

Recent Trends In Post-Harvest Technology of Fish and Fishery Products

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Abstract : This paper presents brief information on current trends in fish production, fish consumption, export of marine products from India, development of value added products and advancement of latest technologies in seafood production. The changing scenario in packaging techniques to increase efficiency in handling and transportation, consumer appeal and product protection has been discussed under different headings. The paper also describes the various value added products such as surimi, battered and breaded products, fibreized products, emulsion products, moulded products that have emerged during recent times in the world fish market to satisfy the changing needs of the consumer. Also live fish transportation has attained importance in recent times in the world fish market to satisfy the changing needs of the consumer. The spectacular achievements recorded in the country on the utilization of fish wastes for the production of valuable products such as chitin, chitosan, shark fin rays, fish maws etc. are evaluated. Various techniques used for reducing bacterial load, increasing shelf life such as irradiation, modified atmosphere packaging, etc. are discussed.

Introduction

Several health benefits have been associated with the consumption of fish. It has now been well established that regular consumption of fish reduces cardiac problems and increases longevity. Therefore, the annual per capita consumption has recorded a global increase. At present, there is a wide gap between supply and demand and therefore, fish which was regarded as a cheap food item years ago has become a luxury in many parts of the world . Since there is a good demand for fish, the techniques for production, processing, product formulation, packaging, stroage and transportation have undergone significant changes in recent years.

Export of Marine Products

The export of marine products registered a spectacular growth over the past 20 years (Anon, 1995). Fig. 1 gives the quantity and value of marine products exported from India from 1990 onwards.

Currently, India is exporting over 55 commodities to the world market, the major commodities being frozen fin fish

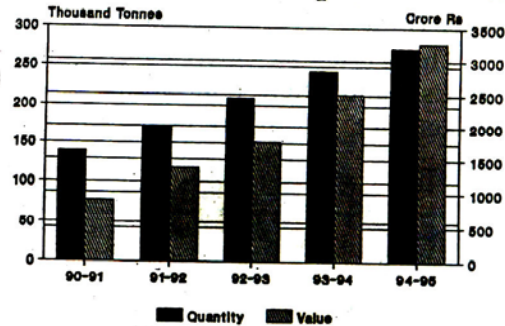


Fig. 1. Export of marine products in terms of quantity and value from 1990-91 to 1994-95 and frozen shrimp followed by frozen cephalopodes (Fig. 2). Though frozen fin fish is the major export item, nearly 67% of the value from aquatic products exports is realised from frozen shrimp (Fig. 3) (Pillai, 1994).

The major market for the marine products from India are Japan, Western Europe and U. S. A. Figs. 4 & 5 give the

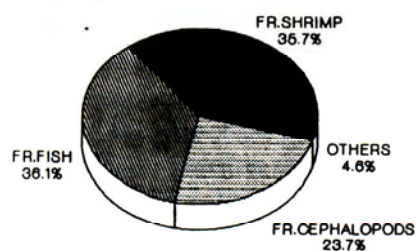


Fig.2. 1992-93 Export of marine products - category of products

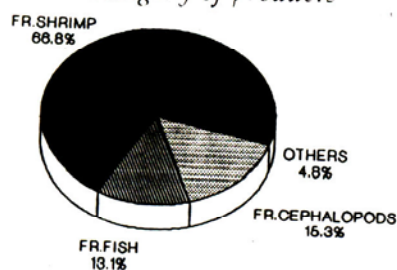


Fig.3. 1992-93 Earnings from exports of marine products

major markets for Indian marine products in terms of quantity and value respectively (Pillai, 1994).

There is an ever increasing demand for fish and shell fish in the global market. But, the future of the industry

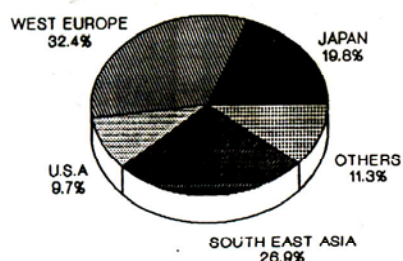


Fig.4. Major markets of marine products based on quantity

will depend on how best these demands can be met for which assured supply of raw materials of sufficient quantity and quality is the primary need.

Handling the catch

Handling of catch is getting high priority since this is the first as well as

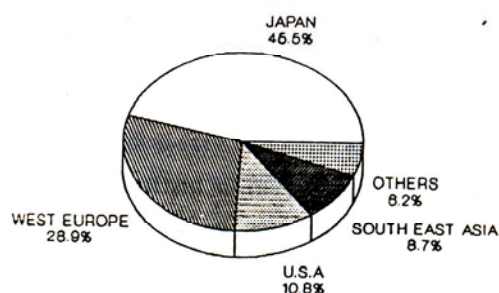


Fig.5. Major markets of Indian marine products based on value

the most important step in the production of a high quality finished product. The intrinsic and extrinsic qualities of fish vary considerably depending upon the location, species of fish, water quality and harvesting techniques. The main objective of any handling method is to preserve quality by bringing down the temperature of fish near to 0°C as quickly as possible. The factors such as delay in handling and chilling of the materials, poor temperature control in the fish hold, damage from rough handling, poor standards of gutting, bleeding and washing the fish and crushing due to overfilling of container have deleterious effect on the quality of fish, reduction in shelf life, and weight loss (Wheaton & Lawson, 1985).

In a developing country like India where most of the fishing vessels are small in size (8-12 m in length), many modern handling and chill storage practices cannot be incorporated onboard. To overcome the difficulties on ice storage, many different designs of ice boxes are available which may suit the requirements of a particular vessel. Boxes made with high density polythene and fibre glass and insulating with polyurethane foam are now available which substitute the second plywood boxes with or

without insulation. Insulated corrugated plastic containers are also convenient to use onboard.

In modern fishing vessels of length 20-30 m or more, the recent development has been to incorporate integrated handling systems on the shelter decks of boats with facilities for bleeding, gutting, washing, grading and transferring to stacking systems. Highly sophisticated factory vessels have been equipped with facilities to produce high quality frozen products in different forms and packs. There are modern factory vessels with sophisticated processing equipments for different operations and the entire process operations are monitored onboard using computers.

Live Fish Transportation

Live fish transportation is a recent development in the fisheries sector. The idea is to take the fish to the end user in the live condition. Mainly three different systems are in vogue viz. the waterless method, tank method and plastic bag method. In waterless method the fishes are kept in a cooled and chilled environment while in the tank system the material is transported in tanks of water and in plastic bag method fish, water and oxygen are sealed in plastic containers. Many condition such as temperature, salinity of the medium used, method of packing etc. affect mortality during transportation. There is considerable demand for live lobsters and crabs both in the domestic and export sector, but the technology is yet to be perfected on a commercial basis (Rao, 1993). Bulk water transport of live fish is carried out in live boats fitted with closed or open circulating pumps and aeration facilities and filters to reduce contamination (Berka, 1986).

Precautions to be taken in the live transportation of fish are:

- i) Maintenance of good water quality
- ii) Less travelling time
- iii) Fish should be held in quarantine for one or two weeks before shipped to ensure that they are disease free
- iv) They should be stressed as little as possible
- v) To be handled with care to avoid crushing
- vi) Fish should be protected from rapid changes in temperature
- vii) Natural environmental conditions to be maintained
- viii) Stocking density to be optimum
- ix) Replenishment of air with oxygen and reduction in accumulation of toxic wastes and controlling acidity or water medium with suitable buffers

Recent Trends in Processing Techniques

Freezing Techniques

Freezing techniques have undergone considerable changes in recent years. The traditional air blast freezers having long conveyor belts have given way to the spiral freezers. The spiral freezers can save both space and time, thus making the freezing operations much easier. Fluidized bed freezers are used for freezing small and uniform sized materials. The material can be frozen in fluidized bed freezers in a short period and the weight loss is also reduced considerably.

The plate freezer has undergone changes in terms of operation and time taken to freeze the material. For freezing packaged materials in flat cartons, semi automatic and automatic plate freezers are now available in the market. The freezing time also has been

reduced from 3 hours to one hour. Though cryogenic freezers like liquid nitrogen freezer or liquid CO₂ freezer which freeze the material in a very short period are available such freezers are not used in large scale for freezing marine products. Though the equipment is simple and cheap, the operation cost is very high which offset the advantage of low initial investment (Garthwaite, 1992; Fennema, 1973). A recent development in the freezing system is the advent of a combination freezing system of cryogenic freezing and air blast freezing. This equipment enables fast and efficient crust freezing of wet or sensitive products using a cryogenic system. These products are then handled in a spiral belt freezer or fluidized bed freezer without deformation (Eek, 1990).

Modified Atmosphere Packaging (MAP)

In MAP, the fish/fish products are packed in an atmosphere of carbon dioxide and other gases like oxygen and nitrogen. Packaging materials generally employed for this purpose are flexible films of Nylon/Surlyn laminates, plastic moulded trays sealed with PVC-LDPE laminate, polyester/low density polythene film at the top. The composition of the gas mixture will vary depending upon whether the fish is lean or oily. MAP chilled fish is an attractive proposition both to the retailer and to the consumer. The MAP chilled fish has an extended shelf life of 30% or more depending on the species (Bhattacharyya, 1993). The shelf life of seafood under current icing and refrigerated storage conditions ranges from 2 to 14 days depending on the species, harvest location and season. Elevated carbon dioxide levels in MAP has been shown to inhibit the normal

spoilage flora of seafood and double or triple shelf life. 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. For MAP 40 to 60% carbon dioxide are used most often (Gopalet *al.*, 1986). Minimum amount of oxygen tension is necessary to prevent the growth of *Clostridium botulinum*. For each variety of fish, gas concentrations have to be standardised to prevent the toxin formation. MAP is relatively expensive, currently about twice the cost of vacuum packaging. The advantages are extended shelf life, active inhibition of bacteria, reduced economic losses and better quality material.

Canning

Tremendous developments have taken place in canning industry especially in the design and development of containers, retorting equipments and nature and type of the products. Some of the containers of recent origin are retortable pouches, rigid plastic containers, aluminium cans, drawn walled and ironed (DWI) cans and drawn and redrawn cans from tin plates, easy open pull table aluminium cans, etc. (Balachandran, 1993). Heat processing of pouches and heat sealed plastic containers are carried out in over-head pressure autoclave. Many different types of retorts are now available. Some of these recently developed retorts are continuous processing retorts, hydrostatic retorts, high temperature short time processing equipments such as seriflame continuous cooker and microwave canning equipments. Product formulation, packing and use of newer filling mediums have also undergone changes to

suit the requirements of the consumer (Horner, 1992; Anon, 1968).

Irradiation

Use of irradiation as a low temperature sterilizing or pasteurizing technique has received interest since many countries have accepted foods receiving atleast limited levels of irradiation as wholesome. The extension of shelf life by irradiation in fish products is effected by destruction of micro-organisms. Irradiation sterilisation has not been widely accepted, but combinations of irradiation with other techniques have been shown to be effective. A synergistic effect has been reported for the combined use of irradiation and heat, to sterilize foods. The technology of food irradiation is simple, effective and well established. The restriction on its large scale application is mainly the consumer resistance (Feenstra & Scholten, 1991).

Cured and Dried Products

The technology of curing and drying has not undergone considerable changes though the products quality has improved substantially (Waterman, 1976). Since the consumers have become more and more aware of quality, the producers are forced to improve the drying/curing conditions so as to produce good quality cured products. Selected chemicals are used to prevent oxidation and rancidity and to reduce bacterial and fungal growth. Natural and synthetic antioxidants, propionates, benzoates are some of these chemicals. Maintenance of quality of raw material is very important to obtain a high quality finished products. The practice of spreading material on the sea shore is now being discouraged since it can yield only poor quality dried material. Raised platforms and rack drying systems are advocated for

quality upgradation of dried products. Many mechanical type of driers with high efficiency such as tunnel drier, heat pump drier, etc. are available. In heat pump drier, a refrigeration system is used for dehumidising air by chilling it and condenser heat is used for heating the dehumidised air. Both temperature and humidity can be controlled in this system depending on the type of products and the quality required. Good quality packaging material with low water vapour transmission and oxygen transmission are used to pack the dried products to reduce oxidative changes, spoilage and insect infestation.

Pickle Cure

In pickle curing fish is treated with dry salt in water tight containers and the self brine is retained. The fish is typically dry salted in barrels, the proportion of salt varying from 15 to 36% in different cures. Fish pickled in this way can be kept for more than a year at European ambient temperature.

Marinades

Marinades are made by preserving fish and shellfish in a mixture of acetic acid and salt. Marinades includes cold marinades, cooked marinades and fried marinades. Some of the marinated products are Ceviche of South America, Escabeche and Paksiw of Phillipines.

Fermented fish products

Many of the processes used in fish preservation are designed to keep the flesh as near possible to its original condition. Fermentation however involves the breakdown of wet protein to simpler substances which are themselves stable at normal temperatures. Fermented products imparts a particular flavour as well as preserve the product. Breakdown is

sometimes effected by enzymes present in fish (autolysis), micro-organisms may also be involved. Many fermented products such as fish sause and fish paste are popular in South East Asia (Adams *et al.*, 1985).

Smoking fish

Smoke curing as a method of food preservation has become less important in many developed countries because of rapid advance in freezing and cold storage techniques. Most smoked products in countries with a developed cold chain are now only lightly cured in order to give them a mild smokey flavour. When stored at normal temperatures they will not remain in a wholesome condition for much longer than fresh fish. So they should be refrigerated during storage. In most tropical developing countries, however, smoking is used not only to impart desirable flavours but also, and more importantly, to accelerate the drying process. Most products in tropical countries are hot smoked.

Traditional kilns used for smoking fish consists of a pit dug in the ground, a fire is lit in the pit and the fish are laid on racks over the fire. Improved traditional type kilns include the Altona ovens and Chorkor oven developed in West Africa (Anon, 1970). Recent development includes the use of Nygesi kiln developed by NRI, London (Rogers *et al* 1991).

Value Added Products

The world seafood processing scenario is undergoing rapid change. Conventional products are slowly disappearing from the market followed by their emergency in new styles. Value addition and diversification to match the changing style of the urban population is the need of the day. There is great

demand for seafood products "in ready to eat forms. A number of such products have already invaded the western markets. One factor responsible for such a situation is the increase in women education and their employment in offices and factories. Reasonably good income in the family, good educational standards and grater awareness and consciousness towards hygiene and health are some of the other reasons for this changed situation. The envious position of India as a major contributor of marine products to the global markets is likely to be substituted unless we come forward with a wide range of value-added products to cater to the world market.

A number of value added marine products both for export and domestic markets based on shrimp, lobster, squid, cuttlefish, bivalves, certain species of fish and minced meat have been identified. The technology for the production of most of these products are readily available.

Battered and Breaded Products

Battered and breaded marine products are one of the most important class of value added foods very much relished by the consumers as a convenience food. The process of coating with batter and bread crumbs increases the bulk of the product and thereby reduce the cost element. In such coated products, 50% fish portion is expected as a convention. Fish fingers, fish portions, fish cakes, etc. are the staple breaded seafood products, while breaded shrimp, lobster, oyster, scallops, etc. cater to a luxury market and are widely used in restaurant trade. The production of battered and breaded products involves several stages and the method varies with the type of product.

In most cases, the following steps are involved.

1. Portioning/Forming
2. Predusting
3. Battering
4. Breading
5. Prefrying
6. Freezing
7. Packaging and cold storage

The pick up of coating can be increased either by adjusting the viscosity of batter or by repeating the process of battering and breading (Sunderman and Cunningham, 1983).

Individual Quick Frozen Products

IOF marine products fetch better price than conventional block frozen materials in the western markets. For the production of IQF products, high quality raw material should be used and the processing is done under strict hygienic conditions. The products are to be packed in attractive moisture-proof packagings and stored at -30° or below without fluctuation in storage temperature. Thermoform moulded trays have now become an accepted packaging container for IQF products. The rise in temperature during storage and transportation should be avoided, as the rise in product temperature may cause surface melting and the individual pieces will stick together forming lumps. Dessication of the product leading to weight loss and surface dehydration are serious problems during storage of IQF products. (Gopal, 1995) A number of factories are engaged in the processing of IQF seafood products.

New Products/Technologies

There are several technologies which are presently in the early stages of commercial development. These tech-

nologies reduce post-harvest losses by utilizing the available fish more completely. Production of minced fish, modified atmosphere storage, heat pasteurization, microwave heating, gas exchange sterilization are some of the new technologies.

Minced Fish

Meat bone separators produce new raw material by separating the flesh from dressed fish or filletting waste by forcing them through the very fine holes of the meat bone separator. The flesh is made into very fine particles and the original texture of the fish flesh is completely changed. This destruction of original texture results in the development of new products. Processing techniques are available by which various products of different texture, aroma and taste can be produced. These products are more easily marketable than fresh fish.

Reformed Fish Products

Fundamental studies on the nature of fish proteins from different species resulted in the development of reformed products from fish mince and surimi. Such products have several advantage. For the producer, there is benefit of better utilization of low-cost white-fleshed fish. The production of re-formed products such as fish burgers, kamaboko, fish cutlets, etc. upgrade the textural and aesthetic quality.

Moulded products are another examples of reformed products. The paste from surimi and other ingredients is moulded into the desired shape and heated to set. Extrusion is the usual procedure and if multi-opening nozzle is employed a meat like texture can be achieved (Fretheim, 1988).

Fibreized Products

Fibreized products such as simulated shell fish products have stimulated lot of interest in recent years. The ingredients to form simulated shell fish products include surimi, water, salt, starch, shell fish meat and flavour enhancers. These are made into a paste in a silent cutter. The paste is extruded as a thin sheet and is heat treated using gas and steam to achieve partial setting. Subsequent to cooling a strip cutter subdivides the sheet into strings which pass through a rope former. The 'rope' is coloured and suitably cut i.e. straight in the case of imitation crab legs and obliquely to get "chunk" type products.

Composite-moulded Products

Composite-moulded products are prepared by cutting strings into suitable lengths. These strings are mixed with surimi paste and extruded and the product gives a better bite.

Emulsion type Products

If surimi is mixed with fat (<10%) and other ingredients and processed stable emulsions are obtained. By stuffing into casings and cooking a variety of products can be made. The Japanese market has received emulsion type products well. Emulsion type products are well accepted in the Japanese market.

Dried products

Flaked dry crab legs are thinly cut and require no soaking before eating. Another snack-type product is cheese sandwiched between layers of dried kamaboko.

Food Preservation by Hurdle Technology

Hurdle technology deliberately combines existing and new preservation techniques to establish a series of preservative factors (hurdles) that the mi-

croorganisms in question are unable to overcome ("Jump over"). These hurdles may be temperature, water activity, acidity, redox potential, preservatives and others. Food preservation is in fact achieved by disturbing the homeostasis of microorganisms in foods and the best way to do this is to deliberately disturb several of the homeostasis mechanisms simultaneously. Examples of foods preserved by using this technology are fruit juices, heat processed cured meat products and modified atmosphere packed fish products.

Fishery By-products

Production of fish products leaves a large percentage of the tissue as by-product. This, along with many trash fishes caught unintentionally can be processed into useful by-products. Some of the important by-products obtained from fish waste and trash fish are minced fish, surimi, fish protein concentrate, fish meal, fish oil, squalene from shark, fish protein hydrolysate, caviar, fish sauce, fish silage, gelatine, glue, leather from fish skin, chitin, chitosan, pearl essence, shark fin, shark fin rays and fish maws (Okerman, 1992). Minced fish is used for the production of a large number of fishery products like reformed products, extruded products, battered and breaded products, etc. Fish meal has been used for many years as a livestock feed because of its high nutritional value. Fish roe from different species of fish can be processed by a special process called maturation and salting and the resultant products is known as caviar (Okerman, 1991). Fish liver oil with its high vitamin A and D levels has been used to prevent night blindness and rickets. Fish skin and bones can be extracted for their gelatin content.

Fish gelatin does not have such good gelling properties as gelatin obtained from land animals. The air bladder is rich in collagen and is used to make isinglass. Good quality fish glue is made from fish skins. The skin from many aquatic species like shark, skate, seal, ray, etc. can be used for leather. Aquatic animal skin produces a flexible, fine-textured, smooth, durable, long wearing, non-scuffing patterned leather.

Most important by-products obtained from shell fish waste is chitin and chitosan. The preparation of chitosan from shells of crustaceans is accomplished by 1) De-mineralisation with dilute acids, 2) De-proteinisation with dil. alkali at moderate acids, 3) deacetylation with concentrated alkali at high temperature. The chitin/chitosan has many uses like wound healing, food-wrapping film, coagulants for flocculating suspensions, absorption for metal ions, photo-graphic products, ion-exchange membranes, chelating solids for chromatography, adhesives, etc.

Shark fin and shark fin rays are very costly commodities. An important product obtained from oils from certain species of shark is squalene which is used to produce costly cosmetics.

Quality Assurance

Quality assurance was the key word of our seafood industry from very inception and the Central Institute of Fisheries Technology, Cochin had a unique position in the quality assurance programme of the seafoods of the export trade for over 3 decades. In the beginning, the processors were free to export their goods without subjecting them to any statutory inspection. In the face of certain setbacks with respect to quality of products exported, Government of

India decided that all consignments exported should conform to certain predetermined standards of quality and enacted a comprehensive legislation entitled "Export (Quality Control and Inspection) Act 1963" which came into force from September 1964. In the initial years, the inspection of fishery products was confined to the end product inspection only. Later, with a view to make quality control and inspection more meaningful and effective it was felt imperative that in addition to carry out end product inspection, the processing factories should be encouraged to adopt Good Manufacturing Practices (GMP). Accordingly, our Government introduced the In-process quality control (IPQC) scheme. Under this scheme, factories having the stipulated infrastructure facilities and employing a qualified Technologist are empowered to inspect and certify their consignment for export.

Over a period of time, there has been considerable change in the concept of fish processing. The modern seafood processing industry is very much technologically advanced and complicated as any other food industry. Simultaneously, the perception of quality has also changed. In the efforts to satisfy the consumer there has been a constant search for suitable methods to assure the quality of seafoods. The global increase in the food borne outbreaks have been the important factors influencing this search. Such outbreaks are mainly caused by microorganisms that gain entry to the product at different stages of handling and where measures taken are not adequate to eliminate them. Further, several ingredients are added to the food material such as additives, colouring agents, emulsifiers, antioxidants, pre-

servatives etc. There are also chances of pesticide residues, toxic metals, mycotoxins, biotoxins, chemicals and antibiotic residues. Under these circumstances, the responsibility of the processor has become increasingly complex and difficult to produce safe and wholesome products. There is a global shift from food standards to food safety. The world is now moving towards the HACCP concept, a preventive strategy to combat food safety problems and above all, a commitment of the management for the production and distribution of safe products. The HACCP based quality system involves the following steps.

1. Systematic Hazards Analysis
 - Identification of hazard
 - Assessment of severity of the hazard.
2. Determination of Critical Control Points (CCP)
 - CCP. 1. which will assure control of hazard
 - CCP. 2. which will minimize a hazard
3. Determination of preventive measures
4. Establishment of monitoring procedures

- Visual inspection
- Sensory evaluation
- Physical/chemical/bacteriological aspects
- Quatitative aspects and recording

5. Establishemnt of critical limits and corrective actions
6. Document of actions and results
7. Establishment of verification procedures

USA, Canada and a few other Countries have already adopted the HACCP concept for their seafood industry. Very shortly, USFDA is going to make it mandatory to implement HACCP in the seafood industry for export. With a view to harmonise the various Quality Managemnt Systems the International Standards Orgnization has developed a set of standards called the ISO 9000 series. The HACCP concept can become a part of these standards. Hence the need of the hour is to further elevate the standard of our seafood industry to the level of these global requirements.

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