SCHEDULE TRIBE COMPONENT
(STC) PROGRAMME

TRAINING MANUAL
ON

Fishing gear engineering for increasing for inland fishing efficiency and improved smoking process for quality smoked fish product

ICAR-Central Institute of Fisheries Technology (ICAR-CIFT)
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Traditional Cured and Dried Fishes

The traditional methods of processing fish by salting, drying, smoking and pickling are collectively known as Curing. It is the oldest method of fish preservation and is still widely practiced in developed and developing countries. Cured fish consumption is more in areas where the availability of fresh fish is comparatively limited, namely interior markets and hilly areas. It is also present in the coastal areas where the excess catch is preserved for later use during the lean season or for sale to other markets. This is also the cheapest method of preservation, since no expensive technology is used. In India roughly 20 % of the fish caught is preserved by curing. Considerable quantities of cured fish are also exported, mainly to Singapore, Sri Lanka and to the Middle East.

Methods

- Drying
- Salting
- Smoking

Drying

During drying the moisture content and water activity, is reduced and hence microorganisms cannot grow and multiply to spoil the fish. This will help in preserving the fish for a long time. Lowering the water activity will also influence the chemical and enzymatic changes in food.

Methods of Drying

There are basically two methods of drying fish.

i. ***Sun drying:***
   - The common one is by utilizing the atmospheric conditions like temperature, humidity and airflow.
   - Depends heavily on the natural weather conditions

ii. ***Dehydration or artificial drying:*** By using artificial means like mechanical driers for removal of moisture from the fish under controlled conditions.

Natural or sun drying

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

i. Drying on the ground

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

ii. Rack Drying

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

iii. Solar tent dryers

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

iv. Solar cabinet dryer

This is a rectangular shaped dryer made up of plywood. The front side of the dryer is double walled. Inlet and outlet are provided for air to enter and escape from the chamber. A

clear polythene sheet covers the upper portion of the drier. Two doors are present for loading and unloading the fish into the drier.

Artificial / Mechanical Dryers

These can be broadly classified into two types. In one type, the heat is transferred into the product through a hot gas, usually air. Examples are Kiln dryers, cabinet dryers, tunnel dryers and fluidized bed dryers. In the second type, the heat is transferred into the product through a solid surface, which may also be used as the cabinet for the product to be dried. Examples are drum dryer, vacuum dryer.

Salting

This is one of the oldest methods of preservation of fish. Salting is usually done as such or in combination with drying or as a pretreatment to smoking. During salting osmotic transfer of water out of the fish and salt into the fish takes place, which affect fish preservation. Loss of water limits bacterial growth and enzyme activity, thus preserving the fish. The high salt content prevents the growth of normal spoilage microflora in the fish; but halophiles, which can survive 12-15% of salt, will survive. 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. Halophilic moulds on the other hand tend to grow on fully dry fish, causing dark patches. These are called “dun”. A mixture of large and small grain sizes is recommended for dry salting of fish. If fine grain is used directly on the fish, salt burn may occur due to the rapid removal of water from the surface and no penetration of salt to the interior of the fish.

Types of Salting

i. Dry salting

This is the most widely used method of fish curing. All types of fishes except fatty fishes, big or small are cured by this method. Here, the fish is gutted, beheaded or ventrally split open and the viscera removed. The fish is then washed clean. Larger fishes are dorso-ventrally split open and cleaned thoroughly. Scores are made along the thick flesh portion for better

penetration of salt. Salt is then applied in the ratio 1:3 to 1: 10 (salt to fish) depending upon the size of the fish. The fish is then stacked in clean cement tanks or other good containers. The bottom of the tank is covered with salt and a layer of fish is placed. Both fish and salt are alternately placed in the tank and wooden planks are 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. Yield of the product by this method is about 35-40%. This product has a shelf life of 6-10 weeks.

ii. Wet salting

The initial stages of processing and salting are the same as for dry curing. Once the fish is put into the tank it is allowed to remain in the self-brine. The fish is not dried at all. The wet fish is then drained and packed in palmyrah leaf baskets or coconut leaf baskets and taken to the market. The fish is taken out only when there is demand. This method is particularly suitable for fatty fishes. This is mainly done for fishes like oil sardine, mackerel, ribbonfish etc. In such fishes the fat gets oxidized on exposure to air.These products have moisture content of 50-55% and the salt content around 25%. They are most susceptible to fungal attacks, bacterial degradation and general putrefaction. They have a very short shelf life.

iii. Kench salting

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

iv. 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.

v. Mona curing

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

vi. Pit curing

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

vii. Colombo Curing

This was a specialty product made for Sri Lanka, and preservation is done by means of a pickling process. A piece of dried malabar tamarind 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.

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. In the underdeveloped and developing countries smoking is used as a method of fish preservation whereas in the developed countries, it is practiced mainly to impart colour of a particular wood rather than for preservation.

Types of smoking

i. Cold smoking

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

ii. Hot smoking

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

iii. Liquid smoking

Use of smoking liquid or concentrates are used in developing countries. The liquids are prepared by dry distillation of wood. The fish is salted, and given a dip in a smoke concentrate and then dried in an ordinary kiln dryer. The liquid thickens and coats the fish thus imparting the particular flavour to the fish.

iv. Electrostatic smoking

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

and gets deposited on the fish. Then the fish passes through a baking oven where the fish is dried to the required moisture level.

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

Preservatives used in Cured Fish

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

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

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

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

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

Direct dusting method: Calcium propionate powder (0.3g/100g cured fish) is taken in a coarse mesh cloth bag and dusted. This method is most effective against fungus “red” discoloration and off smell.

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

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

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

Community Fish Smoking Kilns (COFISKI)

Smoking is a traditional method of preserving fish through a combination of salting, smoking and drying process. Thermal degradation of wood generates numerous smoke components which gets deposited on the surface of fish and imparts preservative action. Smoked products have longer shelf life at room temperature because of the high salt content and long smoking and drying periods which reduce the water content considerably.

Smoke generation

Wood in the form of chips or coarse shavings or as saw dust is most commonly used as the source of smoke. Hard wood species are preferred as the fuel for smoking. The wood species which contains volatile resigns are not suitable as they impart undesirable flavor to the product. A layer of wood chips or coarse wood shavings with a layer of saw dust atop is used for generating smoke. As the air cannot get easy access to fire, the saw dust smolders instead of burning. Lower temperature and limited supply of oxygen causes production of smoke with high content of flavouring and preserving principles.

Smoking process

Hot smoking is the prevalent method of smoking practiced in India where in the fish is fish to be smoked is kept inside on trolleys and heat is supplied either directly or indirectly. Fish may be smoked whole or after gutting, depending on the demand of end user. For large fishes, intestine must be removed. Several designs of kilns/ smoking tunnels are available for hot smoking fish. The fuel is burned either directly inside the kiln on movable trolleys or in internal hearths located near the tunnel. The fish is charged in to the tunnel in cages. The chamber will be having a metal frame structure on brick walls and can hold a number of fish cages. Different models of fish smoking kilns were designed at ICAR-CIFT popularly known as community fish smoking kilns (COFISKI).

In this model, fish is dried and cooked in kiln before it is smoked. Drying is done in an intense draught of hot air at 75-85 0C produced by burning fire. The skin of fish gets dried while the flesh gets cooked. At this stage, the fish is ready for smoking. Covering the burning fire with saw dust produce smoke and the fish is getting smoked.

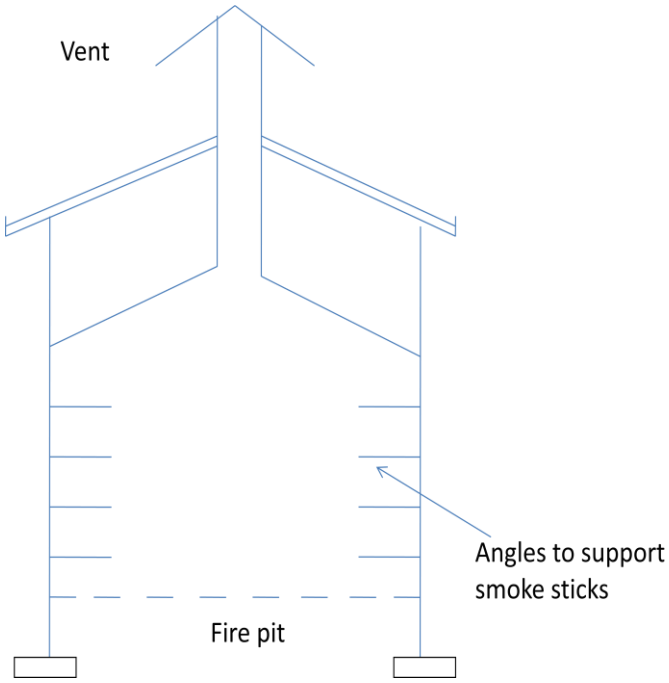

Fig. Conventional smoking kiln

Smoked fish products

Value Added Chilled Fish

The modern food habits along with the fast life have created an enormous demand for ready to make food products, especially in urban areas. Value addition can be defined as an additional activity that changes the nature and form of the fish and help realizing a better price at the point of sale. Value can be added to fish and fish products according to the requirements of consumers. Improved market forms are one kind of value addition to fish and shell fish, through which the consumers can reduce the time required for further preparation of the product. A brief detail on value added chilled and frozen fish styles are given below.

Improved market forms- chilled/frozen fish

Chilling is an effective method for maintaining the freshness of fishery products. This normally involves keeping fish in melting ice or slurry ice to maintain the fish temperature around 1-4^{0}C. Different types of chilled fish products are available in the markets.

Dressed and gutted fish

The purpose of gutting is to remove the viscera, gonads and sometimes the swim bladder. Hygienically gutted fish fetches higher price in the retail as well as export markets. Extreme care has to be taken while gutting to avoid bruises or cut in the fish flesh. This procedure is performed on a table made of special material which is hard, easy to wash and does not absorb fluids. Yield of gutted fish ranges from 75-80%. Dressed and washed fish can be distributed in consumer packs in ice. Vacuum packaging and active packaging further improve the shelf life of the products.

Fish steaks

Steak is a section of fish removed by cutting approximately at right angles to the back bone of fish. Slicing of beheaded whole fish into steaks of 2.5-3.5 cm with a cut perpendicular to the animal's backbone is a very common fish processing method. The high technological efficiency of this processing technique compared to filleting makes it popular in retail markets as well as in the canning industry. Larger fish, particularly cyprinids, which have a massive and more

solid backbone, need slicing mechanically. Most of the mechanical slicer utilize multiple rotating circular saws attached to the drive. The distance between the saws as well as the elements moving the fish along the line can be adjusted. A mechanized cutter can process 20-40 fishes/minute, depending on the fish size. The steaks are packed in consumer packets and kept in chilled condition. The shelf life of steaks can be improved by vacuum packaging, modified atmosphere and active packaging techniques.

Fig. a) Gutted fish and b) Fish steaks in consumer pack

Fish fillet

Fish fillet is a skinless, boneless fish loin cut parallel to the central bone frame and trimmed free of loose or hanging meat. Filleting can be done manually or mechanically. Filleting efficiency depends upon fish species, its sex, size, freshness and nutritional condition. Manual filleting is very labour-intensive and largely depends on the skills of the workers. A sharp knife and flat board made up of metal or plastics are required for manual filleting. The fillet is placed on the board skin down, the meat is grasped in the left hand and the knife is drawn between the skin and meat. Manual filleting is time consuming; however, it gives better yield than mechanical filleting.

The simplest filleting machine for gutted and beheaded fish has two disc knives set from each other at a distance equal to the thickness of the fish's backbone. Filleting speed of these devices is 30-40 fishes/min: they are efficient and the quality of the final product is good. The size

range of the processed fish is 20-45 cm. Machines of different design and with bigger knives are used for processing larger fish. Fillets with low fat and minimum fat content are preferred by the consumers. Average yield of skinless fillet is 40-45%. Skinless fillet can be used as a raw material for the production of a variety of value added products.

Marinated fish

Fish steaks or fillet pieces can be marinated with salt and spices and packed in thermoformed trays. The fish is coated with a paste consisting of spices, salt, seasonings and allowed to remain for 6-12 hrs or preferably overnight at chilled condition. This fish can be fried in oil or roasted before consumption. Ready to fry marinated fish/shell fish shrimp, mussel, oyster, squid, cuttle fish etc. can be stored up to 3-4 weeks at 4^0C. Frozen marinated fish steaks are also available in the market. Cured product like mackerel is suitable for marinating with spices.

Vacuum packaging

Vacuum packaging involves the removal of air from the package and the application of a hermetic seal. The air removal creates a vacuum inside the packs and lack of O_2 in packages may minimise the oxidative deteriorative reactions and aerobic bacterial growth. Vacuum packaging can considerably extend the viable shelf life of many cooked foods. The use of vacuum packaging, in gas impermeable and heat stable materials, has many advantages, which include; no or low risks of post pasteurisation contamination, ease of handling, Inhibition of growth of aerobic spoilage organisms and inhibition or slowing of deleterious oxidative reactions in the food during storage due to oxygen barrier properties of the packaging material.

There are number of criteria required for the films used for vacuum packaging in large scale production methods. These requirements include: high durability, i.e. ability to withstand considerable mechanical stresses during packaging, handling and transport, retention of flexibility even at low temperatures (-2 to 4°C) to enable satisfactory handling in the packaging and refrigeration rooms, ability to withstand heating to at least 150°C without structural damage, leaching of potentially toxic plastics or plasticisers, impermeability to liquids, including oils and fats and macromolecules, impermeability to gases, in particular oxygen, so that oxidative deterioration of the packaged food stuffs is limited or inhibited, manufactured from non-toxic, food acceptable, odourless materials and must be able to create airtight durable heat seals to close packs. Many of these criteria have been met by a range of materials mostly multilaminated plastics.

Vacuum packed foods maintain their freshness and flavor 3-5 times longer than with conventional storage methods, because they don't come in contact with oxygen. Foods maintain their texture and appearance, because microorganisms such as bacteria mold and yeast cannot grow in a vacuum. Freezer burn is eliminated, because foods no longer become dehydrated from contact with cold, dry air. Moist foods won't dry out, because there's no air to absorb the moisture from the food. Dry, solid foods, won't become hard, because they don't come in contact with air and, therefore, can't absorb moisture from the air. Foods that are high in fats and oils won't become rancid, because there's no oxygen coming in contact with the fats, which causes the rancid taste and smell.

Fig. Vacuum packaging machine and Vacuum packed fish

Modified Atmospheric packaging

Fresh fish is highly susceptible to spoilage from post mortem autolysis and microbial growth. The high ambient temperature of our country favours rapid growth of microorganisms. Presently ice and mechanical refrigeration are the most common means of retarding microbial and biochemical spoilage in freshly caught seafood during distribution and marketing. However, as ice melts it tends to contaminate fish accelerating spoilage and reduces shelf life. Modified atmosphere packaging, a technologically viable method has been developed as a supplement to ice or mechanical refrigeration to reduce the losses and extend the storage life of fresh seafood products. In modified atmosphere packaging air is replaced with different gas mixtures to regulate microbial activity and /or retard discolouration of the products. The proportion of each component gas is fixed when the mixture is introduced into the package; however, no control is exercised during storage. The composition of the gas mixture changes from its initial composition as a result of chemical, enzymatic and microbial activity of the product during storage. It is primarily the enrichment of Carbon dioxide in the storage atmosphere as a means of controlling microbial growth, which results in the extension of shelf life of products. Carbon dioxide lowers the intra and extracellular pH of tissues and possibly that of microorganisms. Further it may affect the

membrane potential of microorganisms and influence on the equilibrium of decarboxylating enzymes of microorganisms. The gases normally employed are carbon dioxide, mixtures of carbon dioxide and nitrogen, carbon dioxide and oxygen and carbon dioxide, oxygen & nitrogen with the sole objective to extend the shelf life of the product beyond that obtained in conventional refrigerated storages. Inhibition by Carbon dioxide manifests in an increased lag phase and a slower rate of growth of microorganisms during logarithmic phase. Inhibition by Carbon dioxide was found to be more effective when the product was stored at the lowest range of refrigerated temperatures. Packaging materials generally employed for this purpose are flexible films of nylon/surylyn laminates, PVC moulded trays laminated with polythene, polyester/low density polythene film etc. The use of high barrier film along with MAP that contains CO_2 effectively inhibits bacterial growth during refrigerated storage of packaged fresh fishery products.

The composition of the gas mixtures used for MAP of fresh fish varies, depending upon whether the fish in the package is lean or oily fish. For lean fish, a ratio of 30 % Oxygen, 40% Carbon dioxide, 30% Nitrogen is recommended. Higher values of Carbon dioxide are used for fatty and oily fish with a comparable reduction in level of Oxygen in the mixture leading to 40-60% Nitrogen. By excluding oxygen, the development of oxidative rancidity in fatty fish is slowed. On the other hand, oxygen can inhibit the growth of strictly anaerobic bacteria like *Clostridium botulinum* although there is a very wide variation in the sensitivity of anaerobes to Oxygen. It is also seen that inclusion of only some Oxygen with Nitrogen or Carbon dioxide will not prevent botulism with absolute certainty.

Live Fishery Products

There is a great demand for live fish and shellfishes, the world over. These products fetch maximum price compared to all the other forms of value added products as it maintains the freshness. The candidate species for live transportation include high value species, cultured grouper, red snapper, seabreams, seabass, red tilapia, reef fish, air breathing fishes, shrimp, crabs, lobster, clams, oyster and mussels. These are normally transported in air cargo maintained at low temperature in order to lessen the metabolic activities of the animals.

Battered and breaded fish products

The most important item among the group of value added products is the battered and breaded products or coated products processed out of a variety of fish and shell fish. A coated product is one, where a food material is coated with another food stuff. Coating the food product with a batter and breading before cooking is an established age old domestic practice. However, changing food habits of consumers has created the need for an increased market supply of ready to cook or ready to serve products which include the most prominent coated fishery products.

Breading and battering of food products enhance characteristic such as appearance, flavour and texture. Battered and breaded products offer a convenient food valued widely by the consumer. Many products are coated and immediately frozen, or they may be pre-fried, and then frozen for distribution and sales to consumers and food service establishments. They can be quickly reconstituted by conventional heating methods. As far as fish processing industry is concerned, value addition is one of the possible approaches to raise profitability, since this industry is becoming highly competitive and increasingly expensive.

The coating process

The production of battered and breaded fish products involves several stages; they are portioning/forming, pre-dusting, battering, breading, flash frying, freezing and cold storage.

Portioning/forming

Portioning is an important stage in the production of coated fish products. The objective of this step is to cut or shape the substrate in the most economical way so that minimum loss occurs during portioning and further processing. Cutting loss and surface area of the portions are two important points which determine the economics of coated products. Fish blocks are the common substrate used for the preparation of coated fish products. Fish block refers to frozen fish fillets moulded into a block. A recent innovation for the catering sector is forming of skinless and boneless fish fillet into a pre-determined shape and size using specially designed forming machines. The shapes vary from conventional fillet shape to fingers, nuggets etc.

Pre-dusting

Before dipping into batter, the fish portion is given a pre-dusting in a fine raw flour type material. Batter mix itself can be used for pre-dusting. A more sophisticated and expensive pre-dust may contain salt, spices, seasonings and flavourings for functional and flavouring purposes. The purpose of pre-dusting is to prepare the surface of portion so that batter can adhere uniformly. Pre-dusting machines of varying capacities for different types of products are commercially available.

Application of batter

A batter can be defined as a liquid mixture composed of water, flour, seasonings into which food products are dipped before cooking. Conventional batters are of low to medium viscosity and hence, can be applied with total submersion or overflow batter applicators. The formula for the preparation of batter mix is given in Table 1. The batter flour is mixed with two parts of water to get the required consistency. The fish portion is totally submerged in the batter.

Table 1. Batter mix composition

Maida	1000g
Corn flour	100g
Bengal gram powder	100g
Salt	12g
Sodium tri polyphosphate	5g
Turmeric powder	5g
Hydrocolloids (Guar gum)	5g

Breading

The breading is normally a bread based crumb. The batter coated portions are further coated with bread crumbs. Generally medium sized porous crumbs with relatively large granulations are used. Breading can be done manually or mechanically. The bread crumbs are uniformly applied over the product and excess crumbs are removed using an air blower. The coating picks up depends on the viscosity of batter and type of crumbs. In general, a pick up ratio of 30-35 % is advised.

Pre-frying

The purpose of pre- frying is primarily to set the coating on the fish portion. The temperature of frying oil and the time of frying are critical. The normal frying temperature is between 180-200^{0}C and the time is 20-30 seconds. The term pre-frying is used because the final product frying is completed by the consumer for a duration of 4-6 minutes depending on the portion size and thickness.

Freezing

Immediately after the flash frying, the product is cooled by a fan and then frozen in an IQF machine at -40^{0}C. Freezing is usually carried out in a spiral freezer. Since the fried portions are fragile, care should be taken to avoid contact between the portions while loading in the freezer.

Packing and storage

The coated product may undergo dehydration, discoloration and becomes rancid during frozen storage. Use of proper packaging material can prevent these problems and enhance the shelf life. Thermoformed containers are most commonly used for coated products. The packed products are usually stored in a cold store at -20^{0}C.

Coating equipment

Manual coating is time intensive and is low efficient. Besides hygienic handling of the product is practically impossible and the quality of the product will be inferior. The introduction of coating equipment solves this problem. Each step in coating requires a separate machine or component.

Forming machine

When the consumer demand different shapes like round, oval, star etc., a forming machine is required. A machine with different dyes will serve this purpose. The different shapes can be produced only with surimi or fish mince. Depending on the market demand, the product can be formed into any shape.

Pre-dusting machine

Pre-dust is usually applied by a breading machine suitable for handling flour. This will also have a special sprinkler conveyor that applies a thin and even layer of pre-dust to the top of the product.

Batter application equipment

The main problem during battering is that batter solids settle out during coating operation. To overcome this problem, two types of batter applicators are used. One is over flow type and other is a sub-merger type which has a top sub-merger device. In the earlier type, batter applicator machine will draw the portion through a shallow puddle of batter by a conveyor belt so that the bottom of the product is coated with batter. The continuous overflowing of the batter coats the top of the product. An air blower is used to remove excess batter. In top sub-merger applicators, the batter is recirculated both within the batter machine itself and through an automatic batter make up system. A top sub-merger is used to keep the products under the batter.

Breading application equipment

The design and operation of breading equipment depends on the properties of the bread crumbs. There are 3 types of bread crumbs; free flowing, flour type and Japanese crumbs. A free flowing breading machine coat the product with bread crumbs by recirculating the breading material using a pump. In flour type breading machines, as the breading is not free flowing, the movement of bread crumbs through the machine is mechanically driven by a augers or vibrators. Most Japanese crumbs consists of a mixture of large, coarse and fine particles. In a typical Japanese applicator machine, the different sized particles are separated and then recombined in the proper proportion and deposited onto the product.

Fryers

The frying operation during the coated product preparation may be fully or partially dependent on the type of the product. A continuous food fryer is a material handling conveyor that carries the product through the cooking oil. Speed limit of the conveyor belt is set by the specific frying time of each product. The fryer should have the sufficient heating capacity to maintain the set temperature.

Freezer

Spiral freezers are used for freezing coated products. These freezers require less space and can be easily adapted to the process line.

Coated fish products

A wide variety of coated products can be prepared from fish fillet, mince, crustaceans etc. Generally lean white fleshed fishes are used for the preparation of coated products. Fresh water fishes like catfish, tilapia is suited for this purpose as they have white and easy to prepare fillet. A brief description of different products is given below.

Coated fish fillet

Fried coated fish fillet is a prominent food item in the European markets. Table sized fishes with a minimum pin bones are suitable for making this product. Skinless fillets are given a cold blanching treatment in 2% brine for 3-5 minutes and then drain off. This will improve the color and texture of the fillet. The breading and battering are done as described above. The frozen coated fillets are immediately packed in thermoformed containers or pouches. A specified number of such consumer packs are then packed in master cartons and is stored at -20^0C.

Fish fingers/ fish steaks

Fish fingers are regular sized portions cut from rectangular frozen block of fish fillet or fish mince. Fish fingers are made into different shapes such as rectangular, square, wedge and French cuts. A typical british coated fish finger weighs about 28 g of which upto 50% is contributed by batter and bread crumbs. The cut pieces are given a coating of pre-dust, batter and breading as in the case of fish fingers. It has been observed that sensory quality of fish finger developed from fish fillet is superior to that developed from mince block.

Mince based products

Mechanically deboned fish meat is termed as fish mince. Meat is separated from the fish by forcing the fish against a screened surface, so that the flesh passes through the opening as a finely ground paste known as mince. A meat bone separator is used for this purpose. A common type of meat bone separator is a belt and drum model. The headed and gutted fish is passed between a counter rotating belt and a perforated drum. The meat is passed through the perforations in to the interior of the drum while bones and other solid materials are retained on the outer drum shell where it is removed by a scraper. The perforations in the drum are usually 3-7 mm in dia. The bone free meat/ mince is delivered to one side by means of a screw conveyor in the drum. The initial quality of fish is very important in deciding the yield and quality of the mince. About 50-60% of the whole fish can be removed as mince by using drum type meat bone separators. Generally minced fish is block frozen as 1-2 kg blocks at $-40\ ^0$ C in a plate freezer and

stored in cold store at -18 ^{0} C. Depending on the type of raw material, fish mince can have a frozen storage life up to 6 months without any appreciable quality deterioration.

Molded fish products from mince

Fish mince is a raw material for a variety of value added molded products like balls, cutlets, surimi based analogs etc. Molded fish product occupy an important position among the sea food products. They have all the beneficial features of seafood along with the added nutritional ingredients. The molded products have good market share in the Indian snack food industry. These products also go to the export market and earn foreign exchange for the country.

Fish balls

Fish balls are generally prepared from the mince of low cost fish. The preparation of fish ball is simple and requires only few locally available ingredients. Hence it is an ideal product for small scale units. The simplest way of preparing ball is by mixing the fish mince with starch, salt and spices. The mix is then made into balls, cooked in boiling 1% brine. The cooked balls are cooled and then battered and breaded.

Fish cutlets

Fish cutlet has become a popular snack at celebrations, household functions, tea times etc. The basic raw material required for preparation of this product is cooked fish meat generally from less costly fresh water fish or cooked meat from skeletal frame obtained after filleting of fresh water fish. Cooked fish mince is mixed with cooked potato, fried onion, spices and other ingredients. This mass is then formed into the desired shape, each weighing 30 g. The formed cutlets are battered and breaded. Finally, it is frozen and stored in the thermoformed trays at -20^{0}C.

Fish burgers

Fish burgers are more or less similar to fish cutlets but less spicy. Usually burgers are eaten sandwiched with fresh vegetables and plain buns. Mince from white fleshed species is generally used for the burger preparation. Cooked mince is mixed with salt, cooked potato, fried onion, flour, spice mixture and formed into the preferred shape. Generally, the starch content is to be kept below 15% and the meat content must not be less than 30% for ensuring a meaty flavour.

Fig. Fish burgers

Fish sausage

Fish sausage is an analog of sausage prepared from meat/ chicken sausage. The major ingredient is fish mince. Mince is mixed with salt, sugar, sodium glutamate, starch and soy protein in a silent cutter. Spices can be added according to the preference. The paste thus formed is stuffed into a casing made of animal origin or synthetic origin. Stuffing is done by an automatic screw stuffer. The casing tube is closed by a metal ring. The sausage is then heated in hot water at 90^0C for 40-60 mnts. After cooling, it is cooled down slowly to avoid shrinkage of casing material and then stored at refrigerated condition.

Fig. Fish sausage

Coated fish analogs

Several value added seafood analogs can be prepared from surimi made from white fleshed lean fishes. Surimi is washed and frozen fish mince added with cryoprotectants. The repeated washing of mince removes water soluble nitrogenous matter and flavour compounds. Surimi is used as the raw material for the preparation of sea food analogs. The most suitable Indian species for surimi preparation is threadfin bream, croakers, ribbon fish, lizard fish, barracuda grouper etc.

The formulation for seafood analog comprises surimi, water, starch, other proteins, oil, salt, flavorings and colorants. Salt is added to solubilise the surimi proteins and permit it to make elastic and firm gels after cooking. The texture is modified by other ingredients such as cold water and starch.

Surimi based seafood analogs are developed in several styles, but particularly as crab meat. Crab meat is made as filaments and shaped as crab stick or crab claw. Crab stick is the currently the most prevalent surimi based fabricated sea food products in the world and is manufactured in large quantity. For imitation shrimp, lobster and scallops, the product is made using moulds. All these imitation products can be further converted to coated products by battering and breading process. These seafood analogs possesses the accepted texture, flavour and appearance of the authentic products.

Palm impression technique for popularizing hygiene literacy among fish handlers

Most of the food handlers are unaware that they are potential carriers of pathogenic microorganisms and that poor personal hygiene makes the fish unsafe for human consumption. Palm Impression Technique (PIT), is useful as an effective participatory tool for popularizing good hygiene practices among fish handlers.

PIT was done by placing the palm of fish handler on a large-sized petri dish pre-set with nutrient medium. Briefly, 50 ml of molten Tryptone Glucose Agar (tryptone 0.5%, beef extract 0.3%, sodium chloride 0.5%, D-glucose 0.1%, agar-agar 1.5%, pH 7.1±0.1) was poured in large sized petri dishes (195 mm bottom plate diameter), allowed to set and dry. The handlers were asked to place their soiled palm on pre-set agar plate and allowed to remain in contact for 30 seconds. They were then directed to wash their hands thoroughly with soap and water and after drying their palm, they were then directed to wash their hands thoroughly with soap and water and after drying their palm, they were once again asked to place their palm on a different agar plate. The plates were then incubated at 37°C and observed after 24 hours for visible bacterial growth. The plate on which unclean palm was placed showed very dense bacterial growth, the shape of the fish handler's palm (Fig 1a), whereas the plate on which clean palm was placed showed less bacterial growth (Fig 1b). The result of PIT can be was easily read by all the fish handlers. This can have an everlasting impression in their minds, which in turn makes them follow good personal hygiene. The seafood technologists can employ the Palm Impression Technique to popularize good sanitation and hygiene practices among pre-processing and processing workers.

Effect of washing on the bacterial load as demonstrated using Palm impression technique

Fig. a) Dense bacterial load on unwashed hand (Palm) of a fish handler and b) Bacteria load reduced to a large extent by washing the hand (palm)

Advance Fishing Technologies Developed by ICAR-CIFT

The northeastern region comprising of eight states *viz.*, Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim has a total geographical area of 262180 Km2 which is nearly 8% of the total area of the country with more than thirty nine million populations. The water resource of North Eastern States has19150km of river, 0.24km of reservoirs, 1.43km of tanks/lakes/beels, 0.41km of ponds, 0.03km of paddy cum fish culture. NEH also produces 0.21mt of fish per year.

The north-eastern region of India has rich and diverse types of fishing crafts and gears. To exploit the fishery resources local fishermen are being using traditional crafts and gears since ages. Harvesting methods are varied in different inland water bodies depending on topography, ecology and habitat of the fishery resources. Indigenous technologies are eco friendly and efficient in operation. Better management measures are required for improving the production. Studies on the existing harvest systems are very much essential for further improvement and sustainable development of the fishery sector. Traditional fishermen of NEH are using various types of crafts, traps and gears for exploitation of fishery resources.

FRP coracle:

Fibreglass reinforced plastic (FRP) is an industrially important construction material. Good strength, light weight and long life are the special advantages of this material. It is a suitable material for building boats. CIFT has designed FRP Coracle, Canoes for traditional fishermen. It is a wide mouthed circular flat bottomed basket of 2m diameter made of Fibre glass. Coracles are an effective fishing vessel, steered and propelled using a single paddle. Traditional fishermen are using Coracles made with split bamboos. They are not durable. Gill nets and traps are operated from this vessel and usually one or two persons will be operating this craft. The durability of the trap is around 10 years.

FRP canoes:

Thirty four FRP boats in the size range of 18-27 feet were fabricated and distributed at Manipur. Designed and fabricated 27 feet motorized and 21 feet non-motorized for fast flowing Brahmaputra river, Assam. Designed and fabricated 18ft canoes for Meghalaya and Manipur.

Central Institute of Fisheries Technology has developed a fibre glass reinforced plastic (FRP) coated rubber wood canoe for operation in marine and inland waters. The rubber wood, which comes as a waste from rubber plantations is upgraded through chemical preservative treatment and the canoe made using the treated wood is further given a sheathing of FRP. The technology has made possible the utilization of rubber wood and also provided additional dimensional stability through sheathing. The FRP sheathing provides water proof, reduces maintenance, resistance to impact and abrasion and prevents attack of marine borers and other decay causing organisms besides giving an extended service life and better appearance for the wooden canoe. Canoe made of treated rubber wood and sheathed with FRP will give a maintenance free service life of 15-20 years.

Foldable traps:

Fishermen of reservoir and lakes are using traps made of split bamboo for exploitation of prawns. These box shaped traps occupy more space. The split bamboos used in fabrication of traps are not durable and it decay in 3-4 months. Fishermen have to spend more time for fabrication of traps and could not carry more than two in small boats. He has to destroy bamboo trees in the forest. The research centre of CIFT, Visakhapatnam has designed new foldable traps for fishing in reservoirs. The foldable trap measuring 0.5m x 0.5m x0.5m is made with 6 square shaped iron frames of 6mm diameters rod. All the six frames are covered with plastic coated iron mesh of 20mm mesh size and were fixed in iron frames are cut 10cm in the middle and entrance channel made with split bamboo were fixed in the middle of the frame. Entrance channel frames are tied to free end frames. All the six frames are foldable and it occupied less space and fishermen carry more traps at a time. Before operation all the frames are unfolded and set in to a box shape. These traps are durable and last for more than three years. The total cost of the trap is Rs.500/- approximately. The advantages of these traps are that – they are foldable, easy to fabricate and easy to carry.

Foldable traps for fast flowing rivers:

Foldable traps of 1.0 x 0.5 length x height was fabricated to operate in fast flowing rivers of Arunachal Pradesh and other NEH fast flowing rivers.

There is an urgent need to conserve the resources of this coast. There are many management tools to achieve this. The method used to reduce the under sized fishes in this study is by following mesh size regulations.

Serially Foldable Traps

The technology of sustainable fishing gears now-a-days has been developed to various sophisticated instruments in different countries in the world. However, the use of various fishing gears from primitive to advanced types depend on the various natures of water bodies and as well as the quality and types of fish species. Moreover, the various fishing techniques and modification found on the constructive designs of different fishing tools or gears are also found to be subjected to the different socio cultural aspects of various societies of man of different countries. Among all the fishing methods; Pots/traps is one of the most responsible fishing methods both in marine and inland sectors. When impact on environment is great concern trap/pot fishing is one of the fishing methods which creates less impact to environment needs less investment and at the same time ensuring quality catch. Pots/traps require less energy and eco-friendly fishing gear for resource conservation and sustainable harvest compare to other fishing practices. ICAR-CIFT helps modernizing various fish traps to improve their income of fishermen such as collapsible fish trap, lobster traps, foldable trap etc. Collapsible and Foldable traps have several advantages over traditional fish traps. Presently traditional pots/traps are made of natural material like bamboo which requires more space onboard since it is not foldable or collapsible it can carry only few in number but ICAR-CIFT made pots/traps are foldable and collapsible and need little space. It can be easily fitted during fishing and it can also carry large numbers as a result it increases the probability of catch by many times comparing to traditional pots/traps.

Merits of Foldable and Collapsible Traps over other fishing gears

- Require less space onboard and storage
- More energy efficient
- Better catch quality and higher market value
- Less chance of ghost fishing
- Eco-friendly as well as user friendly
- Less by-catch and discards
- Lower quantity of juvenile catch
- Low economic inputs

Fig. Serially foldable horizontal fish trap

Disadvantage of Dynamite Fishing

Blast fishing or dynamite fishing is the practice of using explosives to kill for easy collection. This is very common in all the hill streams of Northeastern India. It is used for large-scale fishing as well as small scale or adventure way of fishing in this region. This often illegal practice can be extremely destructive to the surrounding ecosystem, as the explosion often destroys the underlying habitat that supports the fish. The frequently improvised nature of the explosives used means danger for the fishermen as well, with accidents and injuries. Dynamite may explode prematurely without warning and have been known to injure or kill the fishermen or innocent bystanders.

Underwater shock waves produced by the explosion stun the fish and cause their swim bladders to rupture. This rupturing causes loss of buoyancy; a small amount of fish float to the surface but most of them sinks to the floor or bottom. The explosions indiscriminately kill large numbers of fish without excluding juvenile and adult fishes and other aquatic organisms. The damaged from blast fishing lead to instant declines in fish species wealth and quantity. A destructive fishing practices like blast fishing is one of the biggest threats in the present situation of upstream fast flowing water. The long-term impact associated with blast tanks is that there is no natural recovery of the sensitive ecosystem.

Fig. 1&2. View of dynamite fishing and high price of dynamite fishing

Disadvantage of Electric and Poisoning Fishing

Fishermen were using a car battery or power generator to power the electric fishing. To make the shock more fatal to the fish it is converted from DC to AC power using a power inverter. Current is passed through a naked wire/plate and the fishes are collected with hands or nets. A fish is killed or stun by inserting the electric rod and wire into small pools on the banks of the lake, rivers, streams etc. The dead fish would float up to the surface and would be handpicked or with scoop net and repeat the process. Local fishermen use very little safety measures and several accidental fatalities have occurred due to this practice.

Beyond the risk of human injury and death is the effect of such fishing practices on fish assemblages in freshwater systems. Electric fishing can yield much higher capture rates compared to traditional methods such as nets and fish traps but it may takes life of person who undergoes this fishing practice. This method is becoming very popular in most part of the north eastern states of India. However, there are no report till date in India that have documented the extent of this illegal fishing practice or the damage it causes to fish populations and aquatic organisms.

Fig. 3&4: Views of fishermen undergoing electric fishing

Poisoning fishing is another common method for fishing methods practicing in the North eastern States of India. The poison used may be of plant derivatives collected from forest or synthetic chemicals. The fish killed by these methods are said to be fit for human consumption. A natural derivatives poison considers lesser effect of killing fish due to decreasing in toxicity level while mixing with more water. However, chemical poison reported to wide out all the fishes once applied whether it is in the ponds, rivers, streams, lakes etc. A synthetic chemical fishing is

dreadful not only to fish and other aquatic organisms but only to the consumer when it is used at high concentration. It is regarded as one of the most harmful fishing in the inland sector due to present of chemical toxicity even to the soil for longer period of time.

Fig. 5&6. Views of fishermen undergoing natural derivative fishing using plant bark/root