

Seafood handling and curing techniques

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Introduction

The significance of fish as a powerful source of nutrients is well known. It's loaded with important components such as proteins, omega-3 fatty acids, vitamins and minerals which are incredibly important for the function of body. However, seafood is simultaneously highly perishable and hence requires effective preservation protocols to maintain its quality and safety. Ensuring the quality of fish begins with harvest and extends throughout the post-harvest chain. Fish being highly delicate, critically requires efficient cold chain management throughout the supply chain to guarantee quality of the fresh, chilled, frozen or processed fishery products. Along the cold chain, right from the harvesting routed through onboard storage, landing center, transportation, till domestic/export/retail marketing, the qualitative loss account for 2 -5 % while quantitative loss ranges from 3 - 17 %, being maximum during harvesting. Therefore, strengthening of the harvest practices by proper measures as well as post- harvest infrastructure facilities such as cold storage facilities, ice plants, freezing/processing units, roads and transportation, modern and hygienic wholesale and retail market outlets etc., as well as effective marketing system in identified areas are the key requirements for the development of this sector. There are, however, several constraints in handling the fish; the important among them are the bacteriological, chemical and physical processes that cause degradation of fish. Proper handling and preservation can increase its shelf life and retain its quality and nutritional attributes. The objective of handling, processing and preservation is to control or reduce the spoilage process so that the final product is wholesome and safe for the consumer. Fish and fishery products brought to market in a well-preserved condition will generally command higher prices, both at wholesale and retail levels, and thus give better returns to the fishing operation.

Food hygiene relates to "all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain". The production of safe and quality fish and fishery products requires effective hygienic practices throughout the food chain from fish harvest to consumption. These hygienic measures aim at preventing or reducing fish contamination and microbial growth covering aspects related to the hygienic design of facilities on-board, during transportation, processing and distribution, to personnel hygiene, cleaning, sanitation and pest control.

Effective handling and transportation can help to deliver the fish in the same condition as it is at the time of catch within the limits of practicability under good commercial practice. For this, the general and important rules to be followed include: Maintaining the fish at low temperature throughout the post-harvest chain by proper icing; Avoid mishandling of the fish; Sorting of fish, catch wise (species-wise, size-wise); Use of clean containers/surface for the holding/transportation of fish; Use of good quality water and ice; Personnel hygiene at every handling stage.

Hygienic Onboard Fish Handling

Careful and hygienic handling of fish onboard the fishing vessel can ensure enhanced longevity of fish. These mainly include proper vessel design and maintenance, cleanliness of vessel premises, workers hygiene and maintenance of cold chain. For this:

- Vessels must be designed and constructed so as to protect fish from contamination by bilge-water, sewage, smoke, fuel or other objectionable substances.
- Equipment, materials, surfaces and surface coatings that come into contact with fish and fishery products must be corrosion-proof, durable, non-toxic as well as easy to clean and disinfect.
- Fishing vessels should be designed and equipped with suitable holds, tanks or containers to preserve fresh fish and fishery products throughout the fishing period.
- Chilling devices must allow easy monitoring of temperatures.
- Ensuring availability of potable water for washing and cleaning of fish and fishery products retained on board as well as for ice that is used to chill the samples.
- All vessels must be kept free of pests using pest control devices.
- Sorting and heading and/or gutting of fish must be carried out hygienically as soon as practicable after capture and the eviscerated products must be washed immediately and thoroughly with either potable water or clean seawater.
- Crew members must maintain a reasonable standard of hygiene and prevent contamination of fish or fishery products and where appropriate, wear suitable protective clothing, head covering and footwear.

Hygienic Fish Handling in Domestic Market

Domestic markets play a very crucial role in the development of fisheries sector in the country as about 85 % of the total fish landing is distributed through domestic markets. They play a major role in strengthening the nutritional and food security. Ensuring hygienic handling practices in domestic market helps to minimize post-harvest losses and leads to food safety. Following minimum basic requirements can ensure good hygiene in domestic market:

- Cleanliness of the market premises
- Availability of potable water, ice facility and cold storage facilities
- Hygienic stalls with proper roofing and flooring and portable display unit with facility for cutting and storage of fish.
- Maintenance of proper hygiene by workers
- Proper drainage and waste management system
- Transportation facilities that ensure maintenance of cold chain
- Communication facilities
- Restroom and toilet facilities

Hygienic Fish Handling in Processing Units

Processing units aims towards value addition of the fish thus improving the market value of the products. Following hygienic practices in these units will ensure improved fish quality which in turn is critical to increase marketing opportunities.

- Appropriate design and layout comprising sufficient working space under adequate hygienic conditions, an area for machinery, equipment and storage, separation of

operations preventing cross-contamination, adequate natural or artificial lighting, ventilation and protection against pests.

- All food contact surfaces shall be smooth, durable, non-absorbent type, easy to maintain and clean and non-toxic.
- Availability of uninterrupted supply of portable water throughout for all processing operations.
- Availability of suitable facilities for temperature, humidity and other controls.
- All pre-processing and processing activities should be scheduled under HACCP system with proper documentation.
- Regular monitoring of processing unit for plant sanitation with an in-house laboratory and an in-process product quality check.
- Effective maintenance and sanitation systems including cleaning and sanitation procedures, pest control systems, waste management and monitoring effectiveness.
- All fish handlers should follow the recommended hygienic handling practices such as periodic medical examinations, regular cleaning and disinfection procedures prior and post to processing activities.

Proper Transportation

During transportation, measures should be taken to protect food from potential sources of contamination and damage likely to render the food unsuitable for consumption. Proper transportation maintaining low temperatures provide an environment which effectively controls the growth of pathogenic or spoilage microorganisms. Care during transportation includes:

- Construction of transportation vehicles and containers such that they can be easily cleaned and disinfected.
- All interior surfaces should be maintained clean, smooth and free of any objectionable odours.
- Vehicles and containers should be maintained at low temperature to ensure cold chain during transportation.

Strictly following these simple but important hygienic practices can definitely ensure high quality and safe fish to the consumers.

Curing techniques

Different processing and preservation methods: traditional and modern techniques including salting, drying, smoking, chilling, freezing, thermal processing, chemical treatments, as well as combination of two or more methods (referred to as hurdle technology) are used for fish preservation. Traditional methods of fish preservation include salting, drying, smoking, pickling, marination and fermentation, collectively known as Curing. Curing being the oldest and cheapest methods of fish preservation is still widely practiced in many parts of the World. These techniques are applied as single or in combination. In the current market situation both wet and dry cured fishery products have commercial importance. Advances have been made in this regard for process standardizations to meet the current demand of the market. Cured fish consumption is more practiced in areas where the availability of fresh fish is comparatively limited viz., interior markets as well as hilly areas. This method is also widely adopted in coastal areas when an excess catch is to be preserved for later utilization during the lean season or for marketing to other areas, thereby assuring its seasonal as well as regional availability.

Drying

The term 'drying' implies the removal of moisture by means of evaporation. Water being the essential component for all living organisms, its removal facilitates microbial retardation, arrest of autolytic activity as well as oxidative changes and hence can be used as a method of preservation. In any process of drying, the removal of water requires an input of thermal energy. The thermal energy required to drive off moisture can be obtained from a variety of sources, e.g., the sun or the controlled burning of oil, gas or wood, electrical heating etc. The thermal energy can also be supplied directly to the fish tissue by microwave electromagnetic radiation or ultrasonic heating. In fish, water constitutes about 70-80% and removal of this constituent to a level that arrests the unfavorable microbial and oxidative activities facilitates its effective preservation.

Drying phases

In foods, there exist three layers of water viz., an adsorption layer, a diffusion layer and a free layer. Water at the adsorption layer, also referred to as the bound water is tightly bound to the particle and hence does not take part in any chemical reactions. The second layer being the diffusion layer is less tightly bound and the third layer consists of free water which has all the properties of ordinary water. Free water involves in all chemical reactions and favors the growth of microorganisms and hence is important in the drying process. Water activity is the measure of the free water available and lowering of this water activity is essential for effective preservation.

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:

Air temperature: At the beginning of drying, 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.

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.

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 resulting in the rate of drying to be faster.

Falling rate drying phase

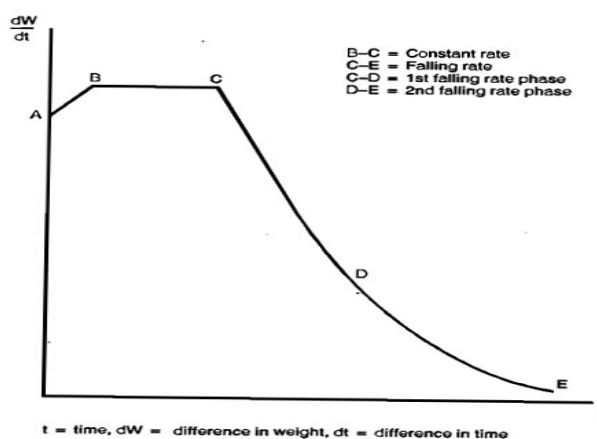
As drying progresses, the water evaporates from the fish surface and is replaced by the water from the interior of the muscles by diffusion. This process is comparatively slower which limits the drying rate and is referred to as the falling rate phase. Drier the product is, slower will be the diffusion of water to the surface. Several factors influence the rate of drying at this phase:

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, slowing down the drying rate.

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. 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. In sun drying, there is no control over the operational conditions and hence generally the losses viz., quantitative as well as qualitative ones, cannot be substantiated. Hence it is essential that the operations be controlled to get a product with superior quality as well as stability. Recently, the controlled artificial dehydration of fish has been developed so that fish drying can be carried out under controlled conditions.

Natural or sun drying:

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

- Drying on the ground
- Rack Drying
- Solar drying using Solar tent dryers, Solar cabinet dryers

Artificial / Mechanical Dryers

- *Hot air dryers*
- Cabinet dryer
- Tunnel dryer
- Multi-deck tunnel
- *Contact Dryers*
- Vacuum dryers
- Rotary dryers
- Drum dryers

Salting

Salting, one of the traditional methods of preservation is usually done alone 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 is 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 together with the removal of some water from the tissue during the salting process will prevent the activity of most 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

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 upto 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 10^5 /g have been recorded. A group of halophiles, also referred to as 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. Halophilic moulds tend to grow on dried fish under favourable conditions causing the formation of dark patches called 'dun'. They tend to occur more frequently in rock salt.

Physical properties

Fine grain salt dissolves more rapidly in water and is preferred for making brines. However on direct application of fine grain salt on fish causes 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'. Hence for dry salting, a mixture of large and small grain sizes of salt 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 upto 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 short shelf 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 salting thereby causing less contamination and the product has 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 palmyrah / coconut leaves. After 2-3 days of maturation, the fish is taken out for marketing in wet condition and 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 upto 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 gutted and cleaned fish which is further stacked in airtight wooden barrels filled with brine. Fishes cured by this method has a shelf life for upto 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 at 12-15% of salt concentration, 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. They are aerobic and proteolytic in nature, grows best at 36°C by decomposing protein and giving out an ammoniacal odour. Spoilage appears on the surface as slimy pink patches. However these bacteria are not harmful in nature. Usage of good quality salt is recommended to avoid this condition. This spoilage is mostly found in heavily salted fish and absent in unsalted fish.
- **Dun:** In salted fish, brownish black or yellow brown spots are seen on the fleshy parts, referred to as “dun”. This is mainly caused by growth of halophilic mould called *Sporendonema epizoum*. This gives the fish a very bad appearance. Moulds usually grow at relative humidity above 75%. The optimum temperature for growth is 30-35 °C. During the initial stages of appearance of moulds on the fish, it is possible to remove them manually. In advanced stages it penetrates into the flesh. To avoid the mould growth, it is necessary that the fish be dried, packed and stored properly to avoid uptake of 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 with no penetration of salt to the interior of the fish.
- **Case hardening:** Under certain conditions, where the constant rate drying is very rapid due to high temperature and low relative humidity, 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 which is dry at surface. However, the centre remains wet and hence spoils quickly.
- **Rancidity:** This is caused by the oxidation of fat, which 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 referred to as rust. This change results in an unpleasant flavour and odour to the product, leading to consumer rejection.
- **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. and develop mainly when conditions are favourable. 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. *Lardoglyphus konoii* 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 45 ° C.
- **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. Insect infestation is also a reason behind fragmentation in dried samples. It is necessary that fresh fish be used as raw material to ensure a good finished product.

Conclusion

Drying and salting are age-old practices followed for seafood preservation on account of its simplicity and effectiveness. However, a major drawback with 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 preservation applicable for low value as well as inferior quality varieties. 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. The recent market trends also indicate rejuvenation of this sector on account of the technical advancements being carried out in this area.

Suggested Readings

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