An Overview of Fish Processing Technologies Developed at Visakhapatnam Research Centre of Central Institute of Fisheries Technology

R. Chakrabarti, Sib Sankar Gupta, D. Imam Khasim[1], S. Basu[2], M.M. Prasad[3] and C.C. Panduranga Rao[4]

Research Centre of Central Institute of Fisheries Technology
Ocean View Layout, Pandurangapuram, Visakhapatnam-530 003
Andhra Pradesh, India
E-mail: cift.vsp@itpvis.ap.nic.in

The Visakhapatnam Research Centre (formerly Kakinada Research Centre) of Central Institute of Fisheries Technology (CIFT) is engaged in the development of different preservation and processing methods to maximize utilization of fish and minimize post-harvest losses. Edible varieties of fish from different water bodies in Andhra Pradesh were analyzed for proximate composition and nutritional elements. Technologies were developed for live fish transportation with and without using anaesthesia, and insulated dismantleable container for iced fish transportation. A simple method was developed to preserve fresh fish muscle pieces and mince at tropical ambient temperature using preservative mixture. Different treatment schedules prior to icing and freezing, were standardized to control black spot in shrimps, improve texture, control drip loss and increase shelf life. The efficiency of the use of modified atmosphere storage at 6-7°C and the use of domestic refrigerator in storing fish chunks was studied. The benefits of drying on raised platform and in solar drier were studied in detail. Monitoring of insect infestation, fungal growth and red halophiles and histamine formation in salted and dried fish and their control was initiated with encouraging results. The presence of carcinogen benzo(a)pyrene in traditional smoked products and the improvement of traditional products by using improved smoking kiln were studied in detail. Various new products such as clam sausages, crab flakes, fish cake, convenience products, bitter less fish hydrolysate, water-stable shrimp feed and fish powder with emulsification capacity, were prepared from under-utilized fishery resources. New technologies were developed for preparation of

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Present address :

[1]Research Centre of CIFT, Matsya Bhavan, Veraval - 362 269, Gujarat, India.
[2]Central Institute of Fisheries Education, Seven Bungalows, Versova, Mumbai - 400 061, India.
[3]Research Centre of CIFT, Burla - 768 017, Sambalpur Dist., Orissa, India.
[4]House No. 2-8-11, Venkatanagar, Kakinada - 533 033, Andhra Pradesh, India.

isinglass from air bladder, carotenoprotein from shrimp process waste and bactopeptone from tuna liver. The research centre also undertook studies on the nutritional evaluation and utilization of deep sea fishes.

Key words : Fish preservation, fish processing technology, nutritional evaluation, product development, packaging, fish transportation

Visakhapatnam Research Centre (formerly Kakinada Research Centre) of Central Institute of Fisheries Technology (CIFT) is situated on the east coast of India. The Research Centre is engaged in the development of different preservation and processing methods to control spoilage rate with minimum loss of nutritional values of fish, with a view to the better utilization of the fishery resources and thus support nutritional and food security of the people.

The natural defense mechanism of the fish prevents the ingress of microbes into the live fish tissues. The live fish tissues are healthy and sterile. In the tropical ambient temperature, spoilage of fish begins as soon as the fish dies. Spoilage is the result of a series of many complicated changes mainly due to enzymes and microbes. Preservation methods are those efforts to keep the fish in a fresh state so that the changes in its texture, taste and appearance are minimized. Processing methods usually change the texture, taste and physical appearance of the fish so that deterioration is slowest or halted.

Proximate composition

Edible varieties of fish from different water bodies in Andhra Pradesh were analysed for proximate composition and nutritional elements such as calcium, phosphorous, sodium, potassium and iron. In general, the protein in fish muscle varied from 16 to 20 %, fat 0.5 to 4.0% and moisture 68 to 82%. The composition of fish varies with numerous factors namely seasons, physiological state and environment. The deep sea fish such as black ruff and bullseye, which are yet to be popular, contain nutritional components same as that of commercially important fish. High fat content (more than 4%) was reported in carangids, black ruff, ribbonfish and silver bellies. High protein content (more than 20%) was reported in drift fish, unicorn file fish and gold band goat fish.

Fish transportation

Live fish transportation

Live fish transportation is a major activity in Andhra Pradesh for sending fish to distant markets, especially to Calcutta. The major three varieties of fishes

are *Anabas testudineus*, *Clarius batrachus* and *Heteropneustes fossilis*. High mortality rate and physical damage to body is common during transportation, particularly during summer. It has been found that the live *Clarius batrachus*, a commercially important species, could survive at the level of 89% and above in aqueous 50 ppm tricaine methane sulfonate (MS222) solution (fish-solution ratio, 1:3) for six days with minimum skin injury (Chakrabarti *et al.*, 1998). Blood cockle (*Anadara granosa*) has a wide distribution along Kakinada coast. Its commercial value as an export item is being explored. 1.5 to 2% salinity was sufficient for survival of live cockle. Change in composition in each component in cockle during depuration was also studied. By removal of mantles and gills from steamed whole meat, acid insoluble ash content of meat could be reduced considerably. Moreover, pepsin digestibility could be increased to 87.8%. Effect of chlorination during depuration was minimal (Chakrabarti and Khasim, 1989).

Iced fish transportation

A double layer dismantleable container for fish transportation has been designed and fabricated using 22 gauge galvanized iron sheet with 25 mm thick expanded polystyrene slabs sandwich as the insulating material between the two layers. The container body consists six pieces, assembled together with bolts and nuts. In case of damage to one piece during transit, only that particular piece need to be replaced. For return to the packing centre, the container can be dismantled, as a result of which the volume gets reduced to 42% of the original. Dismantleable insulated galvanised iron containers were deployed for transportation trials of fresh iced, chilled iced and frozen fish from Kakinada to Howrah. In all the experiments, the container performed exceedingly well and the fish remained in very good condition (Govindan and Gupta, 1978 ; Govindan *et al.*, 1978). Marine, brackishwater and freshwater fishes could be successfully transported in fresh as well as frozen condition by rail in thermocole insulated tea chest from Kakinada to Calcutta. Fillets from seerfishes and eels packed with ice in thermocole insulated plywood boxes, transported from Kakinada to Howrah by rail, reached the destination in fair to good condition (Rao *et al.*, 1979). Traditional bamboo basket and expanded polystyrene insulated plywood box (second-hand tea chest) were compared for transportation of iced marine, freshwater and brackishwater fishes, from Kakinada to Madras, by rail. Traditional bamboo basket apart from being cheaper, was found to be as good as expanded polystyrene insulated plywood box for short distance transportation of iced fish involving less than 24 h journey (Rao *et al.*, 1978).

Preservation at ambient temperature

Most of the bycatch of shrimp trawlers are brought to landing centres un-iced. Shortage of ice is experienced in many remote landing centres. During lengthy handling and transportation at tropical ambient temperature, there is good scope for the accumulation of spoilage bacteria and histamine in fish. Rapid formation of histamine in scombroid fishes such as mackerel, seerfish and tuna, was reported and this group of fishes is widely known for scombroid poisoning. High amount of histamine formation was also reported in non-scombroid group of fishes such as drift fish, scad, sardine and anchovies. In general, fish were acceptable upto 4-8 h at tropical ambient temperature. It was found that the histamine level, in all scombroid and non-scombroid fish in acceptable condition, was below 20 mg% at tropical ambient temperature (Chakrabarti, 1998).

Non-availability of ice and refrigeration facilities in many remote landing centres in India cause difficulty in short-term preservation of fresh fish especially during heavy landings. A simple method was developed to preserve fresh fish muscle pieces and mince. Fresh fish muscle pieces and mince from low priced fish such as sciaenids were preserved for 72 and 48 h, respectively, at ambient temperature (34± 5°C) in media containing 8% sodium chloride, 0.25 % sodium benzoate and 0.5% potassium sorbate. Incorporation of 0.1 % sodium bisulphite in this media slightly improved the texture and flavour of minced fish (Chakrabarti,1988).

Preservation at low temperature

Icing

Studies on the iced storage of different species from freshwater, brackish water and marine fishes were carried out. Storage life of fish in ice varied between 7-14 days, depending on the size, shape and biochemical composition of the fish.

Phenoloxidase activity was maximum in cephalothorax extract among the extracts of body parts in case of *Penaeus monodon* and *Metapenaeus monoceros*, but was maximum in shell (including tail) of *Penaeus indicus*. Phenoloxidase activity in extract from shell of *Penaeus indicus* and *Metapenaeus monoceros* declined sharply after 2 h of storage at ambient temperature (30±5°C), while the activity remained high up to 6 h in *Penaeus monodon* and then decreased slowly. Sulphite required was almost double the molar strength of metabisulphite to get the same inhibiting effect. Phenoloxidase in extract from *Penaeus indicus* was most sensitive to sulphiting agent. Per cent inhibition to phenoloxidase in shell of shrimps was considerably more when dipped in headless form than in whole shrimp (Chakrabarti,1993).

Black discoloration on raw shrimp can cause major marketing problems. It was found that a dip in 0.3% metabisulphite solution for 30 seconds was sufficient to control black spot in *Penaeus monodon* and *Penaeus indicus* during iced storage for 5 days, whereas a dip in 0.4% metabisulphite for 30 seconds, prevented black spot in *Metapenaeus monoceros* for 5 days iced storage. Residual sulphur dioxide in all the cases was below 30 ppm (Chakrabarti *et al.*,1992).

Treatment with sodium tri-polyphosphate (STPP) prior to iced storage decreased the bacterial load in *Labeo rohita* considerably when compared to the untreated sample (CIFT, 2003). Fishes dipped in hot water (90°C; 15 ppm chlorine, 5 sec.) and then in chilled water (8-10°C) were acceptable up to 14 days while untreated samples in ice were acceptable for 10 days (CIFT, 1980). The cold shock effect on live *Clarius batrachus* and *Labeo rohita* were found to occur in 30 min and 60 min, respectively in ice-water slurry. The dead fish remained very rigid for 18-23 h in ice. The same fish became rigid in 2-3 h at ambient temperature (30±1°C) and remained rigid for 4 h at the same temperature. This phenomenon was observed in tropical brackishwater fish such as *Chanos chanos* (CIFT, 1994).

Storage at modified atmosphere (6-7°C)

Small mullets stored at 6-7°C in gas mixture containing different proportion of CO_2 and air was observed and it was found that 80% of CO_2 and 20% of air give three days more shelf life than control samples with shelf life of 7 days in normal atmosphere (Basu *et al.*, 1991).

Treatment prior to freezing and frozen storage

To prevent the incidence of belly bursting in a rainbow sardine, the fish was dipped in 10% brine for one hour, then frozen and kept -18°C. The fish was acceptable even after 8 months (CIFT, 1991). After removing viscera and gills, fresh *Labeo rohita* was treated in sodium tri-polyphosphate, individually frozen in brine immersion freezer and then stored at -18°C. The treated fish was acceptable for 19 months with better quality in all aspects than control samples (CIFT, 1995). Brown head discoloration and black spot formation in the head on *Penaeus monodon* samples treated with sodium metabisulphite (0.5%; 120 sec) was compared to the untreated sample. The treated shrimp samples were acceptable even after 16 months of frozen storage with less loss of glossy appearance when compared to the untreated samples (CIFT, 1993). A dip in 0.5% sodium metabisulphite (100% purity) for 30 sec controlled black spot in frozen brown shrimp (*Metapenaeus monoceros*) upto 10 months at –18°C (Chakrabarti and Gupta, 1998).

Individually quick frozen products

A study of individually quick frozen (IQF) (spiral freezing unit, -35°C) and block frozen (-40°C) shrimps showed that quality of the IQF samples frozen in spiral freezer is no way better than the block frozen samples after 22 weeks storage (-18°C).

Freshwater fish utilization

The presence of bones is an issue in effective utilization of freshwater carps, especially for the export market. With a view to remove the bones from the fish fillets, one block of specific needles was fabricated and the bones were removed using the block manually with little damage to the tissue of the fillet. An overall decrease of around 10% was observed in the weight of the fillet after the bones were removed (Khasim, 2002).

Storage in domestic refrigerator (-8 to -10°C)

Fish chunks of rohu, catla and mrigal wrapped in polythene film were stored at -8 to -10°C in freezer cabinet of the domestic refrigerator. The fish chunks were acceptable upto 33-35 days (Chakrabarti,1984).

Improvement in the quality of traditionally dried fish

Improved method of drying

Drying of fish is performed traditionally by spreading them on bare ground at landing places or open decks of fishing boats, under unhygienic conditions. The quality of dried fish could be vastly improved by drying on raised structures of palmyra leaf mats, stretched nets and cemented platforms. Performance of solar tent drier was studied and compared with conventional drying on cement platform. The temperature inside the tent was 7-20°C higher than the ambient temperature. In most of the trials, drying was slightly quicker in tent drier, compared to the conventional method. Chemical and bacteriological evaluation revealed that there was no appreciable difference between the fish dried on the cement platform and those dried in the tent drier. However, tent drier is very useful to produce hygienically sound dry fish. It protects fish from preying birds and animals and wind-borne dust. It protects the product from contamination with sand and drastically reduces insect infestation. The split bamboo mesh on which fishes are placed for drying was located at a height of one meter from the ground (Rao *et al.*, 1989).

Control of insect infestation

Dry fish is susceptible to blow fly infestation. The blow fly infestation does not occur if the moisture content of cured fish is low. This critical moisture content depends on salt content of the cured fish. The relation between salt content and moisture content to get non-infested fish was found to be salt (%) ≥ 0.335 (moisture %) (Basu *et al.*, 1992).

Sun dried small anchovies without any treatment and samples with citronella oil treatment were stored in polythene bags at room temperature. After six months, the control samples were infected with small dark brown insects whereas there was no insect infestation even after eight months in the treated samples (CIFT, 2002). Different types of cured and dried fishes were treated with STPP and neem cake as well as STPP and neem oil. The samples, both treated as well as control, were free of insect infestation even after 8 months storage when packed in double layer polythene (200 gauge) or in HDPE woven bags. But rancidity and brown discolouration developed earlier in the control samples when compared to the treated samples (CIFT, 1994). The treatment of cured and dried fish samples with a mixture of STPP, sodium benzoate and citronella oil was found to be effective in controlling the four major spoilage problems, namely insect infestation, red halophilic bacterial attack, fungal growth and rancidity development. The treated samples of cured and dried ribbonfish packed in polythene bags were found to be in good condition without red halophiles and insect infestation and fungal growth even after 10 months storage at room temperature, whereas control samples (cured with salt) showed red halophilic bacterial attack after five months. The PV values were comparatively lower in the treated samples. The overall appearance and quality of the treated samples were superior to the control samples after 10 months storage (CIFT, 2002).

Control of fungal growth

The common halotolerant fungi isolated from salted and dried fish at Visakhapatnam coast were found to be *Aspergillus niger, Aspergillus flavus, Pencillium* sp. and *Mucor* sp. The inhibitory effect of a preservative to different species was not equal. *A. flavus,* and *Pencillium* sp. could not grow in medium containing 0.02% sodium benzoate; but *A. niger* could grow on the same medium. *Pencillium* sp. could not grow in medium containing 0.04% propionic acid; but *A. flavus, A. niger* and *Mucor* sp. grew slowly on the same medium. Propionic acid (0.06%) or potassium sorbate (0.02%) or sodium benzoate (0.04%) were adequate to inhibit all four halotolerant fungi isolated from salted and dried fish (Chakrabarti and Varma, 2000).

Control of red halophiles

Naturally contaminated salt contains red halophiles. The heating of salt at a temperature of 80° C for 30 min eliminates red halophilic cocci, which are mostly responsible for red discolouration in salt-cured fish. This heat treatment is inadequate to eliminate red halophilic rods (Prasad and Rao, 1994). The laboratory prepared dried fish treated with sodium benzoate and acid phosphate did not show any red discolouration upto five months (CIFT, 1987).

Control of histamine content

Traditionally sundried *Stolephorus* sp., *Psenes indicus* and *Decapterus* sp. frequently contain high levels of histamine in muscle. An attempt was made to reduce histamine level in their dried product by using suitable processing techniques. It was found that histamine was progressively lower from whole unsalted sun-dried fish, gutted unsalted sun-dried fish, whole salted sun-dried fish, to gutted salted sun-dried fish. Histamine formation in salted *Stolephorus* sp., even with gut was considerably less in comparison with other salted fish under study. The faster penetration of salt in the body of *Stolephorus* sp., due to their thin skin and less thickness may be responsible for arresting the growth of histamine forming bacteria in fish, quickly. Gutting and salting of *Psenes indicus* and *Decapterus* sp., before sun-drying are important steps to prepare dried products with safe level of histamine content (Chakrabarti, 1993).

Improvement in the quality of traditionally smoked products

Benzo (a) pyrene (3,4 benzopyrene), a carcinogenic polycyclic aromatic compound present in wood smoke, is considered to be an indicator of carcinogens in smoked products. During survey on the benzo (a) pyrene content in traditionally smoked shrimp and fish samples available at Kakinada coast, it was found that the level of benzo (a) pyrene in smoked mullet, *Gobioides* sp. and whole shrimp varied from 0.315 to 0.458, 0.431 to 0.550 and 0.316 to 1.192 ppm, respectively. Benzo (a) pyrene content in a few smoked whole shrimp samples was high due to lack of controlling system in traditional *jithaka* smoking kiln. The benzo (a) pyrene content in pre-cooked edible portion, i.e, tail part of traditionally smoked small shrimps, varied from 0.021 to 0.048 ppm. The losses of smoke aroma and benzo (a) pyrene content on storage at ambient conditions were noticed in all samples. Samples with low moisture content had longer storage life than those with high moisture content (Chakrabarti, 1995).

Improved smoking kiln

In coastal delta regions of Krishna and Godavari rivers in Andhra Pradesh small shrimps of mixed species are caught from estuaries. These are processed into smoked shrimps and this process is locally termed as *jithaka*. Traditional smoking is done on a table like structure in a portion of their thatched huts. In this process, there is no control of smoke or temperature around drying area and there are chances of fire hazards. An improved kiln was developed which provide facilities for controlling the smoke and fire. It was also found that the general appearance and flavour of smoked shrimps prepared in improved kiln were good. Shrimps smoked in improved kiln could be stored for more than 6 months in acceptable condition in polythene bags whereas the market samples became unacceptable just after four months (Khasim *et al.*, 1989).

Products from unused and under-utilised fish

Utilisation of blood clam

Blood cockle (*Anadara granosa*) forms a fishery of considerable magnitude in the Kakinada Bay where an estimated 2000 t are landed annually. In addition, culture technology for blood cockle has been standardized in India, throwing open the possibility of large scale farming of this species. Presently clam meat is burnt along with shell to produce lime. In order to enhance the utilization of blood cockle, technologies for icing, freezing and canning have been developed. A pickled product and sausage are the other products developed at the research centre (Rao *et al.*, 1990).

Crab flakes from small crabs

It is extremely difficult to pick meat manually from small crabs and due to this problem, this resource is unutilized. A simple low cost method to separate meat from small crabs and preserve the meat with intermediate moisture and good flavour, has been developed. The dense media (sp. gr. 1.22 - 1.24) containing sodium chloride, potassium sorbate and glycerol can clearly separate shell and meat from cooked and crushed small crabs. The pressed white fibrous crab meat (42 – 43% moisture) with good flavour has been found to be acceptable up to three months in ambient conditions (31±6°C ; RH 80±15%) (Chakrabarti, 1988; 1989).

Salted and pressed products

Psenes indicus and *Decapterus* sp. pose considerable difficulty in preservation and large quantities are being unhygienically cured and dried. These

products become unacceptable to human consumption within a short period due to discoloration and rancidity, due to their high fat content. The preparation of salted and pressed products for human consumption was standardized. It involved immersion of the dressed fish in saturated sodium chloride brine for seven days followed by pressing under pressure in a wooden box, packing in polythene bags and storage in ambient temperature. The salted and pressed *Psenes indicus* packed in 70μ nylon/surlyn bag under vacuum was acceptable for 120-135 days; the same fish when packed in 200 gauge polyethylene bag without vacuum was acceptable for 45-60 days at ambient temperature (Chakrabarti *et al.*, 1991). In case of *Decapterus* sp., the fish under same process could be stored well for one month in 200 gauge polythene bag. Addition of 0.1 and 0.2% propionic acid to the curing brine increased shelf life of the pressed product to 45 and 60 days, respectively, by preventing growth of red halophiles and mold (Gupta and Chakrabarti, 1994).

Ready-to-cook convenience products

Small fish were boiled in water/brine, drained, cooled and dried in the sun to a moisture level of 10%. Low cost ready-to-cook convenience products were developed from dried anchovies, silver bellies, *Pellona* sp., sciaenids, small dry shrimps, incorporating a mixture of spices (Khasim and Prasad, 1998).

Fish powder and wafer from small fish

Fish powder was also prepared from low priced fish by boiling beheaded and degutted fish in water for 10 min, followed by pressing and sun drying. The protein and fat content in the powder were 62 – 70 % and 2.9 – 3.2 %, respectively. This powder at 10% level was used in preparation of wafers incorporating rice powder and sago. The dried wafer remained in good condition even after four months of storage in ambient condition (Chakrabarti and Khasim, 1987).

Fish hydrolysate

Fish protein hydrolysates prepared by using papain and bromelain are bitter in taste and therefore, have limited use in food products. Ethyl alcohol was used to remove bitter peptides from enzyme hydrolysates. The solvent can be re-used after refining, followed by distillation. It was observed that increase in the concentration of alcohol causes an increase in the yield of less bitter fraction. The less bitter fraction contains more proteases and less of α-amino nitrogen than bitter fraction (Chakrabarti, 1983). The growth of micro-organisms in media

containing fish protein hydrolysate, bitter fraction separated from fish protein hydrolysate and bacteriological peptone of BDH, were compared. High correlation among the growth of microbes in different media was found (Chakrabarti, 1984).

Minced meat products from low priced fish

Intermediate moisture products

Raw minced meat was used to develop an intermediate moisture fish cake. Different humactants (glycerol, polyethylene glycol, etc.) single or in combination were screened to study their ability to reduce water activity. A mixture of humactants, a binding agent (starch) and an antimycotic agent (potassium sorbate) were used to develop a product with moisture content around 50% (dry basis) and water activity around 0.85. The product was found to be acceptable and could be stored at room temperature in polythene bags (200 gauge) for more than 3 months (Basu *et al.*, 1989). Sodium tri-polyphosphate, was found to reduce the water activity, act as bactericidal agent, improve the hydration of protein and resist thermal denaturation upto 45°C (Basu,1990).

Fish and clam sausage

Double refined groundnut oil, mutton tallow or hydrogenated vegetable oil either alone or in combination were used in samples. The melted tallow was mixed with groundnut oil 1:1 ratio. Beef and clam meat were separately minced. 30 ml melted tallow and 30 ml groundnut oil were mixed. 100 g minced meat from beef or clam and 60 ml of groundnut oil-tallow mixture or 60 ml melted hydrogenated vegetable oil or 60 ml groundnut oil were blended with additives (garlic 3 g, black pepper 2 g and salt 5 g) in an electric mixture for 10 min. The meat emulsions thus prepared were stuffed into sausage casing (salted, washed goat intestine) by a hand stuffer. The sausage was cooked for 30 min at 80° C, boiled at 100°C for 30 min and fried in deep fat. Acceptable sausages can be prepared with clam meat using 1:1 mixture of groundnut oil and tallow which compared well with beef sausage. This will pave the way for better utilization of clam meat (Basu *et al.*, 1989).

Surimi

Most of the bycatch are used for preparation of dried products and good percentage of these are used for poultry and fish feed preparation. With the fast growing demand for *surimi* and *surimi*-based products, large quantities of fish, particularly low priced fish, are being used for these products throughout the world. *Surimi*, an exportable value-added product, was prepared from low priced

fish such as sciaenids, cat fish and drift fish. The white *surimi* from different fish retained colour and texture at -18°C up to 5-6 months and the slow change in colour and texture was noticed in all stored samples (CIFT, 1993; 1995). Loss of suspended solids including protein and fat in wash and press water could be up to 35% of the total solids during the preparation of *surimi*. Attempt was made to prepare strong gel from unwashed mince of low priced fish available off Visakhapatnam coast. It was found that the mince from bullseye (*Priacanthus hamrur),* marine catfish (*Arius dussumieri),* horse mackerel (*Megalaspis cordyla*), lizard fish (*Saurida tumbil)* and barracuda (*Sphyraena jello),* formed good gel on steaming. The colour of the steamed cake from bullseye, lizard fish and barracuda was white; but it varied from light grey to grey in other species. The mince from the above species could be used for preparation of various steamed and cooked products (Chakrabarti and Gupta, 2000).

Fish powder

Fish powder from mince of low priced fishes such as silverbellies and sciaenids, were prepared by extracting fat using ethyl alcohol and chloroform (5:1) followed by boiling in water and then drying at 50-55°C. The yield is 18-22%. The protein content is 85-90%, but the fat content is negligible. The product with high emulsification capacity has shelf life of more than one year at ambient condition (CIFT, 1987).

Shrimp feed

Commercially available fishmeal and shrimp meal lack functional properties such as water binding property, gel forming capacity and heat coagulability because of denaturation of protein. These meals also lack nutritional quality due to insect infestation, pathogen contamination, high sand content and biochemical changes during processing and storage. Attempt has been made successfully to use wet fish and fishery waste instead of commercial fishmeal in preparation of shrimp feed; thus the loss of the nutritional and functional quality of fish protein can be avoided.

The protein concentrated fish cakes from different low priced fish and locally available raw materials such as groundnut cake, rice bran, tapioca powder, small squid waste, small shrimp meat and vitamins were used in preparation of shrimp feed for *Penaeus monodon*. The proximate composition of the prepared feed PF 42 with protein content from 42-44 %, is the nearest to the recommended dietary requirement (FAO) for shrimp. Combination of the meat of sciaenids and *Psenes*

sp. improved amino acid score to some extent. A combination of fish meat gel and starch gel in PF 42 is responsible to retain shape of pellets up to 48 h in water. Average feed conversion ratio of PF 42 was found to be 0.64 in 60 days and 1.17 in 90 days in feeding trials of *Penaeus monodon* under a specified water management system. Feed PF 42 sealed in 200 gauge polyethylene bags, retained their texture, colour and odour during storage for one year in ambient condition. The projected cost of the feed is Rs. 40 per kg (Chakrabarti *et al.*, 1995).

Pelleted feed with protein content about 35% was prepared for *Macrobrachium rosenbergii* using protein concentrated fish cakes and locally available raw materials. The results of the feeding trial at the ponds of Fisheries Department of Andhra Pradesh and Agricultural University at Kakinada were satisfactory. The pellets retained their shape, colour and odour during storage for one year at ambient temperature.

Utilization of processing waste

Isinglass

Isinglass was prepared in strips form from the air bladder of eel. Finings prepared with this using sulfurous acid and tartaric acid was tested under commercial conditions for clarification of beer. Use of isinglass helped to reduce the suspended solids in the beer from 2 to 0.55 %, increase filtration rate from 25-35 hectoliter per hour to 114 hectoliter per hour and reduce consumption of filter aid from 100-150 g to 53 g per hectoliter (Basu *et al.*,1989).

Carotenoprotein

While extraction of carotenoprotein from brown shrimp (*Metapenaeus monoceros*) shell waste, trypsin showed maximum recovery (55%) of carotenoid pigment in 4 h at (28±2°C); while pepsin and papain showed about 50% recovery during the same period. The yield of protein paste by trypsin was maximum. The average protein content in the protein paste was about 450 $g.kg^{-1}$. The percent of recovery of protein by papain and pepsin were close to that of trypsin. During storage at ambient temperature (28±5°C) loss of carotenoids from cake prepared by trypsin was minimum. The cost of trypsin is twenty times that of papain. Thus papain, easily available and cheapest enzyme, can be used suitably for moderate recovery of carotenoids and good recovery of protein from shrimp shell waste at tropical ambient temperature. The dried colourless solid residue after extraction of carotenoprotein and protein, can be used as raw materials for chitin and chitosan (Chakrabarti, 2002).

Protein concentrate

Tuna liver is a waste from tuna processing factories. Enzymatically soluble protein concentrate and caroteno-protein cake from tuna liver were prepared by using papain, trypsin and pepsin. Papain and trypsin gave good recovery of carotene. It was found that soluble protein concentrate could be used satisfactorily for the growth of anaerobic sulphite reducing bacteria while caroteno-protein could be used as ingredient in food and feed preparation (CIFT, 2002; 2003).

Utilisation of deep sea fish

Many deep sea fish such as black ruff and bullseye, which are yet to be popular, contain nutritional components similar to that of commercially important fish (Khasim *et al.*, 1990). Fresh *Priacanthus hamrur* stored at -18°C showed good overall quality of cooked meat even after 7 months storage. Freshly caught *Psenes* sp. when stored at -18°C remained in acceptable condition even after 12 months. Frozen horse mackerel had good shelf life of 8 months (-18°C). *Decapterus kurroides* frozen onboard remained in good condition even after 6 months at -18°C (CIFT, 1990; 1994).

With the growing demand for value added products, the research centre is taking initiative to prepare various products for better economic utilization of fishery resources. The research centre is, also, taking special initiative to separate valuable components from fish processing waste with an objective of safe disposal of waste without causing environmental pollution. The microbiological, biochemical and toxicological parameters of fish and fishery products are being monitored at regular intervals. The research centre maintains close interaction with the industry and imparts technical guidance as and when required. It conducts training programmes for the benefit of the industry for improving the skills and creating awareness of the latest developments of concern and interest. Human resource development is given special attention by conducting training for fresh graduates and post graduates needed for industry. The research centre is also actively participating in all types of developmental programmes geared for the growth of industry and capacity utilization, particularly in the east coast of India. Development of new technologies and upgradation of existing ones are ongoing processes, as the research centre is gearing itself to meet the emerging challenges in the post-harvest technology of fish and minimization of post-harvest losses.

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References

Basu, S., Gupta, S.S. and Rao, C.C.P.(1989) Intermediate moisture fish cake, In: *Recent Trends in Processing Low Cost Fish* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p. 114-119, Society of Fisheries Technologists (India), Cochin

Basu, S., Khasim, D. I. and Rao, C.C.P. (1989) Isinglass from eel air bladder In: *Recent Trends in Processing Low Cost Fish* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p. 218-220, Society of Fisheries Technologists (India), Cochin

Basu, S. (1989) Sausage from blood clam meat, In: *Recent Trends in Processing Low Cost Fish* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p.128-131, Society of Fisheries Technologists (India), Cochin

Basu, S. (1990) Use of tripolyphosphate in the development of products from minced fish meat, *Fish. Technol.* 27: 36-39

Basu, S., Gupta, S.S., Rao, C.C.P. and Chakrabarti, R. (1991) Preservation of Mullets in CO_2 enriched gas mixture at 6-7°C, *Fish. Technol.* 28: 125-127

Basu, S., Gupta, S.S. and Nair, A.K.K. (1992) Control of blow fly larva infestation in cured fish, *Fish. Technol.* 29: 82-83

Chakrabarti, R. (1983) A method of debittering fish protein hydrolysate. *J.Food Sci. Technol.* 20:154 – 156

Chakrabarti, R. (1984) Change in the muscle of Indian three major carps during frozen storage, *Fish. Technol.* 21: 91 – 93

Chakrabarti, R. (1984) Suitability of bitter fraction separated from fish protein hydrolysis as bacteriological peptone, *Indian J. Microbiol.* 24: 167 – 170

Chakrabarti, R. and Khasim, D.I. (1987) Value added silver bellies, *Fishing Chimes*, October 1987: 71 – 74

Chakrabarti, R. (1988) Use of dense media to separate meat from small crabs, *Intl. J. Food Sci. Technol.* 29(1): 113 – 115

Chakrabarti, R. (1988) A method to preserve fish muscle process and mince from sciaenids, *Fish.Technol.*25: 58 – 60

Chakrabarti, R. (1989) Separation of meat from small crabs and its storage, In: *Recent Trends in Processing Low Cost Fish* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p. 124 – 127, Society of Fisheries Technologists (India), Cochin

Chakrabarti, R. and Khasim, D.I. (1989) Effect of depuration in Indian cockle – *A. granosa*, *Indian J. Fish.* 36: 59 – 62

Chakrabarti, R., Gupta, S.S., Rao, C.C.P. (1991) Preparation of salted-pressed *Psenus indicus* and its storage characteristics, *Fish. Technol.* 28: 37 – 141

Chakrabarti, R., Gupta, S.S., Rao, C.C.P. and Basu, S. (1992) Control of black discoloration in raw shrimps from tropical region, *Fish. Technol.* 29(2): 84 – 85

Chakrabarti, R. (1993) Processing of *Psenus indicus*, *Decapterus* sp. and *Stolephorus* sp. to dried product with low histamine and their storage characteristics, *Fish. Technol.* 30(2): 130 – 133

Chakrabarti, R. (1993) Phenoloxidase activity in different tropical shrimps and its sensitivity of sulphiting agents. *Indian J. Fish.* 40: 43 – 46

Chakrabarti, R. (1994) Benzo(a) pyrene in traditional smoked shrimps from Kakinada Coastal area, *J. Food Sci. Technol.*34: 339 – 341

Chakrabarti, R., Gupta, S.S., Gopalakrishna, G., Rao, C.C.P. and Gopakumar, K. (1995) Prawn feed from low priced wet fish, *J. Aquacultre in Tropics* 10: 87 – 97

Chakrabarti, R.(1998) Shelf life and histamine content of ten species of fish stored in tropical ambient temperature, *J. Food Sci. Technol.* .35: 62 – 65

Chakrabarti, R., and Gupta, S.S (1998) Studies on phenoloxidase activity and its sensitivity to metabisulphite in frozen *Metapenaeus monoceros*, *Fish. Technol.* 35(1): 30 – 33

Chakrabarti, R., Gupta, S.S. and Rao C.V.N. (1998) Effect of the tranquilizer tricaine methane sulfonate on the survival of *Clarius batrachus* during live storage, In: *Advances and Priorities in Fisheries Technology*, (Balachandran, K.K., Iyer, T.S.G., Madhavan, P., Joseph, J., Perigreen, P.A., Raghunath, M.R. and Varghese, M.D., Eds.), p. 274 – 275, Society of Fisheries Technologists (India), Cochin

Chakrabarti, R. and Gupta, S.S. (2000) Characteristics of gel from the meat of twelve species of fish from Visakhapatnam coast, *Fish. Technol.* 37(1): 5 – 7

Chakrabarti, R. and Varma, P.R.G. (2000) The sensitivity of halo-tolerent *Aspergillus flavus, Aspergillus niger and Pencillium* sp. to propionate, sorbate and benzoate, *J. Food Sci. and Technol.* 37(1): 72 – 74

Chakrabarti, R. (2002) Carotenoprotein from tropical brown shrimp shell waste by enzymatic process, *Food Biotechnol.* 16(1): 81-90

CIFT(1980) *Annual Report*, p. 22, Central Institute of Fisheries Technology, Cochin

CIFT(1987) *Annual Report*, p. 44, Central Institute of Fisheries Technology, Cochin

CIFT(1990) *Annual Report*, p. 25, Central Institute of Fisheries Technology, Cochin

CIFT(1991) *Annual Report*, p.32, Central Institute of Fisheries Technology, Cochin

CIFT(1993) *Annual Report*, p. 27, Central Institute of Fisheries Technology, Cochin

CIFT(1994) *Annual Report*, p. 27, Central Institute of Fisheries Technology, Cochin

CIFT(1995) *Annual Report*, p. 27, Central Institute of Fisheries Technology, Cochin

CIFT(2002) *Annual Report*, p.49, Central Institute of Fisheries Technology, Cochin.

CIFT(2003) *Annual Report*, p.44, Central Institute of Fisheries Technology, Cochin

Govindan, T.K. and Gupta, S.S. (1978) Design and fabrication of dismantleable insulated galvanized iron container, *Research and Industry* 23(2): 85

Govindan, T.K., Varma, P.R.G. and Chattopadhyay, P. (1978) Investigations on long distance transportation of fish III- field trial with a dismantleable insulated galvanized iron container, *Fish. Tech.* 15(1): 31-35

Gupta, S.S. and Basu, S. (1985) Pickle from blood clam (*A. granosa*) meat, *Fish. Technol.* 22(2): 109

Gupta, S.S. and Chakrabarti, R. (1994) Production of salted and pressed *Decapterus* sp. and its characteristics, *Fish. Technol.* 31: 181-184

Khasim, D.I. and Prasad, M.M.(1998) Ready-to-fry dried products from low cost fish, In: *Advances and Priorities in Fisheries Technology,* (Balachandran K.K., Iyer. T.S.G., Madhavan. P., Joseph. J, Perigreen P.A., Raghunath, M.R. and Varghese M.D., Eds.), p 261, Society of Fisheries Technologists (India), Cochin

Khasim, D.I., Basu, S., Gupta, S.S. and Rao, C.C.P. (1989) Studies on improvement in Jithaka smoking – a traditional processing of small size prawns in coastal Andhra Pradesh, In: *Recent Trends in Processing Low Cost Fish,* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p. 36-39, Society of Fisheries Technologists (India), Cochin

Khasim, D.I., Chakrabarti, R. and Rao, C.C.P. (1990) Proximate composition, calcium and phosphorus contents of five varieties of deep sea fish of Andhra coast, *CMFRI Bull.* 44 (Part II), p. 478 – 479, Central Marine Fisheries Research Institute, Cochin

Khasim, D.I. (2002) Value addition to freshwater fish processing - a simple process of removal of bones from fillets, In: *Riverine and Reservoir Fisheries in India* (Boopendranath, .M.R., Meenakumari, B., Joseph. J., Shankar, T.V., Pravin, P. and Edwin, L., Eds.), p. 308, Society of Fisheries Technologists (India), Cochin

Prasad, M.M. and Rao, C.C.P. (1994) Storage studies on commercial salt cured dry fish with special reference to red halophiles discolouration, *Fish. Technol.* 31(2): 163-166

Rao, C.C.P., Govindan, T.K., Gupta, S.S., Chattopadhyay, P. and Unnithan., G.R. (1978) Investigations on long distance transportation of fish III, IV – A comparative study of the performance of expanded polystyrene slabs and multilayer gunny (jute) fabric as insulants, *Fish. Technol.* 15(2): 89-93

Rao, C.C.P., Govindan, T.K., Gupta, S.S. and Chattopadhyay, P. (1979) Investigations on long distance transportation of fish V - Transportation of filleted and round seerfish (*Scomberomorus* sp.) from Kakinada to Calcutta by rail, *Fish. Techol.* 16(1): 11-13

Rao, C.C.P., Basu, S. and Prasad, M.M. (1989) Studies on solar tent dryer for drying fish, In: *Recent Trends in Processing Low Cost Fish* (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds.), p. 64 –71, Society of Fisheries Technologists (India), Cochin

Rao, C.C.P., Basu, S., Khasim, D.I., Chakrabarti, R. and Gupta, S.S. (1990) Utilization of blood clam *Anadara granosa*, *CMFRI Bull.* 44 (Part II), p. 470 – 475, Central Marine Fisheries Research Institute, Cochin