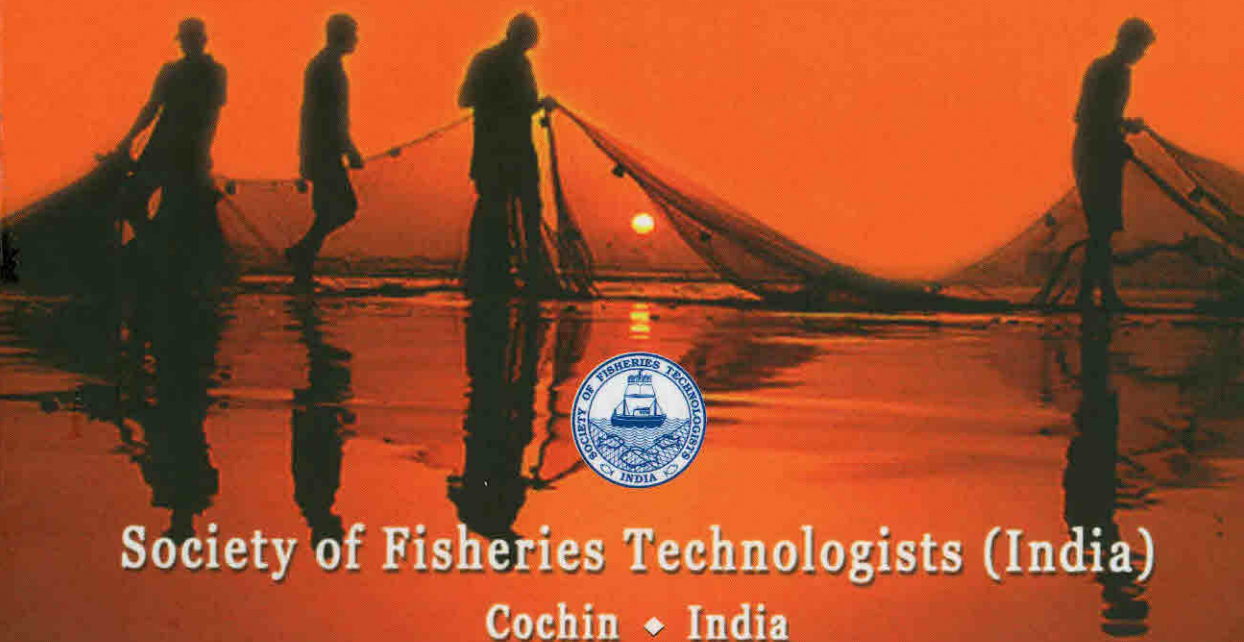


Coastal Fishery Resources of India

Conservation and Sustainable Utilisation



Society of Fisheries Technologists (India)

Cochin ♦ India

Coastal Fishery Resources of India: Conservation and Sustainable Utilisation

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Developments in Fish Processing Technology

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Introduction

The growth rate of Indian marine products industry has been showing an upward trend in recent years in terms of quantity, while it has not been so encouraging in terms of unit value realisation. This is due to the failure of the industry to diversify its products and markets in tune with the changing market trends. The industry still remains mainly shrimp oriented because it is more lucrative. Even though the export of fish is high, the value realisation is less compared to shrimp. India exports mainly whole fish and shellfish, which is processed into several high value products in the importing countries and are re-exported at a very high price. It is noticed that the catches from the capture fisheries are on the decline. Hence it is necessary to conserve the harvested catch judiciously and to increase the production through culture to meet the growing demand for fish. Value addition and introduction of new types of products from low cost fishes is the only solution to the problem. Present market trends reflect a rapidly growing demand for ready to cook and ready to serve convenience products. Value addition can increase considerably the unit value of fish products and, hence, it is necessary to adopt modern technologies in processing of value added fish products and ensure food safety by adopting HACCP and ISO 9000 series. The increased demand for fish has prompted the development of many new preservation techniques which can be adopted by the fish processing industry without sacrificing safety, quality, shelf life and consumer satisfaction. The recent developments in handling, product development, packaging, preservation and storage of fish and fish based products are briefly reviewed in the following sections.

Chill storage

Chilled storage in different containers has been practiced in the case of fish and fish products for a long time. Modified atmosphere (MAP) or

controlled atmosphere storage by the application of CO₂ at concentrations in the range of 50-100% to fresh fish in chilled condition is a recent introduction which substantially increases the shelf life (Wolfe *et al.*, 1976; Gee and Brown, 1978; Fey and Regenstein, 1979; Martin, 1981; 1982)



Fig. 1: Modified atmosphere packaging equipment

In MAP fish and fish products are packed in an atmosphere of carbon dioxide and other gases like oxygen and nitrogen. The modified atmosphere retards the growth of microorganisms and reduces the rancidity in fatty fishes. Hence MAP chilled fish has an extended shelf life of 10 days or more depending on the species. Central Institute of Fisheries Technology (CIFT), Cochin, has standardized the optimum concentration of gases in MAP for different products to get maximum shelf life and retention of quality. The concentration of carbon dioxide varies from 40 to 80%. The studies on *Catla catla* fillets, whole pearlspot, dressed pearlspot, seer fish steaks etc. gave encouraging results (Gopal *et al.*, 1986; 1990; 1996). The threat of botulism, due to the presence of non-proteolytic psychrotrophic *Clostridium botulinum* types B, E and F has been reason for caution in expanding this technology. MAP can be effective if used in conjunction with packaging materials of correct O₂ and CO₂

permeability characteristics. Properties required may not be found in one polymer, hence laminated films are used.

Active packaging changes the condition of the package to extend the shelf life or to improve the safety while maintaining quality of the foods (Vermeiren *et al.*, 1999; Rooney, 1992; Ahvenainen, 2003). There are two types of active packaging systems, viz., scavenging systems (absorbers) and releasing systems (emitters). Scavenging systems remove undesirable compounds such as oxygen, excessive water, ethylene, carbon dioxide, taints and other specific food compounds. Releasing systems actively add compounds to the packaged food such as carbon dioxide, water, antioxidants or preservatives. Most important active packaging concepts includes: O₂ and ethylene scavenging, CO₂ scavengers and emitters, moisture regulators, anti-microbial packaging, antioxidant release, release or adsorption of flavours and odours.

The commercial use of atmosphere modifiers and Oxygen scavengers in particular, with fish products has been mostly limited to the Japanese market and to dried seaweed, salmon jerkey, sardines, shark's fin, rose mackerel, cod, squid or smoked salmon products. These ambient stored products have low water activity (less than 0.85) and so the microbial deterioration is not shelf-life limiting. Here the oxygen scavengers prevent oxidative reactions, discolouration and inhibit mould growth (Brenzon and Saguy 1998; Gill and MacGinnis, 1995; Smith *et al.* 1995; Mohan *et al.* 2008). Other commercial products stored in active packages are fresh yellowtail, salmon roe, and sea urchin. They are stored at super chilling conditions. Here the oxygen scavenger primarily prevent oxidation and discolouration and inhibit bacterial growth to a lesser degree. Different Oxygen scavengers are chosen dependent on the amount of Oxygen to scavenge (pack size and material) and water activity of the product. Oxygen scavengers for high water activity foods react faster compared to scavengers for dry foods but in general the absorption is slow and exothermic. The use of Oxygen absorbers (Ageless SS-100) had only a marginal effect on microbial growth in packages of fish products compared to effect obtained by MAP.

In MAP combined with active packaging partial vacuum is created in the package as a result of dissolution of CO₂ into the product and removal of O₂ using O₂ scavengers. In such cases, simultaneous release of CO₂ from inserted sachets is desirable. Such systems are based on either ferrous carbonate or a mixture of ascorbic acid and sodium bicarbonate (Rooney, 1995). The commercial CO₂ emitters usually contain

ferrous carbonate and a metal halide catalyst although non ferrous variants are available, absorbing the Oxygen and producing equal volumes of Carbon dioxide. Carbon dioxide could also be produced inside the packages after packaging by allowing the exudates from the product to react with a mixture of sodium carbonate and citric acid inside the drip pad, an approach used successfully for fish fillets. Studies conducted using salmon fillets with soluble gas stabilization technique with combined oxygen absorber and carbon dioxide emitter(Ageless G-100) indicates slow microbial growth compared with those stored in air without absorbers.

Work carried out at CIFT indicates significant improvement in the shelf life of Catfish (*Pangasius sutchi*) steaks, seerfish (*Scomberomorus commerson*) steaks and dressed oil sardine (*Sardinella longiceps*) in active packaging systems, compared to the corresponding air packed samples (Mohan *et al.*, 2008; 2009; 2010).

Freezing preservation

Freezing is the most satisfactory method for long-term preservation of fish products. The advancements in the freezing of fish products are mainly in the technological aspects of freezing and also in the introduction of newer frozen products. The freezing time has reduced considerably by the advancement of newer freezing system. The freezing time has reduced considerably by the advancement of freezing technology. The freezing time in plate freezers have been reduced to more than half by the introduction of double contact plate freezers (Hall, 1992). Semi automatic and automatic horizontal plate freezers have also been introduced. For freezing unpackaged fish products rotary drum type freezers are available.

For IQF products, spiral freezers and fluidized bed freezers replaced the conventional tunnel freezers. These freezing systems considerably reduce the space occupied by the freezers and also freezing time (Santos-Yap and En., 1995). Very efficient and effective cryogenic freezing systems are also developed. Another innovation in freezing is the pressure assisted freezing. In this system, freezing occurs due to the pressure induced melting point depression, which enables water to remain in liquid phase at higher pressures. The melting point of ice is lowered to -2°C at a pressure of 207.5 MPa. Release of pressure enables rapid and uniform nucleation of water in a food product leading to freezing. This type of freezing produces smaller ice crystals rather than stress inducing ice front moving through the sample (Venugopal, 2006).



Fig. 2: Laboratory model Air blast freezer

Curing and drying

Cured and dried fish represents fish products with low water activity. The water activity of fish products is reduced by drying, salting or salting and drying. The conventional method of drying is exposing fish with or without salting to sun by spreading over the sand. Since this causes heavy contamination many a times, modifications have been made in sun drying itself to reduce contamination. Solar tent drying, drying on platforms or rack are the results of such attempts. These modified methods improve quality substantially (Horner, 1992). Rack drying of fishes has distinct advantages over beach drying in terms of drying rate and hygiene. The rack drying has another of advantage of saving space (Shamasundar, 2001)

CIFT has developed solar fish driers having capacity with alternate back up systems ranging from 10-1000 kg. The solar drier operates on eco friendly technology. Water is heated with the help of solar vacuum tube collectors installed on the roof and circulated through heat exchangers provided in the PUF insulated stainless steel drying chamber loaded with fish. When solar radiation is not sufficient during cloudy/rainy

days, LPG back up heating system will be automatically activated to supplement the heat requirement (Fig. 3). Thus continuous drying is possible to obtain a good quality dried product (Joshi, 2009).



Fig. 3. Solar dryer developed at CIFT, Cochin

Some of the solar dryers developed in the country are not having any back up heating system. These types of dryers cannot be used in adverse weather conditions. Mechanical driers have been developed to overcome this. When the quantity of fish to be dried is small or seasonal, batch driers are used. Kiln drier and cabinet or tray driers represent the important types of batch drying equipment. The modification in the batch type driers is the continuous hot air driers. They are operated by passing the material on a conveyor belt with co-current or counter current hot air flow.

Other important types of driers are rotary driers, drum driers and osmotic driers. These driers are used in drying of fish products, but hydrolysed products can be dried using them.

Freeze dried products

Freeze dried fish products are prepared by freezing the product and subliming the ice under low pressure. The structural changes in this type of drying are minimum and flavour is retained to the maximum (Robert *et al.*, 1964). There are different types of freeze driers. Some of the important types are tray freeze drier, continuous belt freeze drier, continuous circular plate freeze drier and fluidized bed freeze driers. Very extensive work in the field of freeze-drying is still underway and modified freeze-drying processes are continuously appearing in literature. Some of the process modifications include improved heat transfer using some vibrations and beds of alternate product layer and desiccant layer (Mellor and Bell, 2003)

Extruded products

Extrusion is a process which combines shear, pressure and temperature leading to molecular transformations in the constituents and involves denaturation of the proteins, fragmentation of the starch molecules and changes in the non-covalent bonds between proteins, lipids and carbohydrate. Fish based extruded products have very good marketing potential. Formulation of appropriate types of products using fish mince, starches etc. attractive packaging for the products and market studies are needed for the popularization of such products (Harper, 1981; Gopal *et al.* 2008). Extrusion is a multivariable unit operation in which a variety of raw materials undergo a number of operations, i.e., mixing, shearing, cooking, puffing and drying in an energy efficient rapid continuous process.

The thermo-mechanical action during extrusion brings about gelatinization of starch, denaturation of protein and inactivation of enzymes, microbes and many anti nutritional factors in a shear environment, resulting into a plasticized continuous mass which comes out through restriction called die. The quality of an extruded product determines its success or failure. So it is very much important to understand which extrusion processing parameters and ingredients interactions during processing influence product quality. Extrusion processing variables that directly control product quality attributes are called independent variables and dependent variables are those which are changed as a result of any change made to independent variables. The advantages of extrusion process are (a) better thermodynamic efficiency, (b) destruction of bacteria and anti-nutritional factors, enabled by short time high temperature process, (c) one step cooking process and reduction

in wastage, and (d) destruction of fat hydrolyzing enzymes during extrusion cooking.



Fig. 4. Twin screw extruder

Work carried out at CIFT indicates that extruded product containing rice flour, Bengal gram flour and fish at a temperature of 140°C with a moisture content of 17%, screw speed of 380 rpm give the best result with good expansion ratio, low shear strength and color (Gopal *et al.*, 2007). CIFT has standardized the production of extruded products by incorporating fish mince with cereal flours. One such popular combination is the minced *Nemipterus japonicus*, rice flour and Bengal gram flour (Fig. 5). The product obtained is finally coated with chaat masala to provide a delicious snack that has been christened as "Fish Kure". Extruded products like noodles, wafers and flakes, from vegetable sources are well established in the consumer market. Extruded products with fish are yet to gain popularity.

Smoked products

Smoking of fish products like curing is a very old method of preservation. In addition to preservation, smoke imparts a particular flavour to the product. In addition to provide a typical color, depositing antimicrobial components, smoking deposits carcinogenic compounds like polyaromatic



Fig. 5. Fish Kure

hydrocarbons. Important among them is 3,4 benzopyrene (Simko,1991; Andrzej *et al.*, 2005). In coventional smoke kiln the control depositing solid particles and benzopyrene is very difficult. Modern sophisticated smoke kilns have the facilities to control or minimize to the acceptable level all the above factors.

Radiation preservation

Use of ionized radiation for the preservation of food is a novel concept and is a truly peaceful use of atomic energy. Irradiation of fish helps in disinfection of stored dried fish and extending the shelf life of fresh fish by acting on the spoilage organisms. Many of the pathogenic bacteria like *Salmonella* and *Listeria* also can be destroyed at relatively lower radiation doses. Irradiation can be employed to bring about complete sterilization of the product, or for elimination of the pathogens and reduction in the viable organisms in order to improve the shelf life. The second option however, will not bring about sterility in the product. Sterilization will require higher process of radiation and will bring about several unsavory changes in the food. At lower doses, irradiation will only pasteurize the food and hence it is necessary to hold the food at lower temperature to prevent the remaining microorganisms from multiplying and spoiling the food

(ICMSF, 1980; Mossel, 1985; Hobbs, 1977; Monk *et al.*, 1995; Radomyski, 1994).

Shelf life extension of fresh fish by gamma irradiation

Radurization of fresh fish at 1 to 3 kGy reduces initial microbial loads by 1 to 3-log cycle and extends their chilled storage life 2-3 fold. Studies showed that irradiation of food at an overall average dose of 10 kGy produces no adverse effect and the treated foods are toxicologically safe for consumption (Laycock & Reiger, 1970; Venugopal *et al.*, 1973).

Sanitization of frozen fish by gamma irradiation

Frozen fish products, harbour several cold-tolerant spoilage and pathogenic microorganisms. Radicidation of frozen fish products at a dose of 4 to 6 kGy can eliminate non-spore forming pathogenic bacteria such as *Salmonella*, *Vibrio* and other species. The treatment, however, is limited in its ability to eliminate viruses and *Clostridium botulinum* type E spores (Diehl, 1995; WHO, 1993).

Disinfestation of dried fishery products

A major problem of sun-dried fish stored in tropical countries is infestation by flesh flies, beetles and mites (Gopakumar, *et al.*, 1982; Esser, *et al.*, 1990; Wood, *et al.*, 1982). Irradiation at doses in the range of 0.1 to 1.0 kGy can prevent development of beetle larvae and adults in packaged, salted and dried fishery products. Disinfestation studies of dried mackerel showed that eggs, larval and pupal stages of hide beetles *Dermestes maculates* could be inactivated at a dose of 0.2 kGy (Ahmed 1989; Hussain *et al.*, 1989). Several countries have accorded clearance for irradiation of various food items following the observation of the WHO and the International Atomic Energy Agency in 1980 that any food irradiated up to an overall average dose of 10 kGy does not pose any toxicological problem (WHO, 1981).

Battered and breaded products

Battered and breaded products packed in consumer packs after freezing are sold through super markets as ready to fry items. Such products find good acceptance in fast food outlets. Fish and prawn cutlets also can be classified under battered and breaded products. A large number of coated products both for export and internal market based on shrimp, lobster, squid, cuttlefish, bivalves, certain species of fish and

minced fish have been identified (Joseph, 2003). The technology for their production is readily available (Fig. 6). Meats, fish, vegetables, fruits and cheese are coatable materials, which are commercially prepared on various forms. Battering and breading enhance food product's appearance and organoleptic characteristics in addition to improving its nutritional value. Coating acts as a moisture barrier, minimizing moisture losses during frozen storage and microwave re-heating. The most important function of coating is value addition by increasing the bulk of the substrate thereby reducing the cost element of the finished product.

There are several ingredients used in the formulation of coatings. The commonly used ingredients are polysaccharides, proteins, fats, seasonings and water. Besides small quantities of leavening agents, gums, spices, colour etc. may be added to provide specific functional effects. Most coated products are now available with a three-way cook option. They can be baked in a conventional oven, prepared under the grill or fried. The hunt is now on for coatings, which are suitable for use in a microwave oven. The production of battered and breaded fish products involves several stages. The method varies with the type of products and pickup desired. In most cases it involves portioning/forming, pre-dusting, battering, breading, pre-frying, freezing, packaging and cold storage. Some of the important coated fish and fishery products are fish fingers, fish portions, various shrimp based products, squid products, clam and other related

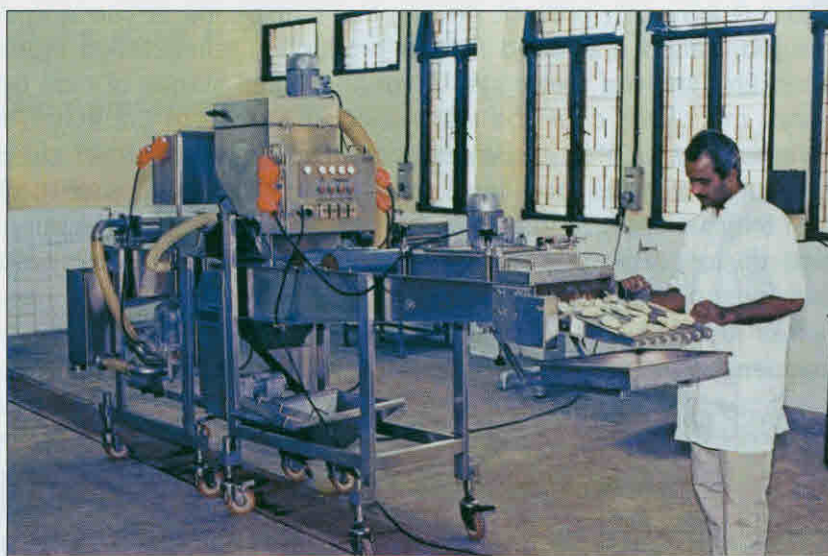


Fig. 6: Battering and Breading machine

products, fish fillets, mince based products such as fish cutlets, burgers, fish balls, imitation products and crab claw balls (Gopal *et al*, 2008)

Individually Quick Frozen Products (IQF)

Radical changes have taken place in the freezing system of fish and fishery products over the years. An important improvement in freezing prawns is the shift from the conventional block frozen to the individually quick frozen products. With the advent and spread of aquaculture of shrimp, individual quick-freezing has become very popular. Farmed prawn offers the advantage of harvesting at a predetermined time and hence can be frozen in the freshest possible condition. Because of this, most of the farmed prawn is frozen as whole IQF. Lobster, squid, cuttlefish, different varieties of finfish etc. are also processed in the individually quick frozen style. IQF products fetch better price than conventional block frozen products. However, for the production of IQF products raw-materials of very high quality need to be used, as also the processing has to be carried out under strict hygienic conditions. The products have to be packed in attractive moisture-proof containers and stored at -30°C or below without fluctuation in storage temperature. Thermoform moulded trays have become accepted containers for IQF products in western countries. Utmost care is needed during the transportation of IQF products, as rise in temperature may cause surface melting of the individual pieces causing them to stick together forming lumps. Desiccation leading to weight loss and surface dehydration is another serious problem met with during storage of IQF products.

Some of the IQF products in demand are prawns in different forms such as whole, peeled and de-veined, cooked, headless shell-on, butterfly fan tail and round tail-on, whole cooked lobster, lobster tails, lobster meat, cuttlefish fillets, squid tubes, squid rings, boiled clam meat and skinless and boneless fillets of white lean fish. IQF products can be easily marketed as consumer packs. Most of the speciality products from shrimp are frozen as IQF. Some speciality products from shrimp are stretched shrimp or Nobashi, barbeque, skewered shrimp, head on centre peeled and cooked shrimp. All these are frozen as IQF and packed in thermoformed trays under vacuum and then frozen stored

Fish mince and mince based products

Minced fish is the meat separated from lean whole fleshed fish in comminuted form free of bones and skin etc. Flesh can be separated

from filleting waste also. Minced fish can be used as a base material for the preparation of a number of products of good demand. The properties of minced fish to a large extent are determined by the nature and quality of raw material. Meat-bone separators of different types are available for the preparation of minced fish. Minced fish from marine as well as freshwater fish is used for the preparation of a number of products like fish sausage, cakes, cutlets, burgers, balls, pastes, *surimi* and texturised products. The processes for the production of most of these products are available and some of them are suitable for starting small scale industries.

Fish cutlet: Cooked fish mince is mixed with cooked potato, fried onion, spices and other optional ingredients. This mass is then formed into the desired shape, each weighing approximately 30g. The formed cutlets are battered and breaded.

Fish burgers: More or less similar to fish cutlets, burgers are made using mince of lean white fish and are only mildly flavored. Cooked mince is mixed with cooked potato and mild spices and formed into burgers using forming machine. Burgers are battered, breaded and flash-fried before packing and freezing.

Fish balls: Fish balls are generally prepared from mince of low cost fish. Balls can be prepared by different ways. The simplest method is by mixing the fish mince with starch, salt and spices. This mix is then made into balls, cooked in boiling 1% brine. The cooked balls are then battered and breaded.

Surimi

Surimi is the myofibrillar protein concentrate produced by repeated washing of fish mince in order to remove water soluble nitrogenous matter and flavour compounds. Washing enhances the gel forming capacity of the structural proteins. *Surimi* is used as a raw material for the preparation of seafood analogues, but in Japan, *surimi* is mainly used to prepare the traditional kamaboko products. *Surimi* has high concentration of myofibrillar proteins, readily forms gel as a result of unfolding and cross linking of actomyosin. Gel formation occurs rapidly when *surimi* is heated at 80-90°C but also takes place slowly at 40-50°C and even at 0°C when held at over night. *Surimi* paste that has initially been set at 40-50°C gives a stronger gel if subsequently heated to 80-90°C. This peculiar property has been used for the processing of a large number of products with varying functional properties.

Surimi based products

Surimi is an intermediate product, which has characteristics gelling and elastic properties. It can be used to develop products that can imitate the appearance, flavour and texture of expensive items like lobster tail, shrimp, scallop, crab leg etc. It can also be used as a substitute for ground beef in certain foods. Texturisation of *surimi* involves modification of elasticity with ingredients such as egg white, starch, polyphosphates etc. The flour is modified by the addition of salts and extracts of natural seafoods. The traditional *surimi* products of Japan are *chikuwa* (tube shaped fish paste), *kamaboko* (boiled fish paste), *satsumaage* (fried fish paste product) and *hampen* (floating type boiled fish paste). Diversified traditional products like *kanikam* (artificial crab leg), *hampen*, cheese sandwiched *hampen*, easy to eat *kamaboko*, *satsumaage* with *hampen* taste, squid *surumi kamaboko* are also being marketed in Japan.

Fish sausage

Fish sausage is an analogue of sausage made from pork. The main ingredient is *surimi* or ground fish meat. The *surimi* is mixed with salt (3-4%), sugar (2-3%), sodium glutamate (0.3%) starch, and soy protein in a silent cutter. At the end of mixing, lard or shortening (5-10%), polyphosphate (0.2-0.3%) and flavourings are added and the minced meat is placed in a casing tube made from vinylidene chloride. Stuffing is done by an automatic screw stuffer. The casing tube is closed by metal rings. The tube is heated in hot water at 85-90°C for 40-60 min. After heating, it is cooled down slowly to avoid shrinking of the tube and then stored at refrigerated temperature.

Fibreized products

Fibreized products are the greatest in demand among the *surimi* based imitation shellfish products. The ingredients used in the formulation of fibreized products includes, besides *surimi*, salt, starch, egg white, shellfish flavour, flavour enhancers and water. All the ingredients are thoroughly mixed and are ground to a paste. The paste is extruded in sheet on the conveyor belt and is heat treated using gas and steam for partial setting. A strip cutter subdivides the cooled sheet into strings and is passed through a rope corner. The rope is coloured and shaped. The final product is formed by steam cooking the coloured and shaped material.

Frozen fish dessert

CIFT has developed a ready to eat and highly nutritious product containing deodorized fish protein christened as *maricream*. It is a mixture

of water, cooked cuttlefish meat, sugar, butter, egg white, flavouring substances, stabilizers and emulsifiers. This mixture is whipped and pasteurized to form a rigid foamy substance and finally frozen at -20°C . Sweet aroma and flavour is provided by butter, vanilla essence and cooked deodorized cuttlefish. One important difference with other desserts is that protein component is provided from a marine source. Colour and odour of the cephalopods are favourably suited for *maricream*.

Frozen fish fillets

Skinless and skin-on fillets from lean and medium fat, white meat, fish have enormous market potential. Many varieties of deep sea fishes such as grouper, red snapper, reef-code, breams and jewfish are suitable for making fillets both for domestic market and export to developed countries in block frozen and IQF forms. In the importing countries these fillets are mainly used for conversion into coated products. Fish fillets can also be used for the production of ready to serve value added products such as fish in sauce and fish salads.

Chilled fish

Chilled fish is another important value added item of international trade. The most prominent among this group is *sashimi* grade tuna. *Sashimi* is a Japanese term for raw fish fillets mainly from tuna and it is a traditional delicacy in Japan. Two species, Blue fin and Big eye are mainly used for this purpose. The best quality *sashimi* tuna is that which is chilled at all stages from capture to final consumption. Other important products of this group are pomfrets, shrimps, lobsters and crabs.

Thermal processing

Thermal processing (canning) involves several heating processes such as cooking, blanching, pasteurization and sterilization. The objective of thermal processing is to inactivate or destroy the microorganisms and the enzymes. At the same time, maximum retention of nutrients is also very important. In preliminary cooking and also in sterilization it is observed that high temperature and short time process favour nutrient retention without sacrificing the rate of destruction of microbial spores. The major problem is the retention of some of the heat resistant enzymes by this method. Another area, which has undergone significant changes, is the thermal processing equipment or retorts. The still retort is the oldest type of equipment used in sterilization or thermal processing. In conventional

system the method consists of loading crates of containers into the retort, closing it and heating with steam. Improvement in the systems have centered on the mechanics of handling the containers. The recent development is the introduction of a "crate less" container handling system. Continuous retorts have distinct advantages over batch type retorts like greater production rate, lower labour cost and higher rate of heat transfer. At least four types of continuous retort systems that use steam as heat transfer medium are in use. Aseptic processing is another method of thermal processing but it is not very much applicable for fish products.

Another area, which has undergone considerable transformation, is the development of new containers. Different types of materials are used now for making containers for canning. The main materials used are glass, tin plate, steel, aluminum and metal foils laminated with plastics. Cans made into different styles from metals like beaded cans, cemented side seam cans, two piece cans, drawn and wall ironed cans, drawn and redrawn cans and necked in cans are available. Easy open end cans and retortable pouches are recently introduced and have become very popular.

Ready to serve fish products in retortable pouch

Ready to serve fish products viz. curry products, in retortable pouches are a recent innovation in ready to serve fish products for local market. The most common retortable pouch consists of a 3 ply laminated material such as polyester/aluminium/cast polypropylene. Some of the products standardized by CIFT are mackerel curry, rohu curry, sardine curry tuna curry, pomfret curry, prawn curry, seer fish moilee, pearl spot moilee, fried mussel, fish sausage, prawn kurma, prawn Manchurian, fried mussel and mussel masala. These products have a shelf life of more than one year at room temperature (Gopal, *et al.*, 2001;2002; Manju *et al.* 2004; Sonaji *et al.*, 2002).

As there is increasing demand in National and International market for ready to serve products the retort pouch technology will have a good future. Coated products and fish mince and mince-based products are also becoming popular now. Retort pouches which are made up polyester/aluminium/cast polypropylene, the product cannot be seen. Pouches made of polyester coated with aluminium oxide or silicon dioxide/mylon/cast polypropylene have become available, in recent years. In these types of pouches the product can be kept for a period of one year, at room temperature.

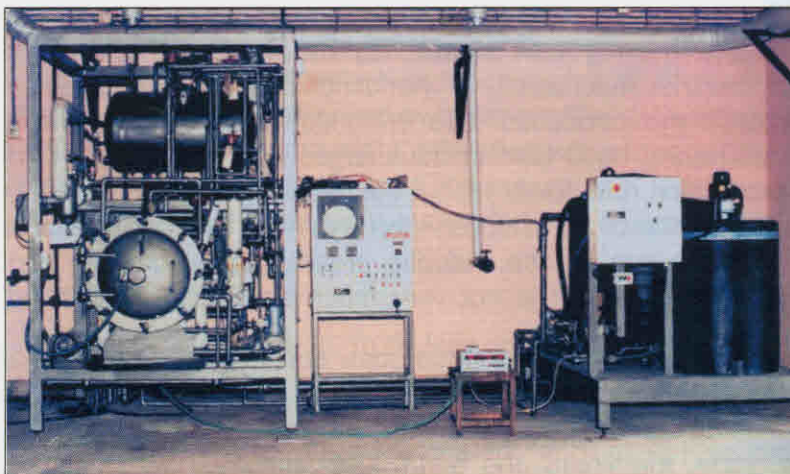


Fig. 7: Overpressure autoclave for retort pouch processing

High pressure processing

High Pressure Processing (HPP) is a method of food processing where food is subjected to elevated pressures (up to 600 MPa), with or without the addition of heat, to achieve microbial inactivation or to alter the food attributes in order to achieve consumer-desired qualities. Pressure inactivates most vegetative bacteria at pressures above 414 MPa. HPP retains food quality, maintains natural freshness, and extends microbiological shelf life. The process is also known as high hydrostatic pressure processing (HHP) and ultra high-pressure processing (UHP) (Rastogi *et al.*, 2007). High pressure processing causes minimal changes in the 'fresh' characteristics of foods by eliminating thermal degradation. Compared to thermal processing, HPP results in foods with fresher taste, better appearance, texture and nutrition. High pressure processing can be conducted at ambient or refrigerated temperatures, thereby, eliminating thermally induced cooked off-flavors. The technology is especially beneficial for heat-sensitive products.

Most processed foods today are heat treated to kill bacteria, which often diminishes product quality. High pressure processing provides an alternative means of killing bacteria without a loss of sensory quality and nutrients. In a typical HPP process, the product is packaged in a flexible container (usually a pouch or plastic bottle) and is loaded into a high pressure chamber filled with a pressure-transmitting (hydraulic) fluid. The hydraulic fluid in the chamber is pressurized with a pump, and this pressure

is transmitted through the package into the food itself. Pressure is applied for a specific time, usually 3 to 5 minutes. The processed product is then removed and stored or distributed in the conventional manner. Because the pressure is transmitted uniformly in all directions simultaneously, food retains its shape, even at extreme pressures. And because no heat is needed, the sensory characteristics of the food are retained without compromising microbial safety.

Like any other processing method, HPP cannot be universally applied to all types of foods. HPP can be used to process both liquid and solid foods. Foods with a high acid content are particularly good candidates for HPP technology. At present, HPP is being used in the United States, Europe, and Japan on a select variety of high-value foods. Some products that are commercially produced using HPP are cooked ready-to-eat meats, avocado products (guacamole), apple sauce, orange juice and oysters. HPP cannot yet be used to make shelf-stable versions of low-acid products such as vegetables, milk, or soups because of the inability of this process to destroy spores without added heat. However, it can be used to extend the refrigerated shelf life of these products and to eliminate the risk of various food-borne pathogens such as *Escherichia coli*, *Salmonella* and *Listeria*. Another limitation is that the food must contain water and not have internal air pockets.

Application of HPP for fish preservation

The main benefits of HPP include inactivation of contaminant microorganisms, texturization of proteins, shucking of oysters and improved freezing and thawing operations. At high pressure, the refrigerated storage life of Atlantic cod was greatly extended. Studies showed that after 30 days fish held in non frozen state at -3°C and 238 atmospheres were not significantly different from frozen controls held at atmospheric pressure at -25°C . It is widely accepted that conformational changes of protein by high pressure takes place which may be the reason for extension of shelf life. In many *surimi* based fish products, gelling is an important function and fish muscle protein paste forms a gel upon application of high hydrostatic pressure (Ohshima *et al.*, 1993). So the application of high pressure helps to formulate a number of products with good functional properties. Carp could be preserved at -8 or -15°C under 170 MPa for 50 days without significant changes in texture. Shelf life of prawns can be extended up to 28 and 35 days in samples treated with 200 and 400 MPa respectively as compared to 7 days for air stored samples (Lopez-Caballero *et al.*, 2000). Tilapia fillets subjected to 50-300

MPa for 12 hours had a high freshness index as compared to control (Ko and Hsu, 2001). The total plate count of fillets decreased from 4.7 to 2.0 log cfu.g⁻¹ for the fillets stored at 200 MPa. High pressure induced blue whiting gels were having lower adhesiveness, higher water-holding capacity, and less yellowness than heat-induced gels. Combination of pressure and temperature produced more elastic gels, whereas gels made under high pressure at chilling temperature were much harder, more deformable, and more cohesive. Cod (*Gadus morhua*) treated with 400 MPa decreased the oxidative stability of lipids due to the release of metal ions from complexes (Angsupanich and Ledward, 1998). Myosin was denatured at 100-200 MPa whereas actin and most sarcoplasmic proteins were denatured at 300 MPa. Several proteinases survived treatment at 800 MPa, although the activity of neutral proteinases decreased at a pressure higher than 200 MPa. The texture of pressure-treated fish differed from that of both raw and cooked fish, being harder, chewier, and gummier than the cooked product. Oysters treated with 100 and 800 MPa for 10 min at 20°C revealed the treatment killed various pathogens that are commonly found in oysters. Protein and ash contents decreased with increasing treatment pressure, while moisture content increased. Oyster muscles get detached from the shells, resulting in shucking, but the recovered tissue has good shape and is more voluminous and juicy than that of untreated oysters. The pH increased following high pressure treatment.

Pulse light preservation

Pulse light technology is an emerging non thermal processing method and involves exposure of foods to short duration pulses of intense broad spectrum light. It involves the use of intense and short duration pulses of broad-spectrum "white light", where each pulse or flash of light lasts a fraction of a second and the intensity of each flash is approximately 20,000 times the intensity of sunlight at sea level. The spectrum of light includes wavelengths in the ultraviolet to the near infrared region. Usually a wavelength distribution having 70% of the electromagnetic energy within the range of 170-2600 nm is used. These high intensity flashes of light pulsed several times in a second can inactivate microorganisms on food surfaces with remarkable rapidity and effectiveness (Moraru *et al.*, 2007; Uesugi and Moraru, 2009). The technology can also be used to sterilize packaging material too. The material to be treated is exposed to at least one pulse light having an energy density in the range of 0.01-50 J.cm⁻² at the surface. The effectiveness of light pulse treatment depends on several factors such as intensity, treatment time, food temperature and

type of microorganisms. Light pulses have the ability to inactivate enzymes in food as well. However at present, industrial implementation of light pulse technology for food has been rather slow, despite its potential to produce safe, nutritious and high quality foods. Studies conducted at McGill University, Canada show promise for pulsed light treatment for cold smoked vacuum packaged salmon to control *Listeria monocytogenes* and *Clostridium botulinum* A and E.

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Developments in Fish Processing Technology

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