CC7;UNIT 3: FISH CURING AND SMOKING

Salting (curing), drying, smoking or a combination of these methods were developed as methods of preservation of fish. This led to the preparation of traditional fish products in many countries. Cured meats are generally dried and / or smoked. The salted meat undergoes complex ripening reactions. These are relatively simple methods and provide typical sensory profile to the product. Cured and smoked meat products have a reasonably long shelf - life.

China, Japan, Indonesia, Philippines, India and Korea are the major cured fish producing countries. In India salted and / or sundried products are most common though fermented fish products are produced for local consumption in certain region of Eastern part of India.

Under this topic following aspects are covered:

1. Salting of fish
2. Drying of fish
3. Smoking of fish
4. Quality of cured and smoked fish

1. SALTING OF FISH

Salting is based on the principle that most food poisoning bacteria do not survive salt concentrations of 6 - 10% in the fish tissue. Salt is also not detrimental to health when used in quantities tolerable to the consumers. The products prepared by salting are known to have a longer shelf-life. However, a group of microbes called halophiles (salt loving) can spoil the salted fish. Drying can remove further moisture in salted fish and can preserve the fish much longer.

Common salt (sodium chloride) is universally used for the curing of fish. Common salt available in India may be (a) Solar salt (or Sea salt) obtained by removal of water through evaporation and (b) Rock salt also called as mineral salt. Common salt normally contains water less than 6%, minimum of 98% sodium chloride by weight on moisture free basis, 0.5% matter insoluble in water by weight on moisture free basis, less than 1.5% by weight of calcium sulphate (as $CaSO_4$), magnesium chloride (as $MgCl_2$) and magnesium sulphate (as $MgSO_4$) all together. .Calcium and magnesium salts present as impurities in common salt affect the salting process, water holding capacity of meat and in turn the quality of finished products.

Process of salting

Salting results in two simultaneous processes in fish: (i) Water moves from fish muscle into the solution outside and (ii) Salt moves from the solution outside into the flesh of the fish.

Salting technique requires minimum equipments. It can be applied in many different ways as mentioned below.

(i) *Dry salting:* In this method dry salt crystals are applied to the flesh side of dressed fish and fish is stacked. As the salt penetrates the flesh, the extracted moisture is allowed to drain away. The method is suitable for lean fish and not for fatty fish such as sardine and anchovy due to oxidation of fat by the atmospheric oxygen giving rise to rancidity. Usually salt at 30 - 40% of weight of fish is used. This method suffers from the disadvantage of differential absorption of salts across the fish flesh.

(ii) *Wet salting:* Brining is a wet salting method. The dressed fishes are immersed into the saturated solutions of salt (~36% salt). Here the salt gets distributed uniformly. Usually brining is the preferred method as salted and dried fish have enhanced shelf life. Brining is more useful for fatty fish since the fish is soaked in a concentrated salt solution.

Salt penetration depends on the condition of fish; those in rigor take longer time to salt than those in the first stage of autolysis due to change in the tissue structure. It is better to use only fresh fish for salting to produce safe product in the interest of public health. Overall, the effectiveness of salting depends on uniform distribution of salt concentration in the fish muscle, concentration and time of salting / brining and the fact that whether salting is done independently or combined with other methods (e.g. drying or smoking).

Ratio of salt to fish varies for species of fish due to quantitative differences in the different fractions of muscle proteins of fish. Too low or too high salt to fish ratio does not result in safe product. Too low salt to fish produces a gelatinous mass which does not allow proper separation of water and it's pressing out. Too high salt gives bitter taste. Optimum salt to fish ratio gives well – pressed, highly compact and non – brittle product. Salt content in fish flesh influences its water holding capacity. Flesh with higher water holding capacity requires more salt for effective curing and preservation. Optimum salt to fish ratio with water holding capacity of meat for different species of fish are presented in Table 1.

General steps in preparing cured fish are as follows.

(i) *Cleaning of fish*: Remove heads and viscera, wash and remove large bones especially in the case of large fish.

(ii) *Separation of meat:* Separate flesh from bones and skin either manually or mechanically,

(iii) *Addition of salt:* Mix sufficient fine salt with flesh to saturate all the water present in fish.

(iv) *Brine formation:* Hold mixture for a few minutes at ambient temperature, salt dissolves in water, the protein is denatured and loses its water holding capacity, and water is released from the solids forming saturated brine.

(v) *Brine removal:* Remove brine by pressing or centrifugation. Brine contains soluble components and blood pigments.

(vi) *Product formation:* The light colored press cake is formed in to cakes of desired shape. It has a neutral odor and flavor and contains approximately 42% water, 26 % salt and 32 % protein.

2. DRYING OF FISH

Salting alone does not allow long term preservation of fish. Therefore most salted fish products are dried to bring down their water activity (aw) sufficiently low to have microbiological stability. Normally the water activity of 0.7 inhibits the growth of microorganisms. Ideally aw of the product should be 0.06. Adequately salted fish (not dried) with an water activity of about 0.75 allows the growth of halophilic bacteria and moulds. The aw of fresh fish flesh is around 0.99. The prime objective of drying is to reduce the moisture content of a raw fish or salted fish to a level which corresponds to aw of 0.7.

Drying of fish can be accomplished in any system that uses heat source (sun, drier, smoking kilns etc) coupled with air flow. The most economical and effective heat source is the natural heat provided by sun and the wind. Most fishes contain moisture content ranging between 55 and 80% (depending on the type of fish). This moisture content needs to be reduced to 15 to 20% in order to prevent spoilage. The lesser the moisture content in the final product, the better would be the shelf life. The most common and traditional method of drying involves spreading the whole (in case of small of fish) or split (in case of large fish) fish on ground (especially beaches) or mats or raised racks (and covered with nylon mesh) under the sun. Sun drying basically does not allow control over the drying time and temperature and allows contamination from sand, insects, etc. The technique is totally climate dependent and hence needs dry weather with low humidity and clear skies for it to be effective. Major alternatives to sun drying include drying fish on racks, solar dryers and tray driers. Most of these alternatives overcome the problems / difficulties experienced in sun drying or beach drying. They minimize dirt / sand contamination and spoilage by insects.

Drying fish on rack

This is a simple but very effective alternative to the methods that were followed traditionally (especially drying on sand, rocks and beaches). Raised platforms would be placed in windy open spaces, fishes to be dried (raw or salted) are spread on the plastic sheets or gunny bags put on these platforms and covered with small meshed nets (Fig. 1). This method is also climate dependent.

The most improved alternative to sun drying involves use of simple solar energy based artificial dryers. Practical and working model of solar dryers for drying fish have been developed. The simple solar driers (Fig. 2) provide increased drying temperatures and reduced humidity thereby increase the drying rates. In Fig. 2, the dryer (A) was first developed in Bangladesh and probably one of the most simple solar tent dryer to date. The dryer (B) is an improved solar dryer which has a separate collector and drying chamber. The

chimney is painted black in order to absorb more heat which in turn will heat the air inside thereby increasing the hot air flow through the dryer.

Fig. 3 shows the artificial dryers which operate on electricity or heating using wood / saw dust. When rain threatens, the perforated trays which can initially be placed in the sun on raised platforms are assembled on top of each other over a simple heating compartment. The chimney (or vents in case of electrical dryers) placed on top of each allow circulation of heated air and drying continues by direct heating. These dryers are energy consuming but produce dried fish of high quality.

Storage life of cured and / or dried fish products

Levels of moisture and salt contents determine the microbiological and eating quality of cured fish products. Generally the products with water activity (aw) of more than 0.7 are liable to suffer from mould attack. Development of rancid odor and flavor may develop during storage due to oxidation of fats. Sometimes proteolysis in stored cured fish products causes bitter and unpleasant taste and change in color (browning / yellowing). The general guidelines for the good storage life of cured and dried fish products are:

(i) The product hard dried to a moisture content of 15% with a salt content between 5 and 20% (on wet weight basis) has a long storage life at ambient temperature.

(ii) A product with 20% moisture and 10 – 20% salt will have a shelf life of about 4 months only.

(iii) With moisture content of 25 – 35 % and salt content of 5- 20 %, storage life may vary between a few days to 2 months.

(iv) A moisture content of 40% with salt content of 5 – 15% may assure a storage life of a few days to 3 weeks; when salt content is higher (20%), the product may be stable up to 4 months.

3. SMOKING OF FISH

Wood contains 40 - 60 % cellulose, 20 - 30 % hemicelluloses and 20 - 30 % lignin. Smoking is a partial dry distillation process, which happens with internal temperature range of 200 - 400 °C. The smoke generated has two major phases: vapor and particle. All the volatile compounds are in vapor phase. The particle phase contains carbon, tar and low volatile polycyclic hydrocarbons. The volatile fraction consists of phenols, alcohols, organic acids, carbonyls and lower hydrocarbons.

Smoking, like drying and salting, is a traditional preservation method used for variety of foods including fish. Fish can be smoked in different ways. As a general principle, the longer the fish is smoked longer will be the shelf life of the smoked product, with only sensory perception limiting the smoke concentration. The phenols and other natural chemical compounds present in the smoke are antibacterial. Smoking also has the drying effect. Thus smoking prevents bacterial growth and enzyme activity resulting in preservation of fish. Smoke components impart a typical color and flavor to the product.

Methods of smoking

Primarily there are two methods of smoking. (i) In *Cold smoking* method, the temperature is not usually higher than 35°C and it does not have the cooking effect; and (ii) In *Hot smoking* method, the temperature is high (60 - 75°C) and it provides cooking effect to the fish flesh. Hot smoking is often preferred as it requires less control and affords longer shelf life to the product as the fish is smoked until dry. The disadvantage of hot smoking is that it consumes more fuel as compared to cold smoking method.

Traditionally, fish is hung on bamboo racks over with slow burning grasses or wood smoke. There are various types of kilns or ovens (equipment used for smoking) available which are cost effective. Though traditional kilns and ovens have low capital costs, they generally have an ineffective air flow system, which results in poor fuel economy and lack of control over temperature and smoke density. The more cost effective and improved smokers are the Oil drum smoker and the Chorker smoker (Fig. 4). Fig. 5 outlines the general stages of producing cured and or smoked fish products.

The equipment required for curing and smoking processes are: (i) Cutting devices (de-headers, de-scalers or simple knives), (ii) Weighing balance and brine meter (in case of salting), (iii) Smoking kilns (for smoking), (iv) Dryers (solar / electrical; in case of drying); and (v) Packing materials and sealing machine.

Packaging: The most important concern regarding packaging of cured products is to prevent moisture pick up by the products and prevention of recontamination by insects / microorganisms. Traditional packaging materials used in case of cured products include cane baskets, leaves, and jute bags. In the recent times, the product is preferably packed in polyethylene film and cardboard box to ensure protection from light (which causes discoloration), air (which causes rancidity) and change in moisture content (to retain acceptable quality). Polyester polyethylene laminated pouches are highly suitable for hygienic packaging of cured fish products. Gunny bags lined inside with 400 gauge polyethylene or unit packs in 400 gauge polyethylene stored in dealwood box possess good stackability, attractive appearance and good acceptability, and are hygienic. Some aging of the product is required to develop a characteristic salt fish odor and flavor. Normally the storage life of well packed salted and cured fish product at 35ºC is about a year.

4. QUALITY OF CURED AND SMOKED FISH

During salting there is extensive hydrolysis of lipids. Hydrolysis ceases when lipids contain about 50% free fatty acids. Slow protein breakdown also occurs during salting, drying and storage increasing in free amino acids content of flesh. Methods of application of salt (dry salting or brining) influence lipid hydrolysis / degradation and oxidation. Hydrolysis of lipids gives undesirable soapy taste and oxidation of fats gives rancid flavor to the product. The changes in proteins adversely affect the nutritional value of products by decreasing the digestibility, protein efficiency ratio (PER), net protein utilisation (NPU) and biological value (BV) of cured products. The nutritional quality of cured mackerel in comparison with fresh fish is presented in Table 2.

Normally after cooking, dried fish with or without prior salting gives a fibrous and tough mouth feel. Salting increases hardness and chewiness of fish muscle. Inclusion of small

amount of additives such as tripolyphospate in a curing mixture results in to soft texture and greater juiciness of cured and dried fish products. Other additives such as sodium benzoate, sodium acid phosphate, potassium sorbate and butylatedhydroxyanisole (BHA) have special roles in improving the sensory quality of finished products. The quantity and role of these additives are presented in Table 3. Smoking of fish imparts a typical color and flavor to the product.

Conclusion: Though traditional curing and smoking of fish is a low cost option for many small scale producers, there may be large losses in terms of wasted fish. Improved techniques require little capital investment in terms of expensive equipment which improves efficiency of the process and quality of the product. Dry or wet salting is done for fish curing. Wet salting has better penetration of curing ingredients in to muscle and thus improving the storability and product quality. Salted fish is usually dried in order to reduce the bacterial load of the product.

Moisture and salt contents determine the microbiological and eating quality of cured and smoked fish products. Dried fish with or without prior salting has a fibrous and tough mouth feel. Salting increases hardness and chewiness of fish muscle. Inclusion of small amount of additives such as tripolyphospate, benzoates, sorbates and antioxidants in a curing mixture results in to soft texture and better juiciness of cured and dried fish products. Gunny bags lined inside with polyethylene or unit packs in polyethylene stored in dealwood box possess good stackability, attractive appearance and good acceptability, and are hygienic.

Table 1. Optimum salt to fish ratios with water holding capacity for different fish species

Name of fish	**Optimum salt : fish ratio**	**Water holding capacity of meat, %**
Barrileta (Skip jack) *Katsuwonus pelamis*	45 : 1	82
Sierra (Spannish mackerel) *Scombermorus siera*	45 : 1	81
Lisa (Mullet) *Mugil cephalus*	40 : 1	76
Carp *Cyprinus carpio*	35 : 1	74

Note: Fish with more moisture content requires more salt for effective curing and preservation.

Source: Sen 2005

Table 2. Nutritional quality of fresh and cured fish

Nutritional parameter	**[1]Fresh fish**	**[2]Cured fish**
Digestibility, %	89.6	85.4
Protein efficiency ratio (PER)	3.0	3.3
Net protein utilisation (NPU)	80.4	75.0
Biological value (BV)	88.9	85.9

[1]Fresh cooked mackerel; [2]Cured, dried, rehydrated and cooked mackerel

Note: Cured products have lower nutritional values compared to fresh fish.

Source: Sen 2005

Table 3. Curing ingredients and their role

Ingredient	**Role of ingredient**	**Proportion by weight**
Common salt	Curing	100
Sodium benzoate	Prevents reddening due to halophiles and incidence of soft and mealy tissue	0.25
Sodium acid phosphate	Enhances the action of sodium benzoate	1.5
Potassium sorbate	Prevents mould growth	0.5
Butylatedhydroxyanisole (BHA)	Retards yellow or brown discoloration and minimizes rancid odor	0.2

Note: Additives in curing mixture improve nutritional quality of cured fish.

Source: Sen 2005

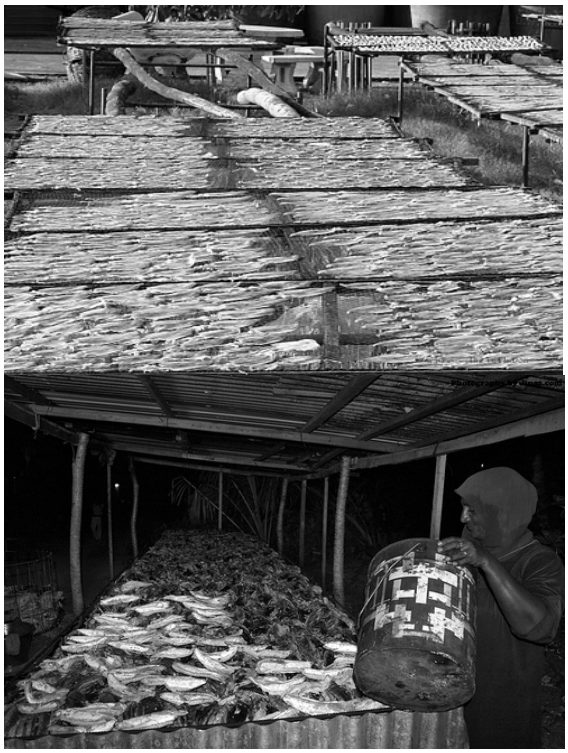
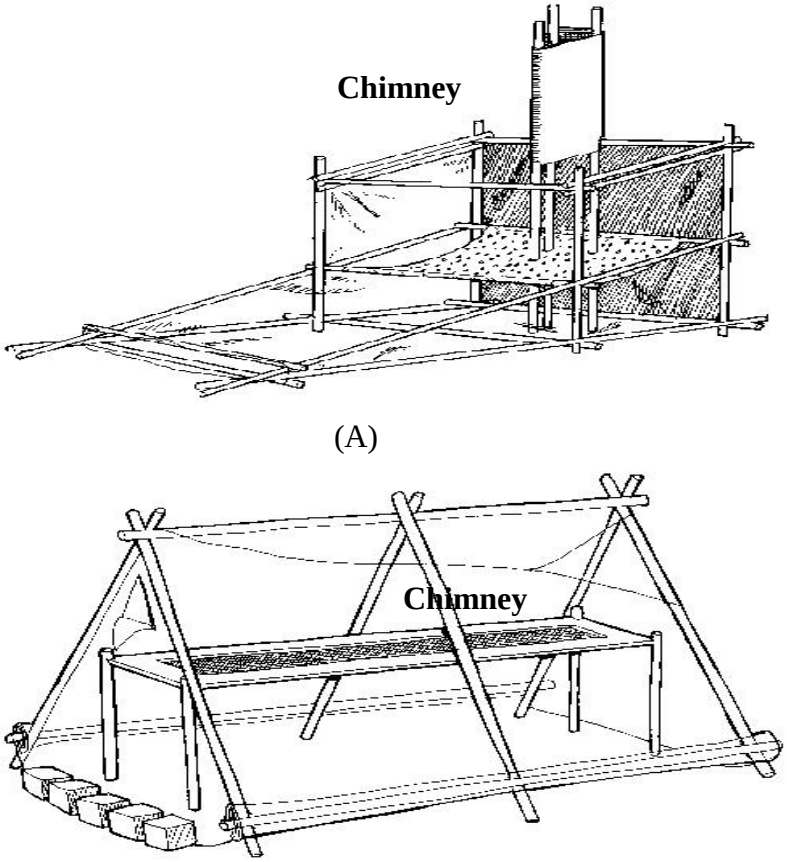


Fig. 1. Hygienic sun drying of fish on raised platforms



(A) Simple solar tent dryer first developed in Bangladesh

(B) Improved solar dryer

Fig. 2. Different types of solar dryers used in various parts of the world

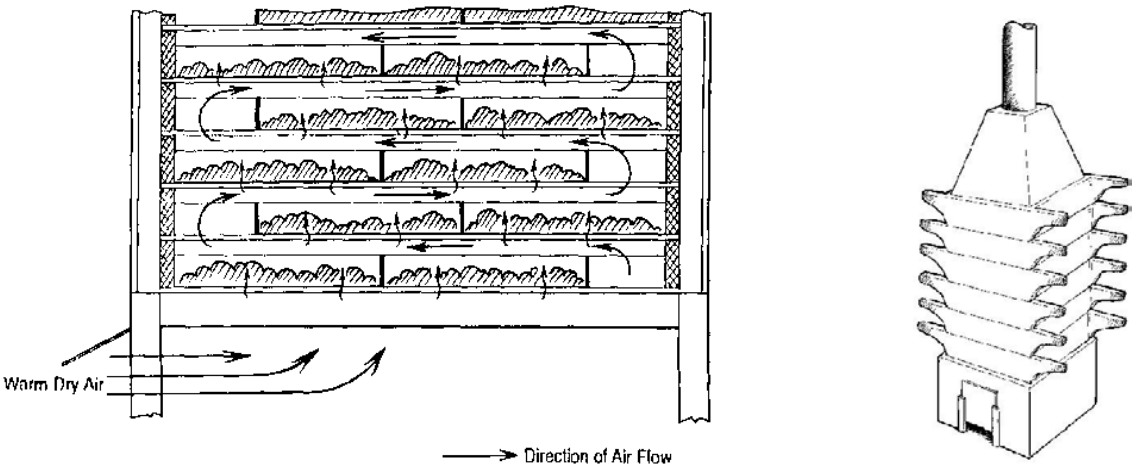
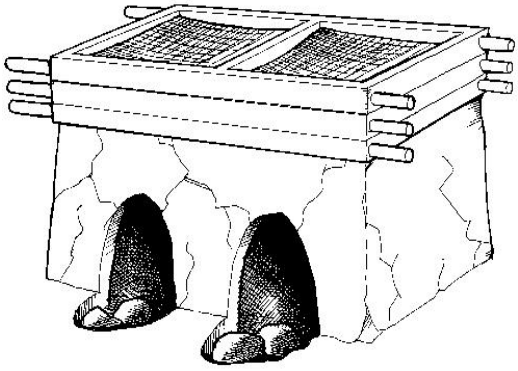
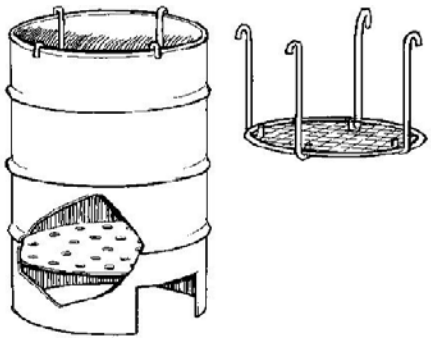


Fig. 3. Tray dryers used for fish drying – heated by electricity or by burning wood / saw dust

Chorker smoker



Oil drum smoker



Smoking kiln

Traditional smoking

Fig. 4. Different types of smoking equipment

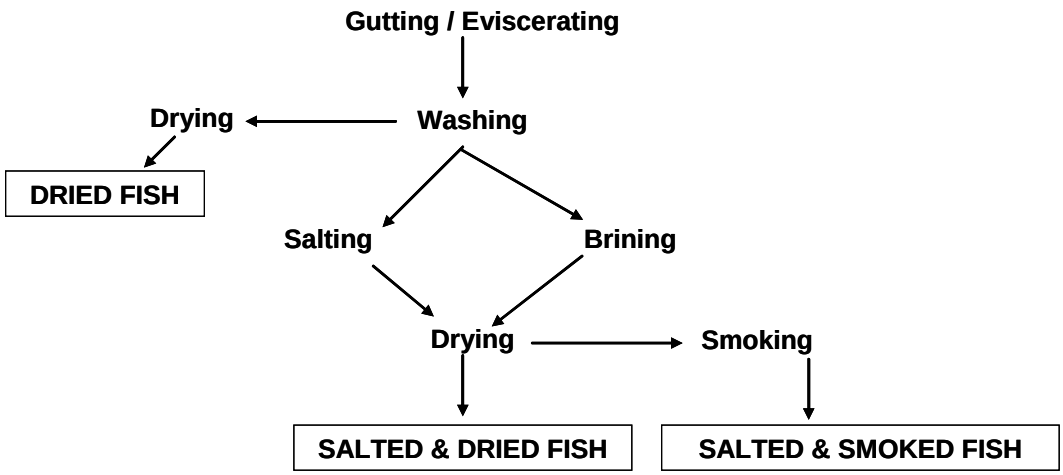


Fig. 5. General stages of producing salted and dried or salted and smoked fish products