# Safety Aspects of Packaging Materials for Seafoods

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When selecting an appropriate packaging system for a food product, a number of criteria must be considered. Foremost is the stability of the food product itself as food components such as proteins, lipids and certain vitamins can undergo detrimental changes due to changes in water activity of the product. The stability of the product will thus be a function of its chemical, biochemical and physical nature and will be influenced markedly by the permeability or barrier properties of the package. Secondly environmental factors, such as temperature, relative humidity, oxygen tension and light intensity, to which the product/package system is exposed during distribution and storage must also be considered when evaluating the barrier properties required for the package. Lastly the nature and composition of the specific packaging material and its potential effect on the intrinsic quality and safety of the packaged food as a consequence of the migration of components from the packaging material into the food also should be considered.

Seafood export earnings from India has now crossed 6500 crores of rupees, the major share of trade being in the quality and environmentally conscious nation's viz. Japan, European Union, USA etc. Success in entering into these markets lies in the hygienic preparation of the product and adopting good packaging meeting the health, safety and environmental requirements of these countries. There is widespread concern on the increasing presence of packaging materials in the waste stream and their effect on environment in the industrialized nations. Environmental legislations concerning packaging are being enacted aimed at their reduction at source or facilitate their recycling or reuse, through incentives, penalties, voluntary and mandatory restraints. Hazardous substances migrating or permeating from the packaging materials and their components into the foodstuffs coming in contact with them and affecting the health and safety of the consumer are also of equal concern. Plastics are increasingly used as packaging media for fish products and migration of left over residual monomers and additives may impair the quality of packed products. Hazardous metals, volatiles etc in printing inks and can solders if permeate beyond acceptable limits endanger health of consumers. There are laws regulating the limits of these hazardous substances in packaging materials and ingredients in food products and there are complete bans on certain packaging materials in some countries. These laws and restrictions vary territorially and the exporter of marine products has to be aware of these, so that his products are not rejected or held up at destination markets due to unacceptable packaging.

Nearly 95% of exports of marine products are in the frozen condition and the balance includes minor items like live/ fresh, chilled/dried fish etc. The packaging materials /packages used in fish industry are both modern as well as traditional types, ranging from bamboo baskets, jute bags, leaf mats, corrugated fibreboard boxes, duplex board cartons, metal containers of *aluminum and tinplate, plastic films and* their laminates, thermoformed trays, polypropylene/ high density polythene crates, expanded polystyrene insulated boxes, glass bottles etc. Of all these types of packaging materials, flexible packaging materials come in direct contact with food in majority of cases. While most of the packaging materials are made indigenously, some plastics are imported to meet the exporter's obligations. The consumption of packaging materials used in fish industry is estimated at 50 million US dollars.

Plastics and plastic based materials are increasingly used in fish industry either as containers/crates for storage of raw materials or processed fish at factories or final packaging in semi rigid and other flexible forms. Some of the plastics commonly used for fish packaging are low-density polythene (LDPE), high-density polythene (HDPE), linear low-density polythene (LLDPE), high molecular weight high-density polythene, polypropylene (cast and oriented polypropylene), polyester (PET), nylon, polystyrene (PS), Ethylene acrylic acid (EAA) and polyacrylonitrile. All plastics, apart from the basic polymer contain several non-polymeric components, either inherent or deliberately added to plastics, which are classified into three categories viz.

1) Polymerisation residues (residual monomers, catalyst remnants, polymerization solvent etc)
2) Processing aids (plasticizers, stabilizers, antioxidants, slip agents, lubricants, antistatic agents, etc) and
3) End-use additives (antioxidants, brighteners, blowing agents, mould release agents, colourants, UV stabilizers, etc)

Among the above, the first type of *compounds is unavoidable whereas those* of the other two types are deliberately *added to the polymer either during* manufacture or subsequently to achieve the desired end properties of the finished plastic material. The useful properties of plastics are not manifested without the use of such additives.

*Polymers themselves being of high* molecular weight are inert and have limited solubility in aqueous and fatty systems. But the non-polymeric components may leach out from plastics to foods whenever direct contact occurs between food and plastics thereby contaminating the food product with the consequent risk of toxic hazard to the consumer. The awareness in this matter has led the national and international regulatory authorities in the formation of guidelines for proper use of plastics for food packaging application. Such guidelines are necessary to restrict the indiscriminate use or abuse of plastics in food packaging.

Different countries like India, USA, UK, Europe and Japan have laid down specifications and codes of manufacture for the safety use of plastics for food contact applications (IS: *10146-1982, IS: 10151-1982,* IS: 10910-1984, IS: 11434:1985, IS: 11435:1985, IS: 11704:1986, IS: 11705:1986, IS: 12229:1987, IS: 12252-1987, IS: 12247:1988, IS: 12248:1988 and IS: 10142–1999, Technical document, Japan, 1984, British Plastic Federal, 1981, EEC (1992), FDA, 1983). This relates principally to the use of various ingredients, additives and other processing aids used by the manufacturer in the formulations of plastics composition. These recommendations are based on the existing toxicological data. In India, agencies like Bureau of Indian standards (BIS) and Prevention of Food Adulteration Act (PFA) have formulated code of practice and specifications for a number of food grade plastics. In this regard BIS has laid down positive list of constituents, which are *generally regarded as safe (GRAS) and* specifications for safe use of plastics commonly used in food packaging. The residual monomer content and heavy metal content in different plastics specified by different countries and limits of heavy metals in colours used are presented in Table 1 and Table 2 respectively.

The other regulations on food packaging materials comprise of regulations for adjuvants (antioxidants, colourants, plasticisers, etc) used in food packaging materials. Only cited materials within given limits i.e. the amount of the adjuvant which can be used and the kinds of plastic in which it can be used are prescribed in Table 3.

The third aspect is the extractive limits for the final food contact article. Here the limitations would thus include the contributions from all the adjuvants and processing aids used in making the food contact packaging material. These regulations spell out the time/temperature/solvent conditions for the short term extraction experiments (migration tests) used to test compliance.

Migration tests for adjuvant transfer into foods should be conducted with each type of food in a given package under normal conditions of use for an expected contact time. However, apart from being economically prohibitive, this type of evaluation with actual foods is analytically difficult because of their complex nature. Foodstuffs vary in composition from place to place and more importantly they are unstable and decompose fairly rapidly. Further, the duration involved makes long-term tests with foodstuffs impractical. Food simulating liquids have been recommended to be used in place of actual foodstuffs and are as follows.

1. Distilled water
2. 3% Acetic acid (w/v) in aqueous solution
3. 8% Ethanol (v/v) in aqueous solution for foodstuffs having alcohol less than 8%
4. 50% Ethanol (v/v) in aqueous solution for foodstuffs having alcohol more than 8% and less than 50%
5. n-Heptane – shall be redistilled before use.

Foods are divided into several types in order to determine the overall migration residue (Table 4). Method for determination of migration residue depends on the type of food, simulating solvents, time and temperature (IS: 9845-1981, Code of Federal Regulations, Foods and Drugs, 1983, *Official Journal of European Community*, 1978)(Table 5). Limits for migration residues are given in Table 6.

**Metal Packaging**

Tinplate was used to make containers for food over 160 years. Many cases of food poisoning occured, due to ingestion of excessive amounts of metal. Levels of tin in food upto 250 ppm are generally tolerated by regulatory authorities and higher levels in food cause gastrointestinal disturbances. The sideseams of three piece cans are soldered with a lead/tin (98:2) solder, resulting in some lead being taken up by the food depending on the amount of solder exposed to the food and the acidity of the food. Some lead contamination may also originate from the tin coating in which it may be present as an impurity. Regulatory limits for lead in almost all countries are now 2 ppm in canned foods. The newer welded cans have eliminated solder altogether and done much to reduce the lead intake from canned foods, to about one tenth.

Aluminium has a long history of safe usage in connection with food and food packaging and is recognized as GRAS material by the US Food and Drug administration. The discovery of aluminium in senile plaques of patients with

Alzheimer's disease has led to the

suggestion that chronic exposure to low levels of aluminium in water and foods may be implicated in the etiology of this form of dementia. *The limit is 1 mg/kg body* weight per day recommended by WHO (Ranau and Oehlenschlaeger, 1997)

**Conclusions:**

Considering the importance of seafoods in the economy of our country, it is very important to devote attention to produce and market good quality seafood products for both export and internal markets. Even though we have implemented strict quality control practices for ensuring food safety for the export trade, there are no proper *guidelines and strict quality control with* reference to packaging materials used. Most of the packaging materials used are not being tested for safety aspects. In order to make the packaging materials safe, testing should be made mandatory for parameters like overall and specific migration for residual monomer content and other toxic components

**Table 1: Limits of monomer and heavy metals in plastics**

| Country | Monomer | Heavy metals |
|---|---|---|
| BIS-India | VCM in PVC-1 ppm; in food migration-10 ppb, Styrene in polystyrene-2000 ppm | Lead 1 ppm and others 0.01 ppm in PVC |
| EEC-Europe | VCM in PVC-1 ppm | Nil |
| *EPF-UK* | *VCM in PVC-1 ppm, styrene in* PS-5000 ppm | Nil |
| Japan | VCM in PVC-1 ppm, Volatile component in polytyrene-5000 ppm Vinylidine chloride in PVDC-6 ppm, Caprolactum in Nylon-15 ppm. | i) Lead, Cadmium & Barium 100 ppm each in PVDC<br>ii) 0.05 ppm Antimony & 0.1 ppm Germanium in PET. |
| FDA-USA | VCM not specified Styrene in PS-10000 ppm, Acrylonitrile in ABS plastics-11 ppm | Nil |

VCM – Vinylchloride Monomer
PVC – Polyvinyl chloride
PVDC – Polyvinylidene chloride

**Table 2: Limits of heavy metals in colors used in Plastic manufacture**

| | |
|---|---|
| Lead | 0.01 % |
| Arsenic | 0.005 % |
| Mercury | 0.005 % |
| Cadmium | 0.20 % |
| Selenium | 0.20 % |
| Barium | 0.01 % |

Table 3: Permitted additives in finished packaging materials (BIS stand.)

| Additive type | LDPE/ LLDPE | HDPE | PVC | PS | IONO MER | EAA |
|---|---|---|---|---|---|---|
| **Polymerisation residues** | 0.2% | 0.2% | — | — | 0.2% | <0.5% |
| Calcium, Aluminium, Silicon, Titanium | — | 0.2% | — | — | — | — |
| Chromium | — | 50 ppm | — | — | — | — |
| *Emulsifying agents* | 0.3% | 0.3% | 3.0% | | | |
| **Catalyst** | 0.2% | 0.2% | 0.25% | 0.2% | | |
| **Lubricants** | 2.0% | 2.0% | — | — | 2.0% | 1.0% |
| Stearyl ethylene diamine | — | — | — | — | — | 0.2% |
| Fatty acid amides | 0.2% | 0.2% | 0.3% | 0.3% | — | — |
| Microcrystalline waxes, paraffin or oil | 0.1% | — | — | — | — | — |
| Octoates, oleate, palmitate & stearate of Zinc | 2.0% | — | — | 2.0% | — | — |
| *Poly (1,2 propylene glycol)* | 0.1% | — | — | 0.1% | — | — |
| Pthalates of monovalent alcohols | 0.2% | — | 3.0% | — | — | — |
| Polyethylene glycol | | | | | | |
| Stearyl erucamide | — | — | — | 0.1% | — | — |
| N, N-bis-stearyl/palmityl ethylene *diamine* | — | — | — | — | — | — |
| Fatty alcohols | — | — | 3.0% | — | — | — |
| **Antioxidants** | 1.5% | 1.5% | — | — | 2.0% | 1.5% |
| 4,4-thio-bis (6-tbutyl-n-cresol) | 0.25% | 0.25% | — | — | — | |
| 4,4-butylidine-bis (6-tert-butyl-n-cresol) | 0.3% | 0.3% | — | — | — | |
| 1,3,5-trimethyl-2, 4,6-tris (3,5-ditert butyl-4-hydroxy-benzyl) benzene | 0.5% | 0.5% | — | — | — | |
| 2,4, dinonyl phenyl,di(4-monononylphenyl) phosphite | 0.3% | 0.3% | — | — | — | |
| 2,2-methylene-bis-6-(1 methyl-cyclohexyl) p-cresol | 0.2% | 0.2% | — | — | — | |
| Thio-bis(6-tert-butyl-n-cresol) | 0.25% | 0.25% | — | — | — | |
| **Antistatic agent** | 0.5% | 0.5% | — | — | 0.5% | 0.5% |
| Tri-iso-propanolamine | 0.5% | — | — | — | — | — |
| N-N-*bis (2-hydroxyethyl) alkyl amines* | 0.3% | 0.3% | — | — | — | — |
| Cetyl pyridinium chloride | 0.4% | 0.4% | — | — | — | — |
| N, N-bis (Polyhydroxyethyl) alkyl amino | — | 0.3% | — | — | — | — |

Table 3: Permitted additives in finished packaging materials (BIS stand.)

| Additive type | LDPE/ LLDPE | HDPE | PVC | PS | IONO MER | EAA |
|---|---|---|---|---|---|---|
| **Polymerisation residues** | 0.2% | 0.2% | — | — | 0.2% | <0.5% |
| Calcium, Aluminium, Silicon, Titanium | — | 0.2% | — | — | — | — |
| Chromium | — | 50 ppm | — | — | — | — |
| Emulsifying agents | 0.3% | 0.3% | 3.0% | | | |
| **Catalyst** | 0.2% | 0.2% | 0.25% | 0.2% | | |
| **Lubricants** | 2.0% | 2.0% | — | — | 2.0% | 1.0% |
| Stearyl ethylene diamine | — | — | — | — | — | 0.2% |
| Fatty acid amides | 0.2% | 0.2% | 0.3% | 0.3% | — | — |
| Microcrystalline waxes, paraffin or oil | 0.1% | — | — | — | — | — |
| Octoates, oleate, palmitate & stearate of Zinc | 2.0% | — | — | 2.0% | — | — |
| Poly (1,2 propylene glycol) | 0.1% | — | — | 0.1% | — | — |
| Pthalates of monovalent alcohols | 0.2% | — | 3.0% | — | — | — |
| Polyethylene glycol | | | | | | |
| Stearyl erucamide | — | — | — | 0.1% | — | — |
| N, N-bis-stearyl/palmityl ethylene diamine | — | — | — | — | — | — |
| Fatty alcohols | — | — | 3.0% | — | — | — |
| **Antioxidants** | 1.5% | 1.5% | — | — | 2.0% | 1.5% |
| 4,4-thio-bis (6-tbutyl-n-cresol) | 0.25% | 0.25% | — | — | — | |
| 4,4-butylidine-bis (6-tert-butyl-n-cresol) | 0.3% | 0.3% | — | — | — | |
| 1,3,5-trimethyl-2, 4,6-tris (3,5-ditert butyl-4-hydroxy-benzyl) benzene | 0.5% | 0.5% | — | — | — | |
| 2,4, dinonyl phenyl,di(4-monononylphenyl) phosphite | 0.3% | 0.3% | — | — | — | |
| 2,2-methylene-bis-6-(1 methyl-cyclohexyl) p-cresol | 0.2% | 0.2% | — | — | — | |
| Thio-bis(6-tert-butyl-n-cresol) | 0.25% | 0.25% | — | — | — | |
| **Antistatic agent** | 0.5% | 0.5% | — | — | 0.5% | 0.5% |
| Tri-iso-propanolamine | 0.5% | — | — | — | — | — |
| N-N-bis (2-hydroxyethyl) alkyl amines | 0.3% | 0.3% | — | — | — | — |
| Cetyl pyridinium chloride | 0.4% | 0.4% | — | — | — | — |
| N, N-bis (Polyhydroxyethyl) alkyl amino | — | 0.3% | — | — | — | — |

**Table 4: Food categorization**

| | |
|---|---|
| I | Non - acid (pH>5.0), aqueous products, may contain salt or sugar or both and including oil-in-water emulsions of low or high fat content. |
| II | Acidic (pH<5.0), aqueous products may contain salt or sugar or both and including oil-in-water emulsions of low or high fat content. |
| III | Aqueous, acid or non acid products containing free oil or fat; may contain salt and including oil-in-water emulsions of low or high fat content. |
| IV | Dairy products and modifications:<br>A. Water-in-oil emulsion, high or low fat<br>B. Oil-in-water emulsion, high or low fat |
| V | Low moisture fats and oils |
| VI | Beverages:<br>A. Non alcoholic B. Upto 8% alcohol C. Morethan 8% alcohol |
| VII | Bakery products A. Moisture bakery products with sugar containing free fat or oil<br>B. Moisture bakery products with sugar containing no free fat or oil |
| VIII | Dry solids with the surface containing no free fat or oil(no end test required) |

**Table 5: Simulating solvents for different types of food and time temperature conditions in global migration tests**

| Condition of use | Types of food (see Table 4) | Food simulating solvents<br>Water | Heptane | 8% Alcohol | 50% Alcohol |
|---|---|---|---|---|---|
| A. High temp. Heat sterilised (eg. over 100°C) | I, IV-B, VII-B | 121°C, 2 hrs. | - | - | - |
| | III IV-A, VII | 121°C, 2 hrs. | 66°C, 2h. | - | - |
| B. Boiling water sterilised | II, VII B | 100°C, 30 min. | - | - | - |
| | III, VII A | 100°C, 30 min. | 49°C, 30 min | - | - |
| C. Hot filled or | II, IV-B | Till boiling, cool to 38°C | - | - | - |
| Pasteurised above 66°C | III, IV-A | Till boiling, cool to 38°C | -<br>49°C, 15min. | - | - |
| | V | - | 49°C, 15min. | - | - |
| D. Hot filled or pasteurised below 66°C | II, IV-B, VI-B | 66°C, 2 hrs. | | | |
| | III, IV-A | 66°C, 2 hrs. | 38°C, 30min. | - | - |
| | V | | 38°C, 30min. | 66°C, 2 h. | - |
| | VI- A | - | - | - | 66°C, 2 h. |
| E. Room temp. Filled and stored (no thermal treatment in the container) | I, II, IV-B, VI-B | 49°C, 24 h. | - | - | - |
| | III, IV-A | 49°C, 24 h. | 21°C, 30h. | - | - |
| | V, VII | | 49°C, 24h. | - | - |
| F. Refrigerated storage (no thermal treatment in the container) | III, IV-A, VII-A | 21°C, 48 h. | 49°C, 24h. | - | - |
| | I,II, IV-B, VI-B VII-B | - | - | - | - |
| | - | | | | |
| | VI- A, VI-C | - | - | - | 49°C, 24h. |
| G. Frozen storage (no thermal treatment in the container) | I,II,III,IV-B,VII | 21°C, 24 h. | | | |

| | | | | | |
|---|---|---|---|---|---|
| H. Frozen or refrigerated storage: Ready-prepared foods intended to be reheated in container at the time of use: | I,II, IV-B | - | - | - | - |
| (i) Aqueous or oil-in-water emulsion of high or low fat. | I, II, IV-B VII B | 100°C, 30 min. | - | - | - |
| (ii) Aqueous, high or low free oil or fat. | III, IV-A, VII | 100°C, 30 min. | 49°C, 30min. | - | - |

**Table 6: Global Migration Limits (GML) in various specifications**

| Standard/ Country | Global Migration Limits (GML) |
|---|---|
| BIS (India), BPF/UK, EEC/Europe | *60 mg/Kg or 0.1 mg/cm² for all polymers for which* specifications are available |
| FDA/USA | a. 50 mg/lit or 0.75 mg/cm² for resinous and polymeric coatings<br>b. 21-197 mg/in² for rubber articles<br>c. 0.15 mg/in² (water) for phenol formaldehyde moulded article<br>d. 0.02-0.5 mg/in² for polyesters (depending on use and conditions)<br>e. 0.2-2.5 wt. Percent for various nylons depending in extractive solvent |
| JIS/Japan | a. 150 mg/lit for PE, PP<br>b. 30 mg/lit *for containers to be used at* >100°C<br>c. 15-30 mg/lit for Nylon |