Chapter 6

Machinery and equipment involved in unit operation of fish and marine food processing

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Equipment and machinery are inevitable for the large-scale processing and manufacturing of fishery products. Manually it is not easy to process fish that are landed in bulk quantities. Machinery help to maximize production with minimum human handling and reduce the wastage of fishes, which is otherwise a highly perishable commodity. For the mass production of fishery products, machinery is needed for fish pre-processing operations (i.e. to remove unwanted parts of the fish, shape the fish flesh into required sizes etc.), for suitable preservation techniques to be applied (i.e. chilling, drying, freezing, retorting etc.), for value addition and pack it in appropriate containers and store it till it reaches the consumer in a good form. Use of appropriate equipment and machines along the fish value chain will help in producing better quality products and fetch higher price.

1) Machinery for pre-processing of fish

Preliminary processing of fish usually consists of the following steps or unit processes: size grading and washing, evisceration, deheading, scaling, cutting of fins and belly flaps, slicing of whole fish into steaks, filleting, skinning, grinding of skinned fillets etc. A variety of equipment and machinery are employed to facilitate these tasks.

a) Size grading and washing machine

The processing sequence starts from grading the fish by species and size. Sorting by species or on the basis of freshness and physical damage are still manual processes, but grading of fish by size is easily done with mechanical equipment. Mechanical graders yield better sorting precision for fish. Generally size graders work on two smooth rotating rollers that are installed above the surface of the conveyor belt and the distance between the rollers and belt can be adjusted according to the maximum thickness of the sorted fish. Thinner animals fall off the belt while the thick ones are retained on it until the end of line. The device serves simultaneously as a grading machine and a conveyor. For shrimps, the equipment mainly consists of a driving device, a transmission drum, a conveyer belt, a groove type upper
supporting roller, a lower supporting roller, a rack, a sweeper, a tension device, a turnabout drum, a guide chute, an electric control device, etc.

![Fish size grader](image1.png) ![Shrimp size grader](image2.png)

**b) De-scaling machine**

Most common type of descaling machine is a cylindrical de-scaler with a horizontal rotation axis that can be periodically tilted during a scaling cycle which causes fish to tumble inside the drum, and consequently scales more efficiently. In some fish species, the scales can be removed from fish with a pressurized stream of water while fish is placed inside the scaler drum. The drums of such devices are made either of stainless mesh with rough edges or of stainless sheets perforated with contoured slits which detach the scales. Water has to be injected into the drum for the machine to operate. Another type is the vertical cylindrical scaler with rotating bottom and fixed side wall is widely used in small fish processing plants. Fish is loaded from the top and unloaded through the door in the side wall. Scales catch on small contoured slits cut in the bottom and side wall of the device, and are thus pulled out of the skin. The same machines can be used for slime removal.

![Cylindrical de-scaler with a horizontal rotation axis](image3.png)

Yet another type is mechanized and power-assisted hand-held scalers commonly used in small processing plants. Electrical hand-held scalers simplify and speed up the scaling procedure. They are most commonly used for secondary scaling of fish which has left the automated scaling device 80-90% free of scales. Use of electrical hand-held scalers reduces labour intensity and assures complete elimination of scales. The power-assisted tool consists of a cylindrical rotating scraper powered by an electric motor and connected to it with a flexible rod.
c) Filleting machine

The simplest filleting machine for gutted and deheaded 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 usually 30-40 fishes/minute: they are efficient and the quality of the final product is good. However, manual processing yields better results. The size range of the processed fish is usually 20-45 cm. Machines of different design and with bigger knives are used for processing larger fish. Filleting devices are produced in several countries and are increasingly used in small processing plants. Meat left on the fish's backbone after filleting can be recovered to a high degree using a meat-bone separator. Up to 50% of the total mass of processed backbones can be recovered as meat.

d) Fish skinner

The simplest and most inexpensive automated tool for skinning of fillet with or without scales can be attached to the processing table. It consists of an oscillating knife powered with a small electric motor and a system of compression springs operated with a foot pedal. Water
is not needed to operate this device. One end of the fillet is placed in a slit between the knife and compression element and the tip grasped manually in a wrench which allows the skin to be pulled off the meat from under the oscillating knife. Some devices are small and can be placed directly on the processing table; running water and electricity are necessary for their operation. Efficiency varies depending upon the fish species. Some are quite expensive and their use is profitable only when a certain level of production is maintained.

### 2) Machinery for coated products

Coated product is one, which is coated with another foodstuff. They are an important item among the group of value added fish products and are processed out of a variety of fish and shell fish. Coated fishery products include fish cutlets, fish balls, fish fingers etc. Depending on the scale of operation, industrial and bench-top model machinery is employed for manufacturing coated products.

#### a) Meat-bone separator

This equipment is used to separate meat from fish. The principle is forcing the fish against a screened or slotted surface when the flesh passes through the openings as finely ground paste. A common type of machine is the belt and drum type. In the separator machine, meat is squeezed through holes into the cylinder under pressure applied by a conveyor belt partially encircling the cylinder. The cylinder rotates slightly faster than the conveyor. The openings in the cylinder are usually 3-7 mm in diameter. For processing of freshwater fish, the holes are 4 and 5 mm in diameter. The smaller the holes is, the stronger the grinding action. Pressure applied by the conveyor to the cylinder can be regulated depending on the type and size of the raw product and on the hole diameter.
b) Fish Meat Strainer

Fish mince produced using the meat bone separator is refined further by passing it through a strainer, which will remove bone fragments and small pieces of bellylining etc. The Fish meat strainer mainly consists of a strainer drum with perforations less than 1 to 2 mm in diameter and a screw conveyor to push the mince through the strainer drum and a valve opening at the end of the drum. When the equipment is operated, bone free mince is forced through the perforations and the fin, bones and other wastes are pushed to the end portion of the drum from there they are periodically removed by opening the valve.

![Meat strainer](image)

Meat strainer

c) Forming machine

When a uniform shape is needed for the coated products like fish fingers, it is easy to cut the blocks into suitable sizes. But when there is demand for different shapes like round, oval, star and other forms a forming machine is required. Dyes with different shapes that can form desired shapes can be designed and fabricated. Depending on the market preference, the product can be framed into any shape. A forming machine does the job of shaping the product to the required shape.

d) Pre-dusting machine

To remove the greasiness or wetness and increase the batter pick up, the substrate to be coated are passed through the pre-dust or the dry batter itself before the application of batter. This process is called as pre-dusting. Predusts are usually applied by a breading machine suitable for handling flour. A special sprinkler conveyor may be added for applying a thin, even layer to the top of the product.

e) Battering and breading machine

The basic purpose of a coating machine is to achieve uniform coating. Also, it is necessary to make all the operations in a uniform style till the product is packed. Battering and Breading Machine is a conventional machine where the two applications viz. battering and breading can be carried out continuously. This equipment is a combination of one battering unit and a breading unit coupled together so that after the application of batter, the fish portions are transferred to the breading unit by the conveyor system.
f) Fryers

Frying is one of the fastest heat transfer methods available for cooking. It is a simple and commonly used technique for developing flavour, colour and unique product characteristics that cannot be duplicated by any other methods. Frying can be accomplished in a batch or continuous system. Batch system is recommended for small-scale production and continuous system for large-scale commercial production. The type of product and its sensory qualities and physical dimensions all have to be considered while selecting a frying system.

3) Freezers

For freezing whole fish and processed fish products, different types of freezers are available. The freezers selected for freezing depends on the type of products, quality requirements of the products and type of packaging. The common freezers used are plate freezers, air blast freezers, and cryogenic freezers.

a) Plate freezers

In a contact freezer or plate freezer the fish is frozen by direct contact with a refrigerated surface, typically between two hollow metal plates cooled by a refrigerant, such that the distance between the plates can be varied up to 100 mm or more. Horizontal and Vertical types of plate freezers are available. Horizontal freezers are generally used in processing plants in which fish, especially in flat packs such as laminated blocks, is frozen between two or more hollow, horizontal, parallel plates through which refrigerant passes. In a vertical plate freezer, the refrigerated, parallel plates are vertical and it is used mainly at sea or onshore for freezing large 25 or 50 kg blocks of whole, gutted, or headed and gutted fish.
b) Air Blast Freezers

In an air blast freezer, fish is frozen in a stream of high velocity cold air either in a batch or continuously, typically in a duct or tunnel in which a stream of cold air is guided over the product on shelves (batch) or on a conveyor (continuous air blast freezer); also called blast freezer, freezing tunnel, tunnel freezer. The advantage of the blast freezer is its versatility. It can cope with a variety of irregularly shaped products and whenever there is a wide range of shapes and sizes can be frozen. Continuous air blast freezers and batch air blast freezers are used.

c) Tunnel Freezer

The equipment has a food grade conveyor belt passing through an insulated chamber. It has an air-cooling system and an air blower to blow the air through the tunnel. Cold air is blown to the tunnel counter to the movement of the belt. The product to be frozen is passed through the belt. Circulating cold air at high speed enables the product to be frozen at a moderately rapid rate. Usually, the air temperature is between -18 and -34°C or lower. The moving of the product counter current to the cold air at a speed of 1 to 20 meter/second enables freezing to take place at a rapid rate. It is the popular method to prepare frozen fish products as IQF(Individually Quick Frozen).

Marine products of small size like prawns in different forms and style can be fluidized by forming a bed of the products on a perforated mesh belt and then forcing cold air upwards through the bed at a rate sufficient to partially lift or suspend the particles. The air used for fluidization should be sufficiently cooled; freezing can be achieved at a rapid rate. An air velocity of at least 2 meter/sec. or more is necessary to fluidize the particles and an air temperature of -35°C is common.


**d) Spiral belt freezer**

Modern designs of belt freezers are mostly based on the spiral belt freezer concept. In these freezers, a product belt that can be bent laterally is used. It usually consists of a self-stacking and self-enclosing belt for compactness and improved airflow control. The number of tiers in the belt stack can be varied to accommodate different capacities and line layouts. The belt is continuous. The products are placed on the belt outside the freezer where it can be supervised. As the belt is continuous, it is easy for proper cleaning. Both unpacked and packed products are frozen and the freezer gives a large flexibility both with regard to product and freezing time. Both horizontal and vertical air flow can be used.

**e) Cryogenic Freezer**

Cryogenic freezing refers to very rapid freezing by exposing food products to an extremely cold freezant undergoing change of state. The fact that heat removal is accomplished during a change of state by the freezant is used to distinguish cryogenic freezing from liquid immersion freezing. The most common food grade cryogenic freezants are boiling nitrogen and boiling or subliming carbon dioxide. Liquid nitrogen is used in most of the cryogenic food freezers. Usually, liquid nitrogen is sprayed or dribbled on the product or alternatively very cold gaseous nitrogen is brought into contact with the product.

**4) Equipments for manufacturing ice**

Cold preserves and maintains the quality of fish and fishery products and protects them against premature spoilage. Ice is a reliable coolant that has been put to good use for cooling fish both on and off shore. Ice can be produced in different shapes; the most commonly utilized in fish utilization are flake, plate, tube and block.
a) Block ice maker

The traditional block ice maker forms the ice in cans which are submerged in a tank containing circulating sodium or calcium chloride brine. The block weight can vary from 12 to 150 kg, depending on requirements. A travelling crane lifts a row of cans and transports them to a thawing tank at the end of the freezing tank, where they are submerged in water to release the ice from the moulds. The cans are tipped to remove the blocks, refilled with fresh water and replaced in the brine tank for a further cycle. With an appropriate ice crushing machine, block ice can be reduced to any particle size but the uniformity of size will not be as good as that achieved with some other forms of ice. In some situations, block ice may also be reduced in size by a manual crushing method.

b) Flake ice maker

This type of machine forms ice 2 to 3 mm thick on the surface of a cooled cylinder and the ice is harvested as dry sub-cooled flakes usually 100 to 1,000 mm² in area. In some models, the cylinder or drum rotates and the scraper on the outer surface remains stationary. In others, the scraper rotates and removes the ice from the surface of a stationary drum, in this case, built in the form of a double-walled cylinder. It is usual for the drum to rotate in a vertical plane but in some models the drum rotates in a horizontal plane. The refrigerant temperature, degree of sub-cooling and speed of rotation of the drum are all variable with this type of machine and they affect both the capacity of the machine and the thickness of the ice produced.
c) Tube ice maker

Tube ice is formed on the inner surface of vertical tubes and is produced in the form of small hollow cylinders of about 50 x 50 mm with a wall thickness of 10 to 12 mm. The tube ice plant arrangement is similar to a shell and tube condenser with the water on the inside of the tubes and the refrigerant filling the space between the tubes. The machine is operated automatically on a time cycle and the tubes of ice are released by a hot gas defrost process. As the ice drops from the tubes a cutter chops the ice into suitable lengths, usually 50 mm.

![Diagram of Tube Ice Maker]

Tube ice maker

d) Plate ice maker

Plate ice is formed on one face of a refrigerated vertical plate and released by running water on the other face to defrost it. Other types form ice on both surfaces and use an internal defrost procedure. Multiple plate units are arranged to form the ice-making machine and often these are self contained units incorporating the refrigeration machinery in the space below the ice-maker. The optimum ice thickness is usually 10 to 12 mm and the particle size is variable. An ice breaker is required to break the ice into a suitable size for storage and use.

![Diagram of Plate Ice Maker]

Plate ice maker

5) Fish dryers

Fish smoking and drying are preservation techniques that are widely used in small-scale fisheries communities in developing coastal regions. This is advantageous compared to fresh or frozen fish which requires cold storage that is largely inaccessible due to electricity scarcity in rural areas.

a) Mechanical dryers

In mechanical dryers, removal of water from the fish is achieved by an external input of thermal energy. This is an expensive method since there is need of fuel for heating and
maintenance of the temperature. The drying chamber consists of a long tunnel in which the washed and cleaned fish is placed on trays or racks. A blast of hot air is passed over the material to be dried. After the required degree of drying the product is removed from the drier and packed. In mechanical dryers usually the heat is transferred into the product through a hot gas. e.g. Kiln dryers, cabinet dryers, tunnel dryers and fluidized bed dryers.

b) Solar Dryers

In solar dryers during sunny days fish will be dried using solar energy and when solar radiation is not sufficient during cloudy/rainy days, other back up heating system will be automatically actuated to supplement the heat requirement. Thus continuous drying is possible in this system without spoilage of the highly perishable commodity to obtain a good quality dried product. Designs of solar dryer vary from very simple direct dryers to more complex hybrid designs. The hybrid model Solar Dryers are having LPG, Biogas, Biomass or Electricity as alternate back up heating source for continuous hygienic drying of fish even under unfavourable weather conditions. The capacity of these hybrid solar dryers varies from 6 sq.m to 110 sq.m tray spreading area for drying fish (capacity 10kg to 500kg). CIFT has developed different models and capacities of solar dryers for hygienic drying of fish

![](image)

CIFT developed hybrid solar dryer

6) Machinery for thermal processing of fish

Thermal processing of fish by canning or retorting is a method of food preservation in which food is packed in metal or glass or plastic containers, sealed air tight and heated sufficiently to destroy the spoilage, pathogenic and food poisoning organisms making the food safe for consumption. The process involves a lot of machinery and the important ones are mentioned below.

a) Pre-cookers

Larger sized fishes like Tuna are given a pre-cook by heating at a temperature range of 100 °C. This operation is necessary to make it possible to hand pick the light meat from the carcass and also to remove some of the oil from oily fish. The most common pre-cookers are live-steam cookers fitted with condensate drains, vents and safety valves. The fish is placed in baskets which are placed on racks. The racks of butchered fish are rolled into the cookers which are usually of rectangular cross section and made of reinforced steel plate with a door, or doors, at one or both ends. The pre-cooking is a batch type operation. Steam is admitted through a steam spreader on the floor of the cooker. Steam vent and drain valves are provided to permit removal of air and condensate. Pre-cooking may also be carried out in boiling brine.
b) Exhaust boxes

The exhaust box is used to heat the contents of cans, so that they may be sealed hot, thus ensuring that, after cooling, a vacuum has formed in the container. Exhausting also drives entrapped air from the pack. Exhaust boxes may take many shapes and forms, depending on the requirements of the cannery; basically they consist of a tunnel through which the open and filled cans pass while being exposed to atmospheric steam.

![Exhaust box](image)

Exhaust box


c) Sealing machines or can seamers

It is a machine used to seal the lid to the can body. The simplest of machines are hand operated or semi-automatic single-head equipment with motorized drives. For those with a low output, hand operated models are ideal. The sealing operation is initiated by depressing a foot pedal which lifts the can up to the chuck on the sealing head and into position for double seam rolling. The first and second action rollers are sequentially brought into action while the can is rotated by the spinning seaming head. At the completion of the seaming operation the sealing chamber is opened to the atmosphere and the hermetically sealed container is removed. Machines of the type described can frequently have the facility for steam flow closing, in which case steam is injected across the headspace of the container immediately prior to double seaming.

![Can seamer](image)

Can seamer

d) Retorts

All canned fish products are sterilized at temperatures above 100 °C. Thermal process sterilization takes place in retorts, with or without water. Overpressure is between 2-3 kg/cm². The simplest and most common retorts today are horizontal, or vertical, batch retorts. The most frequently used style of retort found in commercial fish canneries today, is the static batch system for processing cans in saturated steam. The most significant difference between static retorts and continuous systems is that the latter must have container transfer mechanisms to regulate the movement of cans at a predetermined rate through the heating and cooling sections. Batch retorts heated with water under pressure are vertical or horizontal...
and are most frequently used for sterilization of products packed in aluminium cans with score-line easy open ends.

7) Machinery for packaging

Packaging is a crucial element in the safety and protection of processed fishery products during its shelf life. It uses a variety of different materials to protect food and provide surfaces for labelling. Important machinery used for common packaging applications are discussed.

a) Sealers

Sealers are used in multiple forms of flexible packaging applications. A heat sealer uses heat to melt plastic or adhesive together to seal off a package. Heat sealers are used for many different products to help protect from product tampering and contamination. They can be used in small operations and fully automatic operations. Heat sealing systems use a combination of heat, time and pressure to create a seal with a set of crimp seal heating bars. When the jaws come together, this melts a layer of plastic and bonds the two layers of film together. Different types of sealers are:

Band sealers are used to seal pouches and can be horizontal or vertical. In the typical embodiment, a moving pair of band grasps the top of the package and moves it past the heating elements. Packages can be supported from beneath by a moving conveyor or in the case of lightweight packages, held by the sealing bands themselves.

Blister sealers and tray sealers are used to attach thermoformed blisters to paperboard or film backings and can range from single package per cycle manual shuttle units to automated rotary type machines. In case of tray sealers, plastic films are sealed over open ends of thermoformed plastic trays.

Vacuum packaging involves the removal of air from the package and the application of a hermetic seal. Vacuum sealers are used primarily for packaging owing to the benefit of low oxygen levels for retarding spoilage. Vacuum machines often incorporate a chamber for evacuating the package or tray prior to sealing the top layer or cover into place. They can be manual, semi-automatic, or automatic machines.

A vertical form fill sealing machine is a type of automated assembly-line product packaging system. The machine constructs plastic bags and stand-up pouches out of a flat roll of film, while simultaneously filling the bags with product and sealing the filled bags. Both solids and liquids can be bagged using this packaging system.
b) Labelling and coding machines

Labelling and coding machines are used for industrial and retail packaging applications. Most packaged products use some form of labelling or coding. Labelling machines are used for applying branded labels for advertising and/or bar codes for inventory and batch management.

c) Strapping and bundling machines

The most popular use for strapping machines is a reinforcement of heavy boxes during shipping and retail sales. Polypropylene strapping is commonly used. Strapping machines use heat to mend ends together for durable reinforcement. Another use for a strapping machine is bundling applications. Strapping can help unitize multiple products together and secure products for transport.
References


