings

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