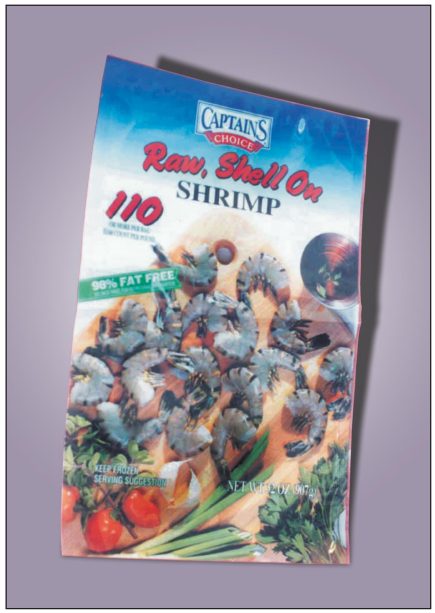
# PACKAGING OF SEAFOOD

India has over 8000 kilometers of coastline, 3 million hectares of reservoirs and 1.4 million hectares of brackish water, which is a vast potential for fishes, both from inland and marine resources. There are about 3,726 fishing villages and about 47,000 mechanised and 2,23,000 non-mechanised fishing vessels actively engaged in marine fish capture. India's fish production is approximately 5% of the total world production. Table 1 gives the fish production in India for the last few years.




*Laminated Plastic Pouch for IQF Shrimps*

Nearly 60% of the production of fish in India is from marine sources. Marine fishes found in India include prawns, shrimps, tuna, cuttlefish, squids, octopus, red snappers, ribbon fish, mackerel, lobsters, catfish and a number of other varieties. Indian exports of marine products fetch valuable foreign exchange of more than Rs.50,000 million. The export was of the order of 41,8070 tonnes during 2001-2002. Japan is the largest buyer of Indian marine products and accounts for 15% of total exports. Out of the total marine landings of our country, 65% of fish are consumed as "fresh", 7% as frozen, 20% as cured and

**TABLE 1**
**Fish Production in India**

(figures in million tonnes)

| Year | Marine | Inland | Total |
|---|---|---|---|
| 1994-95 | 2.69 | 2.09 | 4.78 |
| 1995-96 | 2.70 | 2.24 | 4.94 |
| 1996-97 | 2.96 | 2.38 | 5.34 |
| 1997-98 | 2.95 | 2.44 | 5.39 |
| 1998-99 | 2.69 | 2.56 | 5.25 |
| 1999-2000 | 2.83 | 2.82 | 5.65 |

[Source: Ministry of Food Processing Industry - Annual Report (2001-02)]

0.2% as canned. In the total exports, about 34% of shrimps, 22% of cephalopods and 36% of fish are exported in frozen form. Fish landed in plenty during glut season, are often converted to dried fish or meal without properly preserving them and made available to the interior cities during off-seasons.

*Dry Fish Vending*

Processing of produce into canned and frozen forms is carried out almost entirely for the export market. In all, there are about 393 freezing units, 13 canning units, 160 ice-making units, 12 fish meal units and also about 476 (as in 1999) cold storage units. This sector provides employment to about 110 million people in the country.

Processed fish products for export include - conventional block frozen products, Individual Quick Frozen (IQF) products, minced fish products like fish sausages, cakes, cutlets, fillets, pastes, surimi, texturised products and dry fish.

## Need for Packaging of Fish and Fish Products

Fish is an extremely perishable food and should be handled at all times with great care, in such a way so as to inhibit the growth of micro-organisms. Fish quality deteriorates rapidly and potential life is reduced if they are not handled and stored properly. Most often, the fish landing stations are far away from places where fish is processed or marketed and, therefore, they have to be transported over long distances. Fish must be refrigerated or frozen immediately after landing to prevent microbial deterioration. It is reported that the rate of spoilage doubles with every 5.5°C rise in temperature. Desiccation of chilled and frozen fish during storage causes quality deterioration as well as weight losses. The quality/type of packaging materials and the method of packaging are, therefore, of great importance for preserving the quality of fish. Fish and fish products can be grouped into fresh fish, frozen fish, canned fish, dried fish and other value added fish products. Each category requires special packaging materials and different handling procedures and is, therefore, discussed separately.

## Fresh Fish

In our country, the major portion of fish consumed is in its fresh form. The cities of Kolkatta, Delhi and Mumbai receive fish sometimes from places, which are at long distances. The storage period from the time the fish has landed, till it is consumed may be between 10 -15 hours to 5 days. During this period, the fish quality is maintained by chilling the fish and by keeping the temperature low.

### Packaging Requirements

The most effective way in which the temperature of wet fish is kept down at the required level is by mixing it with ice. Therefore, the design and material of the container used for transporting

fish should have insulating properties to reduce, as much as possible, the rate of melting of ice. In addition, the other requirements of a suitable fresh fish package are to:

- Reduce dehydration
- Reduce fat oxidation
- Provide for less bacterial and chemical spoilage and be capable of being washed reasonably free of bacteria
- Eliminate drip
- Prevent odour permeation
- Provide adequate mechanical strength to reduce handling damages
- Preferably should be light in weight

## Package Forms / Materials

For bulk transport of fresh fish, the traditional bamboo or wicker baskets with polyethylene sheet liners are used. At times, plywood boxes are also used but as they do not offer much resistance to the inflow of heat, therefore melting of ice occurs, resulting in rise in temperature. Other disadvantages are that these boxes cannot be cleaned easily and can also cause bruising of fish.

Collapsible type of aluminum containers are also used for transportation of fish as they can be cleaned easily and have good physical strength. **Since these containers are heavy and of high cost, better option for replacement of these containers are the double walled insulated moulded plastic containers, which are lighter in weight. These containers are hygienic and easily washable and provide good insulation.** The other types of packages used for fresh fish transportation is the moulded container made from expanded polystyrene. This is an excellent choice as such boxes are very light in weight, provide very good insulating properties and can be cleaned easily by washing.

The retail packaging of fresh fish in India is not at all common. In the overseas markets, the most popular form of package for fresh fish is a shallow tray of moulded pulp, foam polystyrene or clear polystyrene, which is over-wrapped with a plastic film which may be printed or over which a pressure sensitive label is applied. Generally food - grade PVC films are used as over-wraps.

## Modified Atmosphere Packaging

Recent introduction in the fish retailing are vacuum packs, Modified Atmosphere Packages (MAP) and active packaging. Table 2 provides a review of the shelf-life and extensions reported for chilled fish and shellfish products in MAP, which have been examined by sensory techniques. The total shelf-life indicates the shelf-life in MAP, while the extension of shelf-life has been calculated relatively to the reference material concerned.

**TABLE 2**
**Reported Storage Life of Fish Products in MAP**

| Species* | Initial Gas Mix | | Shelf-life (Days) | | Storage | |
|---|---|---|---|---|---|---|
| | $CO_2$ (%) | $O_2$(%) | Total | Extension. | Ref. Mat. | Temp. (°C) |
| **Marine, lean fish** | | | | | | |
| Cod | 40 | 20-30 | 10 - 17 | 2 -10 | O | 0 |
| Cod | 60 | 20 | 17 -19 | 10 - 12 | O | 0 |
| Haddock | 40-60 | 20-30 | 11 -13 | 4 - 6 | O | 0 |
| Whiting | 100 | 0 | 15 | 5 | V | 4 |
| Plaice | 40-60 | 20-30 | 7 | 0 | O | 0 |
| Hake | 40-60 | 0-30 | 8 - 10 | 3 - 5 | V / A | 1 |
| Snapper | 40-100 | 0 | 9 - 18 | 2 - 9 | V | -1 |
| **Fatty fish** | | | | | | |
| Herring | 40 | 30 | 8 | 5 | V | 0 |
| Mackerel | 40-60 | 0-30 | 5 - 6 | 1 - 3 | O | 0 |
| Salmon | 60 | 0 | 13 | 1 | V | 0 |
| **Freshwater fish** | | | | | | |
| Trout | 40-100 | 0-30 | 8 - 25 | 2 -13 | O | 0 - 2 |
| *whole (Gutted) | 40-100 | 0-30 | 4 - 11 | 1 - 10 | V | 0 - 1 |
| Catfish whole (dressed) | 100 | 0 | 10 | 2 | V | 3 |
| Catia | 50-80 | 20-50 | 20 - 28 | 8 - 16 | A | 0 |
| **Shell fish** | | | | | | |
| Scampi, shell-on tails | 40 | 30 | 4 | 1 | A | 0 |
| Crab, cocktail claws | 40 | 30 | 10 | 4 | A | 0 |
| Escallops | 40 | 30 | 7 | 3 | A | 0 |

*Fillets, unless indicated otherwise. V=Vacuum pack, O=Overwrap, A=Air.

[Source: Davis H.K., Fish in: Principles & Packaging of MAPackaging of Food, Parry R.T.–1993].

The results in Table 2 show a great variability within and between species, batches, treatments, experimental methods, attributes evaluated and, especially the end point criteria employed. The main source of variation between batches is probably the history of the fish between catching and packaging.

Several researchers indicate that the percentage increase in shelf-life compared with aerobic storage range from 0% to 280%, depending upon the definition and measurement of the shelf-life. If the end of the shelf-life is taken at an early stage (high quality shelf-life), little practical extension of the shelf-life is observed. However, if the end of the shelf-life is taken at a point corresponding to that used by the public health service, then the shelf -life extension can be considerable.

## Selection of packaging Materials for MAP

Apart from actively or non-actively altering the gas composition inside a fish package by using vacuum packaging, MAP or active packaging, several other aspects should be taken into account in order to design a suitable package. Often several types of plastics are combined to achieve the overall desired effect. For fresh fish packaging, because of the specific properties exhibited by various plastics, the materials used are discussed based on the specific requirement.

- **Gas barrier:** MAP for fish requires high barrier to $CO_2$, $O_2$ and $N_2$. The pre-determined gas mixture has to stay inside the package and remain the same mixture. Therefore, packaging films or layers with high gas barrier are applied. PVDC co-polymers and polymers are characterised by exceptionally high gas barriers. Compared to other packaging polymers, EVOH has the highest barrier to oxygen gas.

- **Water Vapour Barrier: Impermeability to water vapour is important for fish packages as its quality is adversely altered by dehydration. Several plastics having good water vapour barriers like PVDC, coated OPP and HDPE are used. Other plastics like PA and PS have poor water vapour barrier and yet some other plastics like EVOH can be adversely affected by moisture. Hence, in most packaging applications the films must be laminated on both sides to protect it from contact with moisture.**

- **Heat Sealability:** A tight seal has to be formed between the tray and lidding material to prevent contamination and dehydration of fish. Since the fish packages are sold in supermarkets along with other food products, the strong fish odour should not be allowed to spread. LDPE, EVA and PP are widely used as a heat seal layer in laminates of fresh fish packaging.

- **Mechanical Damage:** Fresh fish can be easily bruised. EPS (expanded polystyrene) tray is widely used to protect the sensitive product. To provide gas barrier and heat seal properties, EPS is used in combination with EVOH and LDPE to provide a suitable package. At times, rigid HDPE tray is also used. A sufficient head-space with puncture resistant films like polyamides completes the package.

- **Oil Resistance: For fatty fish, oil resistant films like polyamides, PVDC and PVC ( un-plasticised) may be considered. PET and OPP are also used as they provide excellent oil barrier.**

- **Transparency:** For fresh food, the visibility of the product is important to the consumer. PET and PP films have superior optical clarity and, therefore, are applied for fish packaging

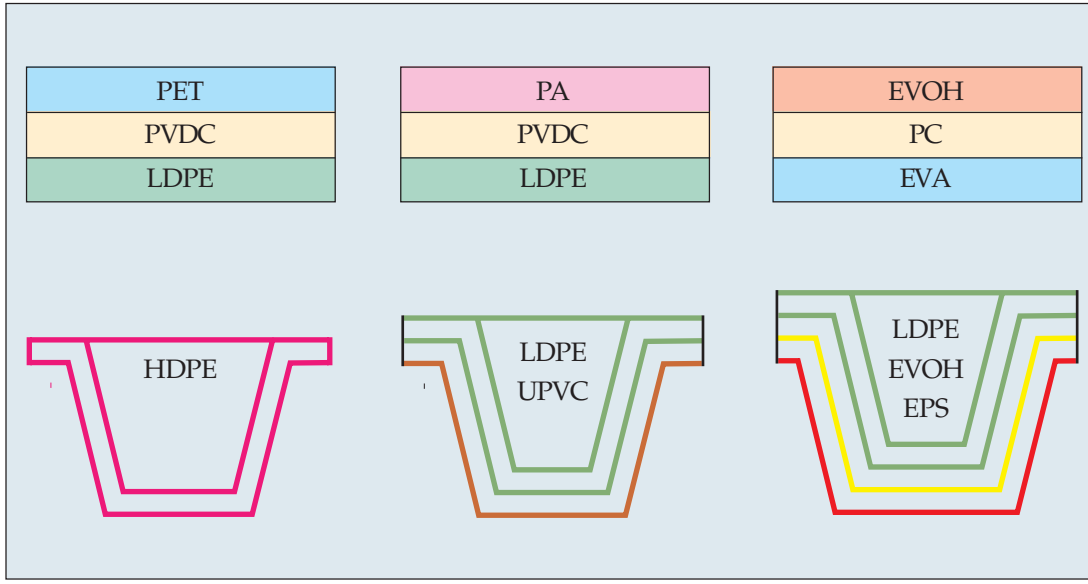
over-wraps and as lidding materials. The polymers may also be blended with antifogging agents in order to reduce condensation on the lidding film.

- **Drip Absorber: Fresh fish packaged under modified atmosphere** conditions may drip. In order to reduce bacterial growth and provide a clean package interior, absorbent pads are enclosed. Pads made of cellulose are placed under the fish or when an EPS tray is used, are integrated as a layer.

- **Insulation:** Insulation is of particular importance in transport packaging of ice chilled fish. Expanded polystyrene trays and boxes are generally used as retail and transport packages respectively.

Typical types of modified atmosphere fish packages for retail are rigid trays combined with a lidding film. Modified atmosphere transport packages are usually of bag-in-box type. Some typical structures of MAP lidding materials and trays for consumer packs are illustrated in Figure 1.

**Figure 1**
**Typical Plastic Containers and Lidding Films for Modified Atmosphere Packaging for Fresh Fish**




## Studies on MAP of Fish / Fish Products

A number of authors have reported considerable increase of up to two or even three-fold in the shelf-life of fish packed in modified atmosphere compared to that of fish packed in air. Generally, higher initial $CO_2$ levels resulted in increased shelf-life. According to Einarsson (1992), the MAP (40% $CO_2$, 30% $N_2$, 30% $O_2$) increased the shelf-life of cod fillets stored at 0°C by a factor of 1.4 when compared to air packaging.

Table 3 gives some shelf-life results of fish fillets in retail packages.

**TABLE 3**

**Shelf-life of Raw Rainbow Trout & Baltic Herring Fillets in Various Retail Packages as per Sensory Evaluation (Flavour of Cooked Fillets) (Randell ET AL 1997)**

| Package type | Shelf-life (days)[1] | |
|---|---|---|
| | Rainbow trout | Baltic herring |
| OVER-WRAP[2] - WOOD FIBRE | 4 - 5 | 2 - 3 |
| - STYROX | 5 - 6 | ca.3 |
| VACUUM[3] | ca. 6 | ca.4 |
| GAS[4] - 35%$CO_2$ + 32.5% $N_2$ +32.5%Ar | ca. 9 | ca.7 |
| - 35%$CO_2$ + 65%$N_2$ | ca. 9 | ca.6 |
| - 40% $CO_2$ + 60% $N_2$ | ca. 9 | ca.6 |

[1] = Storage at +2 ± 1°C

[2] = Film over-wrap LDPE

[3] = nylon-polyethylene bag

[4] = gas/product - ratio 1ml/1g Tray polypropylene and lid polyester / polyethylene

ca = Controlled Atmosphare

## Studies on Active Packaging of Fish /Fish Products

Experiments were conducted on Active Packaging of fish at Universita degli Studi-di Milano, Dept of Science and Technology, Italy. The aim of the study was:

(a) to evaluate the influence of a new patented packaging (European Patent Application No.830018.8-2308) provided with an absorber for liquid and amines on the shelf-life of raw minimally processed fish products, packed under modified atmosphere, and

(b) to characterise the spoilage microflora phenotypically.

*Fresh Fish in EPS Box*

Fresh fillets of sole, steaks of cod and whole, cleaned and thawed cuttlefish were used for the study. For packaging, two different kinds of expanded polystyrene (EPS) trays were used. The first kind of tray was the standard extruded EPS tray and the second kind was the innovative extruded micro-perforated EPS tray, containing a surfactant agent for liquid absorption and a mineral powder for trimethylamine (TMA) scavenging, samples of 100 grams of each fish product, placed in standard and innovative trays, were packed under a modified atmosphere [(40% $CO_2$: 60% $N_2$), into high barrier (50µ) co-extruded bags with $O_2$ permeability of 10 $cm^3$ / $m^2$ / 24 hours / bar at 7°C )]. All the packed samples were stored at chill conditions of 3 ± 5°C and analysed periodically up to 10 days. The results of the experiments indicated that the combination

of an active packaging, with absorbing functions and modified atmosphere without $O_2$ increased the shelf-life up to 10 days.

The time from catching to packaging of fish, and the packaging hygiene and temperature probably have a considerable effect on the shelf-life. Experiments carried out at VTT (Technical Research Centre of Finland) have proved that the quality of fish at the time of packaging is very critical. Besides achieving extended shelf-life, the other important factor to be considered is the safety with respect to various packaging techniques. Some positive and negative effects of using gas, vacuum and active packaging techniques are listed in Table 4.

**TABLE 4**

**Advantages(+) and Disadvantages(-) Encountered with Gas, Vacuum and Active Packaging of Fish (Lyijynen ET AL 1997)**

| Feature | Gas Packaging | Vacuum Packaging | Active Packaging |
|---|---|---|---|
| **Effect on the Product** | | | |
| Need for food preserving agents[1] | – | – | + |
| Shelf-life / food quality | + | + | ++ |
| Suitable for soft products | + | – | + |
| Release of drip | – | – | – |
| **Effect on Packaging** | | | |
| Investment costs | – | + | ++ |
| Packaging costs | + | ++ | – |
| Package volume/space saving | – | ++ | + |
| Ease of leak detection | – | + | – |
| Visible / invisible | + | + | +/-[2] |
| Usable with metal detectors | + | + | +/- |
| Environmental impacts | +/- | + | + |

[1] = not with fresh fish, but with processed products.

[2] = separate pouch in the package (visible = -) or incorporated into the package (invisible = +)

## Frozen Fish

Nearly 90% of exports of marine products is in the frozen form. The most popular items are shrimp, squid, cuttlefish, lobster etc.

### Packaging Requirements

The storage of frozen fish is at minus 18-20°C. Freezing of the product and then storage at that temperature does inhibit major changes caused due to deterioration. However, some small

changes do take place during storage at freezer temperatures. The factors affecting the quality of frozen fish are:

- Moisture loss/dehydration
- Oxidation/Rancidity
- Flavour loss
- Heat radiation and light.

Therefore, for selection of an appropriate package the above factors should be considered. The packaging material should have good barrier properties i.e. low water vapour and oxygen permeability rates. It should retain the odour inside the package. The packaging material should also be able to withstand sub-zero temperatures.

## Packaging Forms and Materials

- **Block frozen:** The conventional and the most common method is plate freezing/block freezing. The components of primary packages of block frozen shrimps are :

- **Glazing:** It is the protective coating of ice given to the product to prevent dehydration. It has been reported that the glazing percentage varies from 8% to 40%. Optimum glazing quantities actually required for preservation are not standardised.

- **Inner Wrapper Bags:** A loose wrapper/liner of low-density polyethylene is generally used to line the primary carton. In rare cases, instead of LDPE film, HM-HDPE film is also used. Some exporters use a LDPE pouch/ bag instead of a loose liner.


*Block Frozen Shrimps in LDPE Pouches*

- **Primary Carton:** It is made from paperboard and has multi-coloured printing over it. The cartons are laminated with a plastic film either on one or both sides. Earlier the cartons used to be wax coated. In some cases where LDPE bag is used, the carton is eliminated. This is so because the 2-kg blocks are institutional packs and once the product reaches the destination market, the cartons are thrown out and the product is either repacked into smaller quantities or is reprocessed.

- **IQF Frozen:** IQF (Individually Quick Frozen) shrimp processing is a fairly recent introduction by the Indian seafood exporters and has a potential market in the West European countries where it is a highly priced value-added product. In these highly discerning markets, presentation of the product and its safety is of prime importance as these are meant to be sold directly to the consumers through the supermarket stores. The package, therefore, has to perform the dual role of providing protection and aesthetic appeal to gain foothold in the highly competitive markets.


*IQF Lobster in LDPE Pouches*

## IQF Lobsters in LDPE Pouches

IQF shrimp may be raw, blanched or cooked. Majority of the plastic packages are of capacities ranging from 1 kg to 5 kgs and even up to 10 kgs at times. This implies that though the product is aimed at the consumer market, the exported packs are not directly sold through the supermarkets to the consumers but may serve the catering or food industry or as in the case of block frozen product, reprocessed and repacked into smaller consumer packs. However, some of the exporters do pack in smaller consumer packs for the importers' brands. India has the capability and availability of packaging materials and machinery to produce value - added consumer packs and exports in such packs by the seafood industry can bring in valuable foreign exchange.

After the freezing operation, the normal practice is to carry out glazing and packaging manually. It is heartening to note that there are a few exporters who have installed the most advanced and latest freezing units, where online glazing and packaging are also included.

## Polylaminated Carton for Frozen Shrimps

The components of primary package of IQF shrimps are:

- **Unit Pouch/wrapper:** A plastic unit pouch or wrapper is used as a primary pack. The pouches vary in capacities ranging from 200 grams to 10 kgs. There is no standardisation on the size and the material of the pouch, in terms of type and specifications. The materials generally used for the construction of the unit pouches are:
  - Monolayered LDPE or LLDPE, film
  - Co-extruded LLDPE - LDPE, two-layered film
  - Co-extruded LLDPE - B - Polyamide - B - LLDPE, five layered film
  - Polyester / LDPE laminate

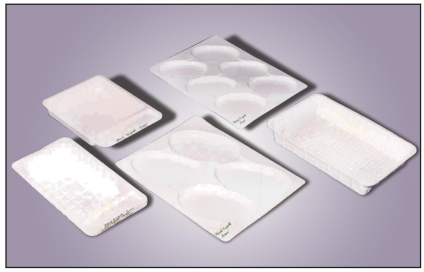
  The unit pouches when not printed are further packed into a plastic coated paperboard unit carton. The pouches used directly as unit packs are printed in one or multicolours. After filling and weighing the pouches are closed by heat sealing.


*Plastic Laminated Cartons for Frozen Shrimp*

- **Plastic Trays:** Some of the processors use plastic trays of Expanded Polystyrene (EPS) or PET as unit packs, specially for head-on shrimps, lobsters, butterfly shrimps. The trays are either placed in a plastic pouch, which is heat-sealed, or in printed paperboard cartons with see-through windows. For butterfly shrimps, after the product is placed on the EPS tray and frozen, they are skin packed with a high barrier plastic film.


*Plastic Trays and Pouches for IQF Seafood Products*

In the case of block frozen and IQF marine products, the primary packs are placed in coated or laminated corrugated fibre board master cartons for storage and



*Plastic Trays for IQF Crabs*

transportation. The frozen products are stored at -18°C to -20°C.

## Other Value-added Fish Products

Value addition is the need of the hour, to satisfy the ever changing and diverse demands from the importing countries as well as urban consumers at home. The technology upgradation and value addition has resulted in adoption of modern technology in processing of several value-added products out of low cost fish and shell fish, which have both export and domestic markets. Some of the important value-added seafood besides IQF products are surimi, fried fish, fish sauce, fish curry, fish salads, fish pickles, dehydrated fish products, fish sausage, shark fins etc. Developing a suitable pack, to provide these products adequate protection and shelf-life as well as consumer appeal is an important task. The Central Institute of Fisheries Technology (CIFT), Cochin has carried out considerable studies in this field to identify and determine the most suitable packaging materials for these products. The packaging requirements and the types of packages used for some of these items are highlighted below.

## Battered and Breaded Products

These form an important class of value added products in convenient form. The changes, which occur during frozen storage of these products, are desiccation, dis-colouration and development of rancidity. Plastic films alone are not suitable for these products as they provide little mechanical protection to the products and as a result, the products get damaged or broken during handling and transportation, hence thermoformed containers are commonly used for this purpose. Thermoformed trays made from food-grade plastics are used for packaging. Materials used for thermoformed trays are Poly Vinyl Chloride (PVC), High Impact Polystyrene (HIPS) and High Density Polyethylene (HDPE) which remain stable and unaffected during prolonged frozen storage.

## Fish Curry

For fish curry, retortable flexible pouches are identified as the ideal choice of package as they offer advantage of low cost, boil-in-bag facility, ease of opening and reduced weight. The suitable flexible laminate is polyester / aluminium foil / cast polypropylene. Recent studies indicate that laminates of polyester / cast PP can also be adopted.

## Surimi

Suirmi is a Japanese term for mechanically deboned fish mince from white fleshed fish. It is generally frozen as rectangular blocks. In order to prevent spoilage like dehydration and oxidative rancidity during storage, the packaging materials used should be a good barrier to water vapour, gases and odour.

The material should also have good mechanical strength and should be stable at

sub-zero temperature. Generally, the packaging adopted for block frozen shrimps is considered suitable for surimi blocks as well.

## Fish Sausage

Fish sausage is an identical product to the popular pork sausage, with surimi as the base material. Paperboard carton lined with a plastic film is ideal for short-term storage at refrigerated conditions, but for longer storage it is best kept frozen. The packaging used for block frozen shrimp is considered to suit the requirement of this product as well.

## Accelerated Freeze Dried (AFD) Products

The AFD products are a relatively recent development in fish preservation. The product has low moisture content, generally below 2%. The product is very fragile and is prone to deterioration due to moisture absorption, oxidation and colour changes. The packaging material for this product should have low water vapour and oxygen permeabilities and sufficient mechanical strength. Laminates of paper / aluminium foil / polyethylene or metallised polyester / polyethylene pouches are found to be suitable.

## Fish Soup Powder

This product is highly hygroscopic in nature and hence the selection of the packaging material assumes great significance. Suitable flexible packaging material identified is 12µ polyester laminated with co-extruded LD-HDPE or a five layered co-extruded film of 90-100µ LD-BA-Nylon-BA-Primocor, which ensures a safe storage of the product up to 180 days.

## Shark Fin Rays

Dried shark fin is a traditionally exported item from India. Moisture resistant packaging having good puncture resistance and sufficient mechanical strength to withstand the hazards of transportation are the major requirements of packaging of this product. Polyester/polyethylene laminates or nylon based five-layered co-extruded films having good puncture resistance are appropriate.

## Dried Fish

In India, the fish generally dried are mackerels, shrimps, Bombay ducks and tuna. The fishes are generally sun dried, sometimes after application of salt. Dried fish is hygroscopic in nature and absorbs moisture when the climate is humid. When it comes in contact with air or oxygen the deterioration due to oxidation is rapid. Dried fish is also prone to attack by insects. Traditionally, dried fish is packed in baskets made of "palmyra" leaves with a hessian lining on the outside. For exports, dried fish is bulk packed in hessian sacks. Such packages do not provide protection from moisture absorption, oxygen or insects. This highly sensitive product needs to be packed in modern plastic based films / laminates and the possibility of vacuum packing/gas flushing of products also needs to be examined.

Table 5 lists some of the common packaging practices adopted for exports.

**TABLE 5**

**Common Packaging Practices Adopted in India for Exports of Selected Fish and Marine Products**

| Item | Packaging Materials / Packages |
|---|---|
| **Live Fish** | |
| Shrimp/Lobsters | Polystyrene foam container, inner and outer bag of polyethylene film (100μ) and outer CFB (in water 1:3 ratio in sealed bag flushed with oxygen). |
| Live Crustaceans | Pre-chilled sawdust, water-absorbing material, ice cubes in polyethylene bag, CFB boxes. Transportation by air. |
| **Chilled Fresh Fish** | Polystyrene foam slabs / boxes (thickness 10-25mm), Polyethylene bag (150g), Ice (2 to 4 kg for 15 kg fish, depending on distance) with or without outer CFB box. Transportation by air. |
| **Dry Fish** | |
| Bombay duck laminated/head and tail cut | 100/200 g. LDPE bags (200 grams net) and further packed (100-150 units) in 7 ply CFB boxes / gunny bags. |
| Other dry fish | Palmyrah leaf mats, Jute liner, Polyethylene film-packed as bundles or in sacks and reinforced with jute twine. Transportation by sea. |
| **Frozen Fish / Shrimp** | |
| Block frozen shrimp whole/ headless/ peeled and deveined/ peeled and undeveined butter fly etc (1.8-2.0 kg/net) | Waxed/poly coated printed duplex board cartons tuck-in-type, LDPE/HDPE liner/pouch to hold individual blocks.<br>5 Ply / 7 Ply CFB box (waxed / unwaxed) for bulk packaging (Regular slotted container type) closure – BOPP tape and PP or HDPE strapping. |
| Individually quick frozen shrimp/fish (200 gm-10kgs) 10 kg)<br>Raw headless/Cooked peeled Cooked salad/ Headless shell on/ Butterfly shrimp, marinara mix (squid/cuttle fish/mussels/ clams etc.) | LDPE. LLDPE, LDPE co-extruded film, multi-layer LLDPE– B –Nylon–B-LLDPE, co-extruded film, Polyester/LDPE laminate as wrapper / pouch, unprinted printed waxed / unwaxed / poly coated duplex board / 3 ply CFB tuck in or lid and tray type carton. Thermoformed PVC (food grade), expanded polystyrene trays.<br>Master carton – 5 ply / 7 ply CFB box RSC / or two piece lid tray type. Closure by BOPP tape. Transportation by sea in refrigerated containers (gross weight 30 kg maximum). |
| **Accelerated Freeze Dried Shrimp** | Bulk packaging (5 kgs) in metallised polyester / LLDPE or LLDPE – PA – LD co-extruded film bags with nitrogen flushing, 2 packs in a 5 ply CFB shipping. |

## Studies Conducted at IIP on Shelf-life of Dry Fish

Shelf-life studies were carried out on **dried Bombay ducks** and **dried prawns** at accelerated conditions of 38±1°C and 90± 2% R.H. and at standard conditions of 27± 2°C and 65± 2% R.H.

Based on field studies, the present method of packaging of Dried fish (Dried Prawns and Dried Bombay Ducks) and the commercial availability of the packaging materials, a number of flexible packaging materials, some of which were considered suitable for gas flushing were identified and procured.

The following flexible packaging materials were selected for the shelf-life studies of dried prawns:

1. 50µ LDPE
2. LDPE-Tie-NYLON-Tie-LDPE (70µ)
3. 12µ PET/30µ LDPE -HDPE
4. 20µ BOPP/ 37.5µ LDPE
5. 12µ PET/12µ MET. PET/37.5µ LDPE
6. 12µ PET/9µ AL FOIL/37.5µ LDPE

The following flexible packaging materials were selected for the shelf-life studies of dried Bombay Ducks:

1. 25µ Polypropylene
2. LDPE - Tie - NYLON - Tie - LDPE (70µ)
3. 20µ BOPP / 37.5µ LDPE
4. 12µ MET. PET/37.5µ LDPE
5. 20µ BOPP/12µ PET/37.5µ LDPE

(LDPE - Low density polyethylene.

Met - Metallised

PET - Polyester

BOPP - Biaxially Oriented Polypropylene

TIE - Tie layer (Bonding Agent )

AL - Aluminium )

Dried prawns and Dried Bombay Ducks were procured from the market in Mumbai. Around 20 kgs of dried prawns and around 1000 nos. of dried Bombay Ducks were collected. The Institute procured the samples of packaging materials and these materials were converted

into pouches to hold about 100 grams of the product. The pouches were packed by different packaging systems viz.:

## For Dried Prawns

- Ordinarily packed- heat sealed
- Vacuum packed - heat sealed
- Gas flushed - heat sealed

## For Dried Bombay Ducks

- Ordinarily packed - heat sealed
- Gas flushed - heat sealed

From the 6 selected packaging materials for the shelf-life studies of dried prawns, material no. 1 was used for packing by ordinary method while packaging material 2, 3, 4, 5 and 6 were used for packing by ordinary, vacuum and gas flushing methods.

From the 5 selected packaging materials for the shelf-life studies of dried Bombay Ducks, material no.1 was used for packing by ordinary method while packaging material 2, 3, 4 and 5 were used for packing by both the methods - ordinary and gas flushing.

The shelf-life/storage studies were conducted using all the selected packaging materials. About 100 grams each of both the products were packed. The pouches were closed by heat sealing. Adequate numbers of filled pouches of all the selected materials were exposed to accelerated conditions of 38±1°C and 90±2%RH and to standard conditions of 27±2°C and 65± 2%RH.

During the exposure period, the samples were drawn periodically at both the conditions. The packed products from these pouches were assessed in the laboratory for the keeping quality. The parameters determined were:

- Moisture Content
- Odour/Aroma
- Texture
- Visual observations on packaging material.

Besides assessing the product quality, the packaging materials were also observed for any changes like retention/leakage of gas from the nitrogen-flushed pouches.

## Analysis of Results

**Dried Prawns:** The shelf-life of the product packed in ordinarily packed pouches, vacuum packed pouches and gas flushed pouches from the selected six packaging materials at both storage conditions is given in Table 6. While analysing the results, the critical factor considered for determination of shelf-life was the moisture content level. (CMC: 20%).

It was observed that there was no change in the texture of the product in pouches (ordinary, vacuum and gas flushed) made from all the six packaging materials even at the end of the storage studies at both the sets of conditions. It was also observed that in case of material

50µ LDPE, the odour of the product was not retained within the pack and was felt outside the pack for both the sets of storage conditions.

The packaging materials did not show any changes with respect to softening, cracking or de-lamination. All the heat seals were found to be intact. Vacuum and nitrogen gas was retained in all the pouches even at the end of the storage period at both the conditions.

Based on the results obtained from the shelf-life studies, the materials recommended to be used for the primary packaging of the product are:

- 12µ PET/9µ Al foil/37.5µ LDPE
- 12µ PET/12µ MET.PET/37.5µ LDPE

**Dried Bombay Ducks:** The shelf-life of the product packed in ordinary packed pouches and gas flushed pouches from the selected five packaging materials at both the storage conditions is given in Table 7. While analysing the results, the main critical factor was the moisture content level (CMC: 15%).

It was observed that there is no change in the odour/texture of the product in pouches (ordinary and gas flushed) made from all 5 packaging materials even at the end of the storage studies at both sets of conditions. The packaging materials did not show any changes with respect to softening, cracking or de-laminating. All the heat seals were found to be intact and the nitrogen gas was retained in all the pouches even at the end of the storage period at both the conditions.

Based on the results obtained from the shelf-life studies, the materials recommended to be used for primary packaging of the product are:

- 12µ MET. PET/37.5µ LDPE
- 12µ BOPP/12µ PET/37.5µ LDPE

**TABLE 6**

**Shelf-life (In Days) Of Dried Prawns**

| Sr. No. | Packaging Materials | Accelerated Conditions of 38±1°C & 90±2% R. H. | | | Standard Conditions of 27±2°C & 65±2% R.H. | | |
|---|---|---|---|---|---|---|---|
| | | Ordinary Pack | Vacuum Pack | Gas Flushed Pack | Ordinary Pack | Vacuum Pack | Gas Flushed Pack |
| 1 | 12µ PET / 12µ MET.PET/ 37.5µ LDPE | 150 | 160 | 153 | >365 | >365 | >365 |
| 2 | 12µ PET/30µ LDPE–HDPE | 125 | 131 | 128 | 312 | 322 | 315 |
| 3 | LDPE-TIE-NYLON-TIE-LDPE (70µ) | 145 | 148 | 146 | 340 | 352 | 345 |
| 4 | 20µ BOPP/37.5µ LDPE | 112 | 118 | 112 | 296 | 302 | 295 |
| 5 | 12µ PET/9µ AL. FOIL/ 37.5µ LDPE | 162 | 170 | 160 | >365 | >365 | >365 |
| 6 | 50µ LDPE | 100 | – | – | 230 | – | – |

**TABLE 7**

**Shelf-life (In Days) of Dried Bombay Ducks**

| Sr. No. | Packaging Materials | Accelerated Conditions of 38±1°C & 90±2% R. H. | | Standard Conditions of 27±2°C & 65±2% R.H. | |
|---|---|---|---|---|---|
| | | Ordinary Pack | Gas Flushed Pack | Ordinary Pack | Gas Flushed Pack |
| 1 | 12µ MET.PET/ 37.5µ LDPE | 80 | 82 | 230 | 232 |
| 2 | 20µ BOPP/37.5µ LDPE | 60 | 58 | 154 | 159 |
| 3 | 20µ BOPP/ 12µ PET/ 37.5µ LDPE | 72 | 75 | 195 | 194 |
| 4 | LDPE-TIE-NYLON-TIE-LDPE (70µ) | 66 | 68 | 172 | 170 |
| 5 | 25µ POLYPROPYLENE | 53 | – | 135 | – |

## Conclusion

The commonly used packaging materials in fish industry as detailed are - paper and board, glass, metals, plastics and traditional items like bamboo baskets, plywood boxes, leaf mats, jute sacks etc. Each packaging type has its own advantages and disadvantages and one cannot be easily replaced by another just for the sake of environmental issues. Complete life cycle analysis from cradle to grave from all aspects of energy consumption, disposability have to be quantified in deciding which packaging material is best suited under given conditions of use and local availability. Duplex board cartons and corrugated fibre board boxes either waxed or polymer coated are extensively used for frozen fish both as unit and bulk packaging. Paper and paper board, though eco-friendly in view of renewable nature of forest resources, requires proper afforestation management and replenishment. Paper industry uses a lot of water during production and presence of chlorinated organics and dioxins in effluent water cause environmental problems at the production centres. The disposal of poly laminated or waxed cartons create problems at the disposal end, as there are technical difficulties to recycle or repulp, due to their tendency to settle on dry rollers of equipment. Exporters are to be prepared to meet additional charges for disposal of these coated / laminated boxes at the destination markets.

**Of all packaging materials, plastics have a major share, as they are versatile and can be converted into any form, lend to excellent decoration, have excellent barrier properties and are hygienic in use.** In the fish industry, plastics are extensively used for replacing traditional packages, either as crates, trays, insulated boxes for storage and for internal movement and distribution of raw materials and finished products. Bare films are used for over-wrapping of wet and frozen fish, pouches from co-extruded films for frozen / dry fish packaging, thermoformed trays of PVC/HDPE for unit packages of IQF fish and shrimp etc.

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