FOOD PACKAGING

UNIT - I

Introduction

Packaging is an industrial and marketing technique for containing, protecting, identifying and facilitating the sale and distribution of agricultural, industrial and consumer products.

(or)

The packaging institute international defines packaging as an enclosure of products, items or packages in a wrapped pouch, bag, box, cup, tray, can, tube, bottle or other container form to perform one or more of the following functions as containment, protection and /or preservation, communications and utility or performance. If the device or container performs one or more of these functions it is considered as a package.

Food, the most basic necessity of life, has also developed into a lucrative business. Since people no longer have time to cook due to their busy lifestyles, packaged food is gaining popularity. Proper packaging plays a crucial role in preservation of quality and delivery of safe, wholesome food products to the end user. Packaging has been with humans for thousands of years in one form or the other. Packaging dates back to when people first started moving from place to place. Originally, skins, leaves, and bark were used for food transport. Mesolithic humans used baskets, and neolithic humans used metal containers and discovered pottery. Four thousand years ago, sealed pottery jars were used to protect against rodents, and in 1550 BC, glass making was an important industry in Egypt. Tin-plating iron became possible in AD 1200, and as steel replaced iron this method became useful after AD 1600. In 1825, Oersted first extracted aluminium. More recently, plastics were developed, particularly the first commercial plastics in the United States around 1935–1942. Over the last three decades, packaging has grown in volume and importance into one of the most significant areas of food production.

Indian food packaging industry

- Early 1950's showed slow pace but 1980-85 onwards greater change was witnessed.
- The market volume of the Indian packaging industry amounts to about Rs. 77,570 crore and has constantly grown by approximately 15 percent year per year.
- It is expected that the pace of growth will accelerate to between 20-25 percent per year.
- The highest demand for packaging and the associated equipment come from the food processing industry at 50 percent and from the pharmaceutical industry at 25 percent.
- The Indian packaging industry contributes nearly 2 per cent to the country's overall GDP.
- Food and beverages which will apply mainly packaging are using some 60-65 per cent of all packaging materials.
- Rapid urbanization increased spending power of large growing middle class, growing number of working women, changing life style/standard of living,

liberalization and organized retail sector are the catalysts to the growth of packaging.

- According to the 'India Food Report 2008' published by Research and Markets. The Indian food market is estimated to total about Rs. 8,82,350 crore.
- Food retail turnover is expected to grow from the current Rs 3,39,365 crore mark to 7,27,212 crore by 2025.
- There are about 600-700 packaging machinery manufacturers, 95 percent of which are in the small and medium sector located all over India.
- Indian packaging machinery imports are around Rs 606 crore (20-25 percent) while the Indian packaging machinery exports are rapidly growing.
- Germany and Italy are the largest suppliers of packaging machinery to India but focus is now shifting to Taiwan and China.
- Indian companies are now placing increasing emphasis on attractive and hygienic packaging. This promises enormous potential for the future.
- Today consumer is showing greater awareness towards food packaging for assurance on quality, quantity and hygiene of foods.
- Potential benefits offered by unit packaging in retailing are also well realized.
- Self-service groceries, super markets (especially in urban sector) increased the demand for retail packs.
- Changes in purchasing power, family sizes, frequency of shopping, inflation, changed food habits lead to changes in packaging material and pack sizes.
- Every sector of user industry has become package conscious and the need for scientific, functional and aesthetic packaging is being realized.
- Nationwide marketing becoming common trend for processed foods.
- Expanding electronic media unprecedented audience reach (Paper, radio, TV) widen market of packaged food.
- Thus, dramatic change is observed bringing overall revolution in packaging concept, style and forms.
- New concepts like aseptic packaging, system packaging, thermoforming, in-pack sterilization of foods have taken industrial footing in Indian market.

Need of packaging

Packaging is the art and science of encasing food products to safeguard them during distribution, sale, and storage. It is also the process of designing and evaluating packages. Product packaging design not only lends aesthetic appeal, but also helps your products stand out from those of others. Packaging performs five main functions (5Ps): product containment, preservation and quality, presentation and convenience, protection, and provide storage history.
1. Product containment: The primary purposes of packaging are containment and protection. Containment refers to holding goods in a form suitable for transport, whereas protection refers to safekeeping goods in a way that prevents significant quality deterioration.

2. Preservation by maintaining quality: The second function of packaging is to control the local environmental conditions to enhance storage life and safety.

3. Presentation and convenience: It is important to display the product in an attractive manner to the potential buyer. For a package to be effective, it must present the product well and should do its own publicity. In many cases, packaging provides convenience to the consumers. Eating styles, such as ready-to-eat meals, snacks, and microwaveable ready meals, have been changed over the years, which need innovation in packaging. For children, the packaging might represent innovation or fun. Other conveniences could be ease of opening, smaller portions and tamper-proof methods.

4. Protection during distribution and processing: The fourth function is to protect the product during transit to the consumer. Packaging can handle better when there are challenges in food distribution chain, such as heat, humidity, or dew. It is important to be aware of the distribution challenges and designing the package to suit it.

5. Provide storage history: Time-temperature indicator (TTI) is effective for predicting microbial concentrations and other parameters of food quality during shipping and storage. It helps in ensuring proper handling and provides a gauge of product quality for sensitive products in which temperature control is imperative to efficacy and safety. TTIs are tags that can be applied to individual packages or shipping cartons to visually indicate whether a product has been exposed to time and temperature conditions that adversely affect the product quality. TTI could be used in chilled foods to identify temperature abuse during storage and distribution.

Packaging Requirements

Some of the important general requirements of food packages are given below

1. Be nontoxic
2. Protect against contamination from microorganisms
3. Act as a barrier to moisture loss or gain and oxygen ingress
4. Protect against ingress of odours or environmental toxicants
5. Filter out harmful UV light
6. Provide resistance to physical damage
7. Be transparent, be tamper – resistant or tamper – evident
8. Be easy to open
9. Have dispensing and resealing features
10. Be disposed of easily
11. Meet size, shape and weight requirements
12. Have appearance, printability features
13. Be low cost
14. Be compatible with food
15. Have special features such as utilizing groups of products together.

Functions of packaging

Efficient packaging is a necessity for every kind of food, whether it is fresh or processed. It is an essential link between the food producer and the consumer, and unless performed correctly the standing of the product suffers and customer goodwill is lost. The basic functions of packaging are more specifically stated.

1. Containment

The containment function involves the ability of the packaging to maintain its integrity during the handling involved in filling, sealing, processing (in some cases, such as retorted, irradiated, and high-pressure-processed foods), transportation, marketing, and dispensing of the food.

2 Protection

The need for protection depends on the food product but generally includes prevention of biological contamination (from microorganisms, insects, rodents), oxidation (of lipids, flavors, colors, vitamins, etc.), moisture change (which affects microbial growth, oxidation rates, and food texture), aroma loss or gain, and physical damage (abrasion, fracture, and/or crushing). Protection can also include providing tamper-evident features on the package. In providing protection, packaging maintains food safety and quality achieved by refrigeration, freezing, drying, heat processing, and other preservation of foods.

3 Communication

The information that a package provides involves meeting both legal requirements and marketing objectives. Food labels are required to provide information on the food processor, ingredients (including possible allergens in simple language), net content, nutrient contents, and country of origin. Package graphics are intended to communicate product quality and, thus, sell the product. Bar codes allow rapid check-out and tracking of inventory. Other package codes allow the determination of food production location and date. Various open dating systems inform the consumer about the shelf life of the food product. Plastic containers incorporate a recycling code identification of the plastic material.

4 Preservation

Product protection is the most important function of packaging. Protection means the establishment of a barrier between the contained product and the environment that competes with a man for the product.

5 Convenience

Providing convenience (sometimes referred to as utility of use or functionality) to consumers has become a more important function of packaging. Range of sizes, easy handling, easy opening and dispensing, resealability, and food preparation in the package are examples of packaging providing convenience to the consumer.

6 Unitization

Unitization is an assembly or grouping of a number of individual items of products or packages into a single entity that can be more easily distributed, marketed, or purchased as a single unit. For example: a paperboard folding carton containing three flexible material pouches of seasoning or soup mix delivers more product to a consumer than does a single pouch. A paperboard carton wrapped around 12 beer bottles provides more desired liquid refreshment for home entertainment than does an attempt to carry individual bottles in one's hands.

Unitization reduces the number of handlings required in physical distribution and, thus, reduces the potential for damage. Because losses in physical distribution are significantly reduced with unitization, significant reductions in distribution costs are affected.

7 Information about the product

Packaging is one of the major communication media. Usually overlooked in the measured media criteria, the packaging is the main communications link between the consumer or user and the manufacturer, at both the point of purchase and the point of use. Packaging educates consumers about requirements, product ingredients and uses etc.

8 Presentation

Material type, shape, size, colour and merchandising display units etc. of packaging improve display of food.

9 Brand communication

Packaging provides brand communication to the consumers by the use of typography, symbols, illustrations, advertising and colour, thereby creating visual impact.

10 Promotion

Packaging helps to promote the food as it informs to consumers about many offers i.e. free extra product, new product, money off etc.

11 Economy

The package is also an important part of the manufacturing process and must be efficiently filled, closed, and processed at high speeds in order to reduce costs. It must be made of materials which are rugged enough to provide protection during distribution but be of low enough cost for use with foods. Packaging costs, which include the materials as well as the packaging machinery, are a significant part of the cost of manufacturing foods, and in many cases, these costs can be greater than the cost of the raw ingredients used to make the food. Therefore, packaging materials must be economical, given the value of the food product.

Other functions of packaging

Other functions of packaging include apportionment of the product into standard units of weight, measure, or quantity prior to purchase. Yet another objective is to facilitate product use by the consumer with devices such as spouts, squeeze bottles, and spray cans. Aerosols not only serve as dispensers, but also prepare the product for use, such as aerating the contained whip toppings. Still other forms of packaging are used in further preparation of the product by the consumer, for example tea bags that are plastic-coated, porous paper pouches, or frozen dinner trays, which were originally aluminum and now are fabricated from other materials such as crystallized polyester and polyester-coated paperboard.

Classification of Packaging

Primary packaging - is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents (viz. butter in parchment paper).

Secondary packaging - is outside the primary packaging – perhaps used to group primary packages together (viz. paper board pack containing butter wrapped in veg. parchment paper).

Tertiary packaging - is used for bulk handling, warehouse storage and transport shipping. The most common form is a palletized unit load that packs tightly into containers (viz. Boxes containing 20-25 or 50 butter packs are put together).

Hazards acting on package during transportation and storage

Mechanical hazard: Impact (vertical, horizontal), stationary package impacted by another, vibration, compression, Racking or deformation, piercing, puncturing, tearing etc.

Climatic hazard: (High / low temperature / pressure) light, liquid/water (fresh / polluted), dust, and water vapour, R.H.

Biological hazard: (Microorganisms, fungi, moulds, bacteria, beetles, moths, flies, ants, termites, mites, rodents (rats and mice), birds.

Contamination by other goods

• By materials of adjacent packs

• By leaking contents of adjacent packs

• Radioactivity.

Packaging and Labelling Laws

Packaging laws and Regulations

The Indian Government has enacted laws to take care of quality standards of packaged foods. Standards have also been fixed for the particular kind of packaging required to be undertaken, depending on the product to be packed. The regulations on quality standards of packaging that govern food products in our country are given as under:

Standard Weights and Measures Act (SWMA) 1976 and the Standards of Weight and Measures (Packaged Commodities) Rule, 1977
It is mandatory and applicable to all commodities including foods. The emphasis is on quantity and value declaration on the label to facilitate value comparisons and protect consumer interests. The standard specifies quantities to be packed, expressions to be avoided and size of type depending on the size of the panel in a package.
The SWMA requires certain declaration to be made on every retail package, which includes

common/ generic name of the product, net quantity, retail sale price, unit sale price, month and year of manufacturing or pre-packing, and name and address of the manufacturer or the packer. As far as possible, all declarations required to be made under SWMA should appear on the principal display panel (PDP) of the package.

Prevention of Food Adulteration Act, 1954 and the Prevention of Food Adulteration Rules, 1955

This is basically intended to protect health and safety of consumer and is mandatory for internal trade. The labelling rules are very elaborate and applicable to all packaged foods. The declarations include product name, net quantity, batch number, month and year of manufacture and additives incorporated and ingredients.

Fruit Products Order, 1955

This is concerned mainly with the regulation of quality and hygiene of fruit and vegetable products including beverages, syrups etc and is mandatory for export and internal trade. It also specifies the type of packages that can be used for various fruit and vegetable products. All labels should be approved by the authority and should carry the license number allotted. The batch/code number along with the date of manufacturing should also be declared.

Meat Food Products Order, 1973

This order is mandatory and regulates the licensing and labelling of meat products. It also specifies the type of packages that can be used for various meat products. All labels have to be approved by the licensing authority and number should be declared on the label.

Agriculture Marketing (AGMARK) Rules, 1937

Agricultural products such as nuts, ghee, honey, pulses, spices and condiments, vegetable oils etc. are covered under AGMARK for their quality parameters. The Agmark rules also specify the type of packages that can be used and labeling declarations that have to be given. It is voluntary for internal trade and compulsory for export of modified products.

Bureau of Indian Standards (BIS) Act, 1986 and BIS rules, 1987

The BIS has formulated specifications for packaging materials, packages and components. Also, it specifies the types of packaging materials that can be used for various types of food products. These specifications are voluntary for most of the foods, but are compulsory for certain items like food colours and packaged drinking water.

Food Safety and Standards Act, 2006 and Food Safety and Standards (Packaging and Labelling) Regulations, 2011

Under Food Safety and Standards Act, 2006, the regulations on packaging and labelling has come into force on/ after 5.8.2011 as Food Safety and Standards (Packaging and Labelling) Regulations, 2011, that overrides all existing rules and regulations related to food packaging and labelling.

Labelling of the package

Labelling of package is done to inform the customer about the product, which is present in the package.

Food labelling can be defined as the primary means of communication between the producer and the seller of food on one hand and the purchaser and consumer on the other.

Label is a piece of paper or any other material (such as tag, brand, mark, pictorial or other descriptive method) on which the legend and design concerning the product is printed, stenciled, marked, embossed or impressed on. Label is affixed to a container/article containing the product.
Mandatory labelling requirements of pre-packaged foods indicate that every package of food shall carry the following information on the label:

- Name of the food
- List of ingredients
- Declaration of food additives
- Name and address of manufacturing units/ importer
- Country of origin
- Net contents and drained weight
- Lot/Code/Batch identification
- Date of manufacture or packing
- Date marking i.e. Expiry date and Best Before Date
- Instructions for use

The Gazette of India stipulates that all food products packed should have a label indicating whether it is totally vegetarian or not. A green dot contained in a green square indicates vegetarian origin, whereas, a brown dot in a brown square denotes that the product or ingredients are non-vegetarian.
Apart from these, the Gazette of India stipulates certain additional mandatory requirements on packaged food items. These include quantitative labelling of ingredients and international irradiated foods symbol in close proximity to the name or brand of the food.

Nutrition labelling and nutrition claims:
Nutrition labelling is a description of the nutrient content of a food and is intended to guide the consumer in food selection. It consists of two components namely nutrient declaration, which means a standardized statement or listing of the nutrient content of a food and supplementary nutrition information like serving size, claims etc.
The nutrition label indicates nutritional facts to help find information fast and make general comparison without making a lot of calculations between different food products. The serving size is fixed so that the size of one serving is same for different brands of the same food, which makes comparison easier between different products. The dietary values label contains information regarding overall diet.

Nutrition claims, on the other hand, means any representation which states, suggests or implies that a food has a particular nutritional properties including but not limited to the energy value and to the content of protein, fat and carbohydrates, as well as, the content of vitamins and minerals. The information on ingredients; nutrients as a mandatory part of nutrition labelling, and quantitative or qualitative declaration of certain nutrients or ingredients on the label if required by national legislation are not included under nutrition claims.

Bar coding of food products:
Coding denotes assignment of numerical, alphabetical or symbolic identification mark to containers, packaging material or articles to provide information concerning the qualities of

the contents or containers or date, plant or line in which it was manufactured. A common form of coding the packaged food is through bar coding. It is done in the form a Universal Product Code (UPC) or the bar code.

A bar code is a series of bars and spaces arranged according to the encoding rules of a particular specification in order to represent data. Its purpose is to represent information in a form that is machine-readable. The bar codes are printed as labels on packages on consumer packs for laser reading at retail checkouts. This makes the process much easier and faster and avoids the need for individual price labelling of packs and allows itemized bills to be produced for customers.

Bar coding technology is used extensively in the supply chain of goods ready for shipment and as a means of inventory control. For example, corrugated board shipping containers are bar coded to inform the carrier about the destination. A manufacturer’s code is printed on to the containers to identify the factory, the production line and the shift during which the product was made.

UNIT – II

PACKAGING MATERIALS

PAPER/PAPERBOARD

Pulp is the raw material for the production of paper, paperboard, corrugated board and similar manufactured products. It is obtained from plant fiber and is, therefore, a renewable resource. Today about 97 percent of the world's paper and board is made from wood pulp, and about 85 percent of the wood pulp used is from spruces, firs and pines – coniferous trees that predominate in the forests of the North Temperate Zone. There are three main constituents of wood cell wall:

- **Cellulose**

This is a long chain, linear polymer built-up of a large number of glucose molecules and is the most abundant, naturally occurring organic compound. Cellulose is moderately resistant to the action of chlorine and dilute sodium hydroxide under mild conditions but is modified or dissolved under more severe conditions. It is relatively resistant to oxidation and therefore bleaching operations can be used to remove small amounts of impurities such as lignin without appreciable damage to the strength of the pulp.

- **Hemicelluloses**

These are lower molecular weight mixed sugar polysaccharides consisting of one or more of the following molecules: Xylose, mannose, arabinose, and galactose. Hemicelluloses are usually soluble in dilute alkalis.

- **Lignin**

This is a highly branched, thermoplastic polymer of uncertain size, built up largely from substituted phenyl-propane units. It has no fibre-forming properties and is attacked by chlorine and sodium hydroxide with the formation of soluble, dark brown derivatives. It softens at about 160^{o}C.

MANUFACTURE OF PAPER AND BOARD

Paper and board production involve two steps. First, the fibres need to be produced. This is done in a pulp mill where the pulp is produced using chemical or/and mechanical processes. Pulp production can be integrated with paper production, or the pulp can be produced in a separate pulp mill. The paper itself is then produced on a paper machine from a mixture of fibres, chemicals and additives.

1. The preparation and the cleansing of the pulp: This untwists the fibers. Beating is a mechanical treatment intended for swelling, fibrillating and shortening the fibres. The result is a better sheet formation and the development of paper’s mechanical properties.

2. Before sending to the paper machine: The pulp is initially purified, and diluted and air bubbles are eliminated. Sometimes pulp is also bleached if made from recycled paper.

3. The wet-end part: Raw material fibres and chemicals (and 99% of the water) are pumped to the head box, which feeds the stock evenly onto the wire section. This is a woven plastic mesh conveyor belt that can be 35 metres long and up to 10 metres wide. As the paper stock flows from the head box onto the wire, the water drains away through the mesh leaving small fibres as a mat on top of the mesh. The paper machine can travel at speeds of up to 2000 m/minute and by the time the paper stock has travelled halfway down the wire, a high percentage of water has drained away. By the time the thin mat of fibres has reached the end of the wire section, it has become a sheet of paper, although very moist and of little strength.

4. **The press section:** This section consists of a number of sets of felts and heavy cylinders through which the moist paper web passes. More water is pressed out to felts and drawn away by suction. Pressure binds the fibres together and consolidates the web.

5. Dryer: This section consists of a large number of steam-heated drying cylinders which have a temperature of slightly over 100°C. Synthetic drier fabrics carry the paper web around the cylinders until the paper is dry.

6. Coating/Calendering: In many applications, the surface of the sheet needs improvement in order that any characters imposed on the sheet be legible. This is achieved by calendering, a process which reorients the surface fibres in the base sheet of paper (or the coating applied to the surface) by the use of pressure. This serves to smooth the surface, control surface texture and develop a glossy finish. Such papers are known as machine-finished.

7. Finishing: At the end of the drying process, the sheet is smoothed using an "ironing" method, which consists of hot polished iron rollers mounted in pairs with synthetic material rollers, one above the other. This also helps to consolidate, polish and glaze the surface of the paper: the characteristics of the surface of the sheet are improved.

8. Shipping: Still travelling at very high speeds, the paper comes off the machine ready for reeling up into large reels (called parent reels), which can be cut or slit into smaller ones, according to customer requirements. These large reels are produced and changed without any interruption of the production process.

9. Quality control: Sensors and computers verify parameters such as the production speed, pressure, and resistance at every step of the process to ensure that the paper or board is of consistently high quality. Moreover, for food contact applications, microbiological, chemical and organoleptic controls have to be carried out. A board machine often has several formation devices in the wet end producing a multiple sheet, combined on the forming table and press. The basis weight of the boards can be as high as 500 g/m2, whereas the printing and writing papers are usually 40-120 g/m2. Paper and board machines are each different – the size of the production capacity and technology varies. Each one is tailored to the specification of the paper mill.

ADVANTAGES OF PAPER PACKAGING

- Versatile
- Rigid
- Semi-rigid
- Flexible

- Mechanical protection
- Logistics functions
- Barrier to light
- Renewable resource
- Recyclable
- Biodegradable

TYPES OF PAPER

Paper is divided into two broad categories: Fine papers, generally made of bleached pulp, and typically used for writing paper, bond, book and cover papers, and coarse papers, generally made of unbleached Kraft softwood pulps and used for packaging. The main types of packaging papers are:

Kraft paper

Natural kraft paper is the strongest of the common packaging papers and is used when maximum strength is required, such as in industrial bags, grocery bags, inner plies of multiwall sacks, or plain wrapping paper. This is typically a coarse paper with exceptional strength, often made on a fourdrinier machine and then either machine – glazed on a Yankee dryer or machine-finished on a calender. Kraft paper is produced during the sulfate pulping process – the chemical conversion of wood into wood pulp. The material is FDA approved for direct food contact.

Bleached paper

These are manufactured from pulps which are relatively white, bright and soft and receptive to the special chemicals necessary to develop many functional properties. They are generally more expensive and weaker than unbleached papers. Their aesthetic appeal is frequently augmented by clay coating on one or both sides. Bleached kraft paper is the strongest white paper. It is used where strength, printability, and appearance are important, such as flour and sugar bags, labels, and envelopes. Bleached kraft fibers are also used in the production of solid bleached sulfate (SBS), a high-quality paperboard. Bleaching is done during the paper manufacturing process while the paper is still in pulp form. Bleaching can also help to prevent discolouration during storage, stop yellowing during exposure to sunlight, and maintain the strength of the material during the rest of the manufacturing process.

Greaseproof paper

This is a translucent, machine-finished paper which has been hydrated to give oil and grease resistance. Prolonged beating or mechanical refining is used to break the cellulose fibers which absorb so much water that they become superficially gelatinized and sticky. Greaseproof paper is typically a sheet of unbleached paper with a specialized silicone coating. This coating provides a heat-proof, non-stick surface, making it indispensable in cooking, baking and food packaging.

Glassine paper

Glassine paper derives its name from its glassy, smooth surface, high density and transparency. It is produced by further treating grease-proof paper in a super calendar.

Vegetable parchment

Vegetable parchment takes its name from its physical similarity to animal parchment, which is made from animal skins. Because of its grease resistance and wet strength, it strips away easily from food material without defibring, thus finding use as an inter-leaver between slices of food such as meat or pastry. It was first used for wrapping fatty foods such as butter. Vegetable parchment paper is made by running sheets of paper pulp through a bath of sulfuric acid (a method similar to the way tracing paper is made) or sometimes zinc chloride. This process partially dissolves or gelatinizes the paper. This treatment forms a sulfurized cross-linked material, with high density, stability, heat resistance, grease resistance, water resistance, no loose fibres as well as low surface energy — thereby imparting good non-stick or release properties. It has a semi-translucent appearance (which is how you can identify it Vs greaseproof paper). The parchment can have its properties further extended by the application of a silicone coating (normally both sides) which makes it heat resistant and gives it a non-stick surface and therefore suitable for baking.

Tissue paper

Tissue papers range from semi-transparent to totally opaque, and can be waxed. They are generally either machine – Finished (MF) or machine – Glazed (MG). MG papers may also be machine finished to improve the smoothness on both sides.

Waxed paper

Waxed papers provide a barrier against the penetration of liquids and vapours. Wet waxed papers have a continuous surface film on one or both sides achieved by shock-chilling the waxed web immediately after the application of the wax. This also imparts a high degree of gloss on the coated surface. Dry waxed papers are produced using heated rolls and do not have a continuous film on the surfaces. Wax-laminated papers are bonded with a continuous film of wax which acts as an adhesive. The primary purpose of the wax is to provide a moisture barrier and heat-sealable-able laminate.

Waxed Coated Kraft Paper

Kraft paper is produced from virgin fibre and is a very strong, durable paper. It tends to be wax coated to make it water-repellent and is seen as a very traditional product for the wrapping of foods, especially high-moisture foods. It has a very premium, artisan feel and appearance. It is however unsuitable for any baking or cooking applications as the wax has a low melting temperature and will soon start to smoke. It tends to be bleached (white) or unbleached (natural brown) and is a great medium for printing.

TYPES OF PAPER BOARDS

Paperboards are made from the same raw materials as papers. They normally are made on the cylinder machine and consist of two or more layers of different quality pulps. The types of paperboard used in food packaging include:

Chipboard

Chipboard is made from a mixture of repulped waste with chemical and mechanical pulp. It is dull grey in colour and relatively weak. It is available lined on one side with unbleached, semi or fully-bleached chemical pulp. A range of such paperboards are available, with different quality liners. Chipboards are seldom used in direct contact with foods, but are used as outer cartons when the food is already contained in a film pouch or bag e.g. breakfast cereals.

Duplex board

Duplex board is a kind of paperboard or cardboard. It is called duplex board because it is made up of two layers, or plies. The exterior of the board is very often coated to make it more water-resistant and to give it a glossy sheen.

Duplex board is tough, thin and able to take on a bright white appearance, unlike common corrugated cardboard. It is used for some frozen foods, biscuits and similar products, paper plates and cups.

Milk cartons can be made out of duplex board, and wines and liquors packaged in boxes may be inside duplex board containers. Duplex board used in the food industry is not made from recycled paper for hygiene reasons.

Solid white board

In Solid white board, all plies are made from fully, bleached chemical pulp. It is used for some frozen foods, food liquids and other products requiring special protection.

Corrugated paper board/box

Corrugated is made up of three layers of paper that include an inside liner, an outside liner, and fluting with a ruffled shape, which runs in between the two. This type of material enhances the packaging process across the board. Corrugated board is the most common form of secondary food packaging and is used by virtually every industry in the manufacture of corrugated boxes and shipping containers. It is a substitute for wooden boxes and it is Eco-friendly packaging. Corrugated box is made of craft paper and is manufactured with the cushioning affect. The boxes are lightweight. Corrugated boxes are the favored packaging for exports since developed countries are particular about eco-friendly packaging. These boxes by their very nature are destroyable and recyclable. Printing and stencilling are possible and are designed specifically for display purposes. So corrugated boxes can serve as sales tools. They occupy less storage space and their weight reduce the cost of freight. These boxes are designed with special ventilation, like air holes for perishables such as vegetables, fruits and frozen foods.

GLASS

The American Society for Testing Materials defined glass as 'an inorganic product of fusion which has cooled to a rigid state without crystallizing' (ASTM, 1965). The atoms and molecules in glass have an amorphous random distribution. Scientifically this means that it has failed to crystallize from the molten state, and maintains a liquid-type structure at all temperatures. Glass is hard and brittle, with a conchoidal (shell-like) fracture.

GLASS COMPOSITION

Glass is primarily formed from oxides of metals, with the most common being dioxide which is common sand. Glass is made by mixing several naturally-occurring inorganic compounds at a temperature above their melting points. The molten mixture is then cooled to produce a noncrystalline, amorphous solid. The main ingredient is silica (sand) (SiO_2) which serves as the network-forming backbone of the glass. However, silica has a very high melting temperature, and molten silica has a high viscosity that makes it difficult to form into shapes. Adding soda (Na_2O) modifies the silica network by disrupting some of the Si-O bonds, resulting in lower melting temperature and viscosity but reduced resistance to dissolving in water. Thus, lime (CaO) is added as a network stabilizer, with the result that durability is increased but the tendency to crystallize is also increased. Finally, alumina (Al_2O_3) is added as an intermediate to resist crystallization. Minor amounts of colourants are added to produce coloured glass, including chromium oxide for green, cobalt oxide for blue, nickel oxide for violet, selenium for red, and iron plus sulfur and carbon for amber. Amber provides the best protection for light-sensitive foods and beverages, transmitting very little light with wavelength shorter than 450 nm.

TYPES OF GLASS

White flint (clear glass)

Colorless glass, known as white flint, is derived from soda, lime and silica. This composition also forms the basis for all other glass colors. A typical composition would be: silica (SiO_2) 72%, from high purity sand; lime (CaO) 12%, from limestone (calcium carbonate); soda (Na_2O) 12%, from soda ash alumina (Al_2O_3), present in some of the other raw materials or in feldspar-type aluminous material; magnesia (MgO) and potash (K_2O), ingredients not normally added but present in the other materials. Cullet, recycled broken glass, when added to the batch reduces the use of these materials.

Pale green (half white)

Where slightly less pure materials are used, the iron content (Fe_2O_3) rises and a pale green glass is produced. Chromium oxide (Cr_2O_3) can be added to produce a slightly denser blue green colour.

Dark green

This colour is also obtained by the addition of chromium oxide and iron oxide.

Amber (brown in various colour densities)

Amber is usually obtained by melting a composition containing iron oxide under strongly reduced conditions. Carbon is also added. Amber glass has UV protection properties and could well be suited for use with light-sensitive products.

Blue

Blue glass is usually obtained by the addition of cobalt to a low-iron glass. Almost any colored glass can be produced either by furnace operation or by glass colouring in the conditioning forehearth. The latter operation is an expensive way of producing glass and commands a premium product price. Forehearth colors would generally be outside the target price of most carbonated soft drinks.

ADVANTAGES OF GLASS

- Inert
- Total barrier to Gas, Water vapour, Aroma
- Good compression resistance
- Good heat resistance
- Allow viewing of product
- Microwavable
- Customer perception of high quality
- Reclosable
- Recyclable
- Refillable

DISADVANTAGES OF GLASS

- glass is a heavy packaging material than others.
- breakage and subsequent loss of product
- hermetic seal that is more easily compromised
- the increased possibility of broken glass contaminating the finished product
- color changes of the product due to exposure of light
- expensive food packaging material

Attributes of food packaged in glass containers

The glass package has a modern profile with distinct advantages, including:

Quality image

Consumer research by brand owners has consistently indicated that consumers attach a high quality perception to glass packaged products and they are prepared to pay a premium for them, for specific products such as spirits and liqueurs.

Transparency

It is a distinct advantage for the purchaser to be able to see the product in many cases, e.g. processed fruit and vegetables.

Surface texture

Most glass is produced with a smooth surface, other possibilities also exist, for example, for an overall roughened ice-like effect or specific surface designs on the surface, such as text or coats of arms. These effects emanate from the moulding but subsequent acid etches treatment is another option.

Colour

A range of colours is possible based on the choice of raw materials. Facilities exist for producing smaller quantities of nonmainstream colours.

Decorative possibilities

Decorative possibilities include ceramic printing, powder coating, coloured and plain printed plastic sleeving and a range of labelling options.

Impermeability

All practical purposes in connection with the packaging of food, glass is impermeable.

Chemical integrity

Glass is chemically resistant to all food products, both liquid and solid. It is odourless.

Design potential

Distinctive shapes are often used to enhance product and brand recognition.

Heat processable

Glass is thermally stable, which makes it suitable for hot-filling and the in-container heat sterilization and pasteurization of food products.

Microwaveable

Glass is open to microwave penetration and food can be reheated in the container. Removal of the closures is recommended, as a safety measure, before heating commences, although the closure can be left loosely applied to prevent splashing in the microwave oven. Developments are in hand to ensure that the closure releases even when not initially slackened.

Tamper evident

Glass is resistant to penetration by syringes. Container closures can be readily tamper-evidenced by the application of shrinkable plastic sleeves or in-built tamper evident bands. Glass can quite readily accept preformed metal and roll-on metal closures, which also provide enhanced tamper evidence.

Ease of opening

The rigidity of the container offers improved ease of opening and reduces the risk of closure misalignment compared with plastic containers, although it is recognized that vacuum packed food products can be difficult to open. Technology in the development of lubricants in closure seals, improved application of glass surface treatments together with improved control of filling and retorting all combine to reduce the difficulty of closure removal. However, it is essential in order to maintain shelf life that sufficient closure torque is retained, to ensure vacuum retention with no closure back-off during processing and distribution.

UV protection

Amber glass offers UV protection to the product and, in some cases, green glass can offer partial UV protection.

Strength

Although glass is a brittle material glass containers have high top load strength making them easy to handle during filling and distribution. While the weight factor of glass is unfavorable compared with plastics, considerable savings are to be made in warehousing and distribution costs. Glass containers can withstand high top loading with minimal secondary packaging. Glass is an elastic material and will absorb energy.

METAL

Two basic types of alloyed metals are used in food packaging i.e. steel and aluminum. Steel is used primarily to make rigid cans, whereas aluminum is used to make cans as well as thin aluminum foils and coatings. Nearly all steel used for cans was coated with a thin layer of tin to inhibit corrosion, and called as “tin can”. The reason for using tin was to protect the metal can from corrosion by the food. Tin is not completely resistant to corrosion, but its rate of reaction with many food materials is considerably slower than that of steel.

The strength of the steel plate is another important consideration especially in larger cans that must withstand the pressure stresses of retorting, vacuum canning and other processes.

Aluminum is light weight, resistant to atmospheric corrosion, and can be shaped or formed easily. However, aluminum has considerably less structural strength than steel at the same gauge thickness. This means that aluminum has limited use in cans such as those used with retorted foods. Aluminum works well in very thin beverages cans that contain internal pressure such as soda or beer. This internal pressure from $CO2$ gives rigidity to the can. Aluminum in contact with air forms an aluminum oxide film which is resistant to atmospheric corrosion. However, if the oxygen concentration is low, as it is within most foods containing cans, this aluminum oxide film gradually becomes depleted and the underlying aluminum metal is then no longer highly resistant to corrosion.

ADVANTAGES OF METAL CONTAINERS

- Total barrier to Gas, Water vapor, Aroma

- Good compression resistance

• Good heat resistance

• Good thermal and physical shock resistance

• Light protection

• Recyclable

DISADVANTAGES OF METAL

• metal is corrosive material, that can affect the quality of food

• metal is a moderately heavy packaging material.

• Can't see the food content after packaging

• Due to multi-step can manufacturing process, can making is time taking process

• Metal can react with the food material.

METALS USED IN PACKAGING

The metal materials used in food packaging are aluminum, tinplate and electrolytic chromium-coated steel (ECCS). Aluminum is used in the form of foil or rigid metal.

Aluminum Foil

Aluminum foil is produced from aluminum ingots by a series of rolling operations down to a thickness in the range 0.15–0.008 mm. Most foil used in packaging contains not less than 99.0% aluminum, with traces of silicon, iron, copper and in some cases, chromium and zinc. Foil used in semi rigid containers also contains up to 1.5% manganese. Foil is a bright, attractive material, tasteless, odorless and inert with respect to most food materials. For contact with acid or salty products, it is coated with nitrocellulose or some polymer material. It is mechanically weak, easily punctured, torn or abraded. Foil is used as a component in laminates, together with polymer materials and, in some cases, paper. Examples of foods packaged in this way include dried soups, sauce mixes, salad dressings and jams. Foil is included in laminates used for retortable pouches and rigid plastic containers for ready meals. It is also a component in cartons for UHT milk and fruit juices.

Tin

Tinplate

Tinplate is the most common metal material used for food cans. It consists of a low-carbon, mild steel sheet or strip, 0.50–0.15 mm thick, coated on both sides with a layer of tin. This coating seldom exceeds 1% of the total thickness of the tinplate. The mechanical strength and fabrication characteristics of tinplate depend

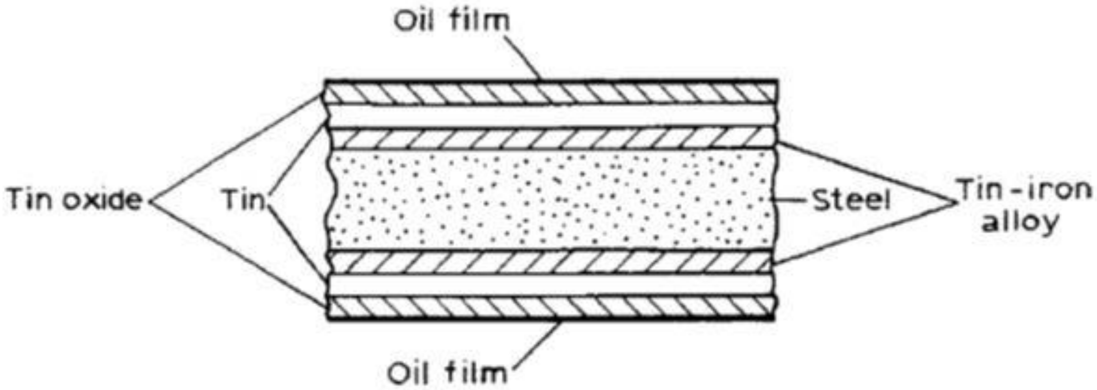

Figure 9.1: Structure of tin plate

on the type of steel and its thickness.

Tin coating

The role of tin coating is an essential component of the can construction and plays an active role in determining shelf life. The most significant aspect of the role of the tin coating is that it protects the steel base-plate which is the structural component of the can. Without a coating of tin, the exposed iron would be attacked by the product and this would cause serious discoloration and off-flavors in the product and swelling of the cans; in extreme cases the iron could be perforated and the cans would lose their integrity. The second role of tin is that it provides a chemically reducing environment, any oxygen in the can at the time of sealing being rapidly consumed by the dissolution of tin. This minimizes product oxidation and prevents colour loss and flavor loss in certain products.

Tin toxicity

High concentrations of tin in food irritate the gastrointestinal tract and may cause stomach upsets in some individuals, with symptoms which include nausea, vomiting, diarrhoea, abdominal cramps, abdominal bloating, fever and headache. Tin corrosion occurs throughout the shelf life of the product. It is therefore imperative to take steps to reduce the rate of corrosion. Accelerating factors include heat, oxygen, nitrate, some chemical preservatives and dyes, and certain particularly aggressive food types (e.g. celery, rhubarb). A high vacuum level is one effective method of reducing the rate of tin pick-up in cans with un-lacquered components.

Electrolytic Chromium-Coated Steel (ECCS)

Electrolytic chromium-coated steel (ECCS), sometimes described as tin-free steel, is finding increasing use for food cans. It consists of low-carbon, mild CR or DR steel coated on both sides with a layer of metallic chromium and chromium sesquioxide, applied electrolytically. ECCS is less resistant to corrosion than tinplate and is normally lacquered on both sides. It is more resistant to weak acids and sulphur staining than tinplate.

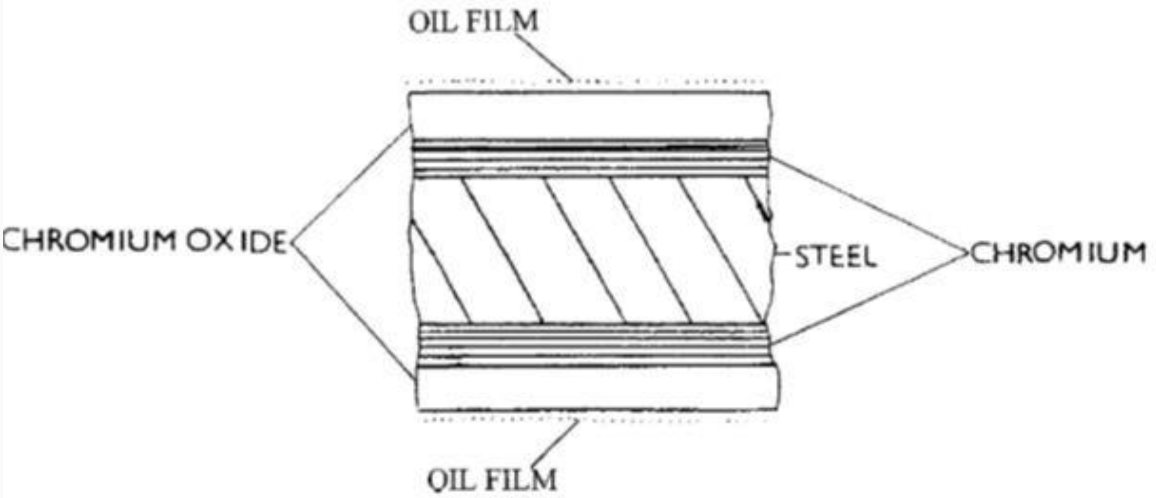

Figure1: Structure of ECCS plate

Aluminum Alloy

Hard-temper aluminum alloy, containing 1.5–5.0% magnesium, is used in food can manufacture. It is lighter but mechanically weaker than tinplate. It is manufactured in a similar manner to aluminum foil. It is less resistant to corrosion than tinplate and needs to be lacquered for most applications.

Lead

Lead was a problem with older, soldered cans but levels are now very low. However, some tinplate is contaminated with minimal amounts of lead. The manufacture of lead soldered cans may still be found in the developing world.

Lacquers

The presence of lacquer or enamel very effectively limits dissolution of tin into the product, and so the use of lacquers is becoming increasingly common, even with those products which were previously packed in plain tinplate cans. There are several different types of lacquer in common use today. By far the most common type is the Epoxy Phenolic group, which are suitable for packing meat, fish, vegetable and fruit products. These have largely replaced the oleoresinous group, which had a similar wide range of application. Some canners use cans lacquered with vinyl resins, which have the important quality of being free from any taste and odor, and are therefore particularly suitable for dry packs such as biscuits and powders, but also some drinks. White vinyl lacquers have been used where staining of the underlying metal caused by reaction with the product is a problem. Also, white vinyl lacquers have been used for marketing reasons in order to present a hygienic/clinical appearance and not the aesthetically undesirable corrosion patterns on tinplate.

PLASTIC

Plastic is an organic macromolecular compound obtained by polymerisation, polycondensation, polyaddition or any similar process from molecules with a lower molecular weight or by chemical alteration of natural macromolecular compounds.

Plastics are used in the packaging of food because they offer a wide range of appearance and performance properties which are derived from the inherent features of the individual plastic material and how it is processed and used. Plastics are resistant to many types of compounds – they are not very reactive with inorganic chemicals, including acids, alkalis and organic solvents, thus making them suitable, i.e. inert, for food packaging. Plastics do not support the growth of microorganisms. Some plastics may absorb some food constituents, such as oils and fats, and hence it is important that thorough testing is conducted to check all food applications for absorption and migration. Gases such as oxygen, carbon dioxide and nitrogen together with water vapor and organic solvents permeate through plastics. The rate of permeation depends on:

- type of plastic
- thickness and surface area
- method of processing
- concentration or partial pressure of the permeant molecule
- storage temperature

Plastics have properties of strength and toughness. Polyethylene terephthalate (PET) film has a mechanical strength similar to that of iron, but under load the PET film will stretch considerably more than iron before breaking.

Advantages of plastics

- Inexpensive materials
- Inexpensive conversion to packaging
- Versatile
- Flexible
- Rigid
- Semi-rigid
- Moldable
- Light-weight
- Noncorrodible
- Shock-resistant

• Heat-sealable

• Transparent

• Can be pigmented

• Microwavable (some)

• Good heat resistance (some)

• Recyclable (some)

Disadvantages of plastic

• Permeable to Gas, Water vapor, Aroma

• Monomers

• Additives

• Food components can sorb into plastic

• Low compressive strength

• Lack heat resistance (some)

• Not recyclable (some)

Application of Plastic in food processing

Plastics are used as containers, container components and flexible packaging. In usage, by weight, they are the second most widely used type of packaging and first in terms of value. Applications of plastic are

- rigid plastic containers such as bottles, jars, pots, tubs and trays
- flexible plastic films in the form of bags, sachets, pouches and heat-sealable flexible lidding materials
- plastics combined with paperboard in liquid packaging cartons
- expanded or foamed plastic for uses where some form of insulation, rigidity and the ability to withstand compression is required
- plastic lids and caps and the wadding used in such closures
- diaphragms on plastic and glass jars to provide product protection and tamper evidence plastic bands to provide external tamper evidence
- pouring and dispensing devices to collate and group individual packs in multipacks, e.g. Hi-cone rings for cans of beer, trays for jars of sugar preserves etc.

- plastic films used in cling, stretch and shrink wrapping films used as labels for bottles and jars, as flat glued labels or heat shrinkable sleeves components of coatings, adhesives and inks.

Types of plastic used in packaging

Polyethylene

PE is structurally the simplest plastic and is made by the addition polymerization of ethylene gas in a high-temperature and pressure reactor. A range of low, medium and high-density resins are produced, depending on the conditions (temperature, pressure and catalyst) of polymerization.

- Polyethylenes are readily heat sealable.
- They can be made into strong, tough films, with a good barrier to moisture and water vapor.
- They are not a particularly high barrier to oils and fats or gases such as carbon dioxide and oxygen compared with other plastics, although barrier properties increase with density.
- The heat resistance is lower than that of other plastics used in packaging, with a melting point of around 120°C, which increases as the density increases.

MDPE or medium-density PE film is mechanically stronger than LDPE and therefore used in more demanding situations. LDPE is coextruded with MDPE to combine the good sealability of LDPE with the toughness and puncture resistance of MDPE, e.g. for the inner extrusion coating of sachets for dehydrated soup mixes.

HDPE or high-density PE is the toughest grade and is used for boil-in-the-bag applications. To improve heat sealability, HDPE can be coextruded with LDPE to achieve a peelable seal.

Polypropylene (PP)

PP is an addition polymer of propylene formed under heat and pressure using Zieger-Natta type catalysts to produce a linear polymer with protruding methyl (CH_2) groups. The resultant polymer is a harder and denser resin than PE and more transparent in its natural form.

- The high melting point of PP (160°C) makes it suitable for applications where thermal resistance is needed.
- The surfaces of PP films are smooth and have good melting characteristics.
- PP films are relatively stiff.
- When cast, the film is glass clear and heat sealable.
- It is used for presentation applications to enhance the appearance of the packed product.
- PP is chemically inert and resistant to most commonly found chemicals, both organic and inorganic.
- It is a barrier to water vapor and has oil and fat resistance.

Polystyrene (PS)

It is less well known as an oriented plastic film, though the film has interesting properties. It has high transparency (clarity). It is stiff, with a characteristic crinkle, suggesting freshness, and has a dead fold property. It has a low barrier to moisture vapor and common gases, making it suitable for packaging products, such as fresh produce, which need to breathe. PS is easily processed by foaming to produce a rigid lightweight material which has good impact protection and thermal insulation properties.

Polycarbonate

In order to have all the properties in a single form of polymeric materials so as to meet the requirement of processed food products especially for dairy products with desired shelf-life, a remarkable development has taken place to produce multiplayer plastic film either as laminate form or Co-extruded form. Properties of multi-layer Co-extruded Plastic films: High barrier properties to moisture and oxygen gas, improved in flexural endurance properties, dart impact strength properties increased, no possibility of delamination of individual layer unlike laminates, cheaper as compared to laminates and amenable to easy printing on the surface.

Polyvinyl chloride (PVC)

PVC has excellent resistance to fat and oil. It is used in the form of blow moulded bottles for vegetable oil and fruit drinks. It has good clarity. As a film, it is tough, with high elongation, though with relatively low tensile and tear strength. The moisture vapour transmission rate is relatively high, though adequate for the packaging of mineral water, fruit juice and fruit drinks in bottles. PVC softens, depending on its composition, at relatively low temperatures (80–95°C). It is plasticized, and the high stretch and cling make it suitable for overwrapping fresh produce, e.g. apples and meat in rigid trays using semi-automatic and manual methods.

Polyamide (PA) or Nylon-6 film

Polyamides (PA) are commonly known as nylon. However, nylon is not a generic name; it is the brand name for a range of nylon products made by Dupont. They were initially used in textiles, but other important applications were subsequently developed including uses in packaging and engineering. Polyamide plastics are formed by a condensation reaction between a diamine and a diacid or a compound containing each functional group (amine).

PA can be blended with PE, PET, EVA and EVOH. It can be blow moulded to make bottles and jars which are glass clear, low in weight and have a good resistance to impact. PA film is used in retortable packaging in structures such as PA/aluminum foil/PP. The film is non-whitening in retort processing. PA is relatively expensive compared with, for example, PE, but as it has superior properties, it is effective in low thicknesses.

Polyethylene terephthalate (PET)

PET melts at a much higher temperature than PP, typically 260°C, and due to the manufacturing conditions does not shrink below 180°C. This means that PET is ideal for high-temperature applications using steam sterilization, boil in the bag and cooking or reheating in the microwave or conventional radiant heat ovens. The film is also flexible in extremes of cold, down to −100°C. PET is a medium oxygen barrier on its own but becomes a high barrier to oxygen and water vapour when metalized with aluminium. This is used for vacuumed coffee and bag-in-box liquids, where it is laminated with EVA on both sides to produce highly effective seals. It is also used in snack food flexible packaging for products with high-fat content requiring barriers to oxygen and ultraviolet (UV) light.

PET is the fastest-growing plastic for food packaging applications as a result of its use in all sizes of carbonated soft drinks and mineral water bottles. PET bottles are also used for edible oils, as an alternative to PVC.

Ethylene vinyl acetate (EVA)

EVA is a copolymer of ethylene with vinyl acetate. It is similar to PE in many respects, and it is used, blended with PE, in several ways. The properties of the blend depend on the proportion of the vinyl acetate component. Generally, as the VA component increases, sealing temperature decreases and impact strength, low temperature flexibility, stress resistance and clarity increase. EVA is also a major component of hot melt adhesives, frequently used in packaging machinery to erect and close packs, e.g. folding cartons and corrugated packaging.

Modified EVAs are available for use as peelable coatings on lidding materials such as aluminum foil, OPP, OPET and paper. They enable heat sealing, resulting in controllable heat seal strength for easy, clean peeling. These coatings will seal to both flexible and rigid PE, PP, PET, PS and PVC containers.

RECENT DEVELOPMENTS

Plastic crates

Plastic crates are well-established in the dairy industry, bottled beer, mineral water and soft drinks. High-density polythene is used for milk crates. Expanded polystyrene is employed as a shipping container for grapes and also for both cured and fresh fish.

High barrier plastics

Previously for infinite barriers glass and metal were used. Polyvinylidene chloride, ethyl vinyl alcohol and ethyl vinyl copolymers are found to fulfill the requirements of high barrier properties. These are used as coatings or films. A recent development combines scavenging with barrier plastics to provide a near-perfect barrier to oxygen.

Micro-ovenable Packages

The most commonly used material today is crystalline polyester in the form of trays. The advantages of using these trays are with respect to flexibility in shape and design and resistance to oils and greases. High barrier resins like EVOH and PVDC are generally used in contact with the food to over-come these losses of food flavours.

Retortable pouches and Trays

Flexible pouches, semi-rigid/rigid plastic trays and cans, and paperboard-based cartons have been developed as alternatives to heat processing (retorting) in rigid metal cans or glass containers. The pouches, trays, and tubs are always multilayer laminate structures that contain different polymers which provide heat resistance, strength, and toughness (PET), pierce and pinhole resistance (nylon), oxygen barrier (EVOH, nylon or PVDC) and (for the pouches and trays) heat sealability (PP). An aluminium foil layer often serves as the moisture and oxygen barrier in pouches. The retortable paperboard cartons have external and internal PP layers that are impermeable to liquid and allow heat sealing, along with an internal aluminium layer that provides a gas and light barrier.

The advantage of retortable pouches and trays is that they have thinner profile than conventional metal or glass containers. The results are shortened process times, reduced energy consumption, and improved food quality due to more rapid and even heat transfer. In addition, retort pouches, trays, and tubs are convenient because of easy transport (due to shape and light weight) and easy opening. Plastic (with no foil layer) pouches, trays, and tubs are microwaveable. The main disadvantage of retortable pouches, trays, tubs, and cartons is more difficult recycling.

Aseptic packaging

Aseptic packaging is a method in which food is sterilized and then aseptically placed in previously sterilized containers which are subsequently sealed in an aseptic environment. Aseptically processed foods can be packaged in the same types of containers used for retorted foods. However, another advantage of aseptically processed foods is that they can be packaged in containers that do not have to survive the conditions of a retort.

The disadvantage of these packages is that they are not as easily recycled as metal and glass containers. Aseptic filling systems have also been developed for HDPE and PET bottles. Aseptic filling of PET containers may have a cost advantage over hot filling of heat-set PET containers. Another advantage of aseptically processed foods is that they can be filled into drums, railroad tank cars, tank trucks and silos that have been previously sterilized with steam. The food can be later reprocessed and packaged to meet market demands. The sterilization agents available for aseptic packaging include heat, chemical treatment with hydrogen peroxide and high energy irradiation (UV light or ionizing (gamma) irradiation). A combination of hydrogen peroxide and mild heat is most commonly used with plastic and paperboard-based laminate packaging.

The most commercially successful form of aseptic packaging utilizes paper and plastic materials which are sterilised, formed, filled and sealed in continuous operation. The package may be sterilized with heat or a combination of heat and chemicals. In some cases, the disinfectant property of hydrogen peroxide (H_2O_2) is combined with heated air or ultra violet light to make lower temperatures effective in sterilizing these less heat resistant packaging materials.

Aseptic packaging is also used with metal cans as well as large plastic and metal drums or large flexible pouches. Great quantities of food materials are used as intermediates in the production of further processed foods. This frequently requires the packaging of such items as tomato paste or apricot puree in large containers. The food manufacturer then may use the tomato paste in the production of ketchup or the apricot puree in bakery products. If such large volumes were to be sterilized in drums, by the time the cold point reached sterilization temperature the product nearer the drum walls would be excessively burned. Such items can be quickly sterilized in efficient heat exchangers and aseptically packaged.

Modified Atmosphere Packaging

Modified atmosphere packaging (MAP) is a procedure which involves replacing air inside a package with a predetermined mixture of gases prior to sealing it. Once the package is sealed, no further control is exercised over the composition of the in-package atmosphere. However, this composition may change during storage as a result of respiration of the contents and/or solution of some of the gas in the product. Vacuum packaging is a procedure in which air is drawn out of the package prior to sealing but no other gases are introduced. This technique has been used for many years for products such as cured meats and cheese. It is not usually regarded as a form of MAP.

The gases involved in modified atmosphere packaging, as applied commercially are carbon dioxide, nitrogen and oxygen. Carbon dioxide reacts with water in the product to form carbonic acid which lowers the pH of the food. It also inhibits the growth of certain microorganisms, mainly moulds and some aerobic bacteria. Lactic acid bacteria are resistant to the gas and may replace aerobic spoilage bacteria in modified atmosphere packaged meat. Most yeasts are also resistant to carbon dioxide. Anaerobic bacteria, including food-poisoning organisms, are little affected by carbon dioxide. Consequently, there is a potential health hazard in MAP products from these microorganisms. Moulds and some gram-negative, aerobic bacteria, such as Pseudomonas spp, are inhibited by carbon dioxide concentrations in the range 5–50%. In general, the higher the concentration of the gas, the greater is its inhibitory power. The inhibition of bacteria by carbon dioxide increases as the temperature decreases.

Nitrogen has no direct effect on microorganisms or foods, other than to replace oxygen, which can inhibit the oxidation of fats. As its solubility in water is low, it is used as a bulking material to prevent the collapse of MAP packages when the carbon dioxide dissolves in the food. This is also useful in packages of sliced or ground food materials, such as cheese, which may consolidate under vacuum. Oxygen is included in MAP packages of red meat to maintain the red colour, which is due to the oxidation of the myoglobin pigments. It is also included in MAP packages of white fish, to reduce the risk of botulism. Other gases have antimicrobial effects. Carbon monoxide will inhibit the growth of many bacteria, yeasts and moulds, in concentrations as low as 1%.

However, due to its toxicity and explosive nature, it is not used commercially. Sulphur dioxide has been used to inhibit the growth of moulds and bacteria in some soft fruits and fruit juices.

Argon, helium, xenon and neon, have also been used in MAP of some foods. MAP packages are either thermoformed trays with heat-sealed lids or pouches. With the exception of packages for fresh produce, these trays and pouches need to be made of materials with low permeability to gases (CO_2, N_2, and O_2). Laminates are used, made of various combinations of polyester PET, polyvinylidene chloride (PVdC), polyethylene (PE) and polyamide.

Edible films

Edible films and coatings formed from polysaccharides, proteins, lipids, resins, and/or waxes fall within the active packaging definition, since they can enhance the protective function, provide convenience, and minimize package environmental impact. Edible films placed or formed between components of a packaged food control transfer of moisture, oils, etc. over which the package has no control. Edible coatings or edible film pouches (as a primary package) work to complement the protective function of the nonedible (secondary) package. Such coatings and films can act as barriers to the external environment and maintain food integrity, thus reducing the amount of packaging required. Edible film pouches carrying premeasured amounts of ingredients can provide the convenience of placing pouch with ingredients into the food formulation. Edible coatings can also carry antimicrobials that can inhibit microbial growth at both the food-coating interface and the coating outer surface.

Several polysaccharide-sucrose-ester-,lipid- and resin-based edible coating formulations are available commercially to control moisture loss and respiration in fresh fruits and vegetables. Starch, hydroxypropyl methylcellulose (HPMC), zein, gelatin, and shellac coatings are available for confectionery and other food products. Edible collagen casings and wraps for meat and HPMC pouches for dry foods are available commercially. A large number of foods would benefit from development of suitable edible films or coatings.

Food materials can be protected from loss of volatiles or reaction with other food ingredients by being encapsulated in protective edible materials. This can be done by spray drying various flavoring materials emulsified with gelatin, gum Arabic, or other edible materials to form a thin protective coating around each food particle. The coatings of raisins with starches to prevent them from moistening a packaged breakfast cereal and the coating of nuts with monoglyceride derivatives to protect them from oxidative rancidity are additional examples of edible coatings.

Food materials such as amylase starch and the proteins zein and casein when solubilized can be cast to give sheets of edible films on drying. These films may then be used to fabricate small packets to hold other food ingredients. One application of such films has been to package baking ingredients which can then be added directly to the mixing bowl as an intact packet, on addition of water, the edible film dissolves and releases the packed ingredients.

Edible films are also used to coat fresh fruits and vegetables to reduce moisture loss and to provide increased resistance to growth of surface molds. The most common and oldest edible film is wax. A wide range of products such as apples are waxed for appearance and improved keeping quality. Newer edible films are being developed which can keep produce longer.

Active packaging

Selected active packaging systems

S.N.	Systems	Mechanisms	Food application
1.	Oxygen scavengers	1. Iron-based 2. Metal/acid 3. Metal (e.g. platinum) catalyst 4. Ascorbate/metallic salts 5. Enzyme-based	Bread, cakes, cooked rice, biscuits, pizza, pasta, cheese, cured meats, cured fish, coffee, snack foods, dried foods and beverages
2.	Carbon dioxide scavengers/	1. Iron oxide/calcium hydroxide	Coffee, fresh meats, fresh fish,

	Emitters	2. Ferrous carbonate/metal halide 3. Calcium oxide/activated charcoal 4. Ascorbate/sodium Bicarbonate	nuts, other snack food products and sponge cakes
3.	Ethylene scavengers	1. Potassium permanganate 2. Activated carbon 3. Activated clays/zeolites	Fruit, vegetables and other horticultural products
4.	Preservative releasers	1. Organic acids 2. Silver zeolite 3. Spice and herb extracts 4. BHA/BHT antioxidants 5. Vitamin E antioxidant 6. Volatile chlorine dioxide/ sulphur dioxide	Cereals, meats, fish, bread, cheese, snack foods, fruit and vegetables
5.	Ethanol emitters	1. Alcohol spray 2. Encapsulated ethanol	Pizza crusts, cakes, bread, biscuits, fish and bakery products
6.	Moisture absorbers	1. PVA blanket 2. Activated clays and	Fish, meats, poultry, snack foods, cereals, dried foods,

		minerals 3. Silica gel	sandwiches, fruit and vegetables
7.	Flavour/odour adsorbers	1. Cellulose triacetate 2. Acetylated paper 3. Citric acid 4. Ferrous salt/ascorbate 5. Activated carbon/clays/ Zeolites	Fruit juices, fried snack foods, fish, cereals, poultry, dairy products and fruit
8.	Temperature control Packaging	1. Non-woven plastics 2. Double-walled containers 3. Hydro fluorocarbon gas 4. Lime/water 5. Ammonium nitrate/water	Ready meals, meats, fish, poultry and beverages

Active packaging refers to the incorporation of certain additives into packaging film or within packaging containers with the aim of maintaining and extending product shelf life. Packaging may be termed active when it performs some desired role in food preservation other than providing an inert barrier to external conditions. Active packaging includes additives or ‘freshness enhancers’ that are capable of scavenging oxygen, adsorbing carbon dioxide, moisture, ethylene and/or flavor/odor taints, releasing ethanol, sorbates, antioxidants and/or other preservatives and/or maintaining temperature control.

Active packaging techniques for preservation and improving quality and safety of foods can be divided into three categories; absorbers (i.e. scavengers, releasing systems and other systems. Absorbing (scavenging) systems remove undesired compounds such as oxygen, carbon dioxide, ethylene, excessive water, taints and other specific compounds. Releasing systems actively add or emit compounds to the packaged food or into the head-space of the package such as carbon dioxide, antioxidants and preservatives. Other systems may have miscellaneous tasks, such as self-heating, self-cooling and preservation. The main active packaging systems are:

Oxygen scavenger

The most common oxygen scavengers take the form of small sachets containing various iron-based powders containing an assortment of catalysts or enzymes such as glucose oxidase. These chemical systems often react with water supplied by the food to produce a reactive hydrated metallic reducing agent that scavenges oxygen within the food package and irreversibly converts it to a stable oxide. The iron powder is separated from the food by keeping it in a small, highly oxygen permeable sachet.

Carbon Dioxide Scavengers/Emitters

Carbon dioxide (CO2) has innate antimicrobial properties. CO2 emitters actively produce and release this gas within the package to inhibit spoilage and control harmful microorganisms, preserving food quality. CO2 emitters are often found in products like coffee, snack foods, nuts, bakery items, dried and fresh meats, and fish. Additionally, bifunctional AP systems are often used which include oxygen scavengers working in tandem with CO2 emitters, whereby as oxygen is absorbed, it is replaced by CO2, optimizing the atmospheric conditions within the package. Carbon dioxide scavengers widely used for food packaging are made of calcium oxide and hydrating agents, such as silica gel, in which the reaction between water and calcium oxide occurs, forming calcium hydroxide, which subsequently reacts with carbon dioxide producing calcium carbonate.

Ethylene Scavengers

Ethylene is a phytohormone which accelerates produce ripening and results in spoilage of the packaged product if not properly controlled. Ethylene scavengers are used to control the ripening process in packaged fruits and vegetables by absorbing ethylene from the packaged environment, preventing deterioration and increasing shelf life. The most common ethylene scavenger is potassium permanganate embedded in silica gel sachets. Another option on the market is the addition of ethylene absorbers to zeolite clay, which is then embedded into food-grade films used in packaging materials for fruits and vegetables.

Ethanol Emitters

The use of ethanol as an antimicrobial agent is well documented. It is particularly effective against mould but can also inhibit the growth of yeasts and bacteria. Ethanol can be sprayed directly onto food products just prior to packaging. The size and capacity of the ethanol-emitting sachet used depends on the weight of food, a_w of the food and the shelf life required. When food is packed with an ethanol-emitting sachet, moisture is absorbed by the food and ethanol vapor is released and diffuses into the package headspace.

Preservative Releasers

One most commonly used preservative releaser is a synthetic silver zeolite that has been directly incorporated into food contact packaging film. The purpose of the zeolite is apparently to allow slow release of antimicrobial silver ions into the surface of food products. Many other synthetic and naturally occurring preservatives have been proposed and/or tested for antimicrobial activity in plastic and edible films. These include organic acids, e.g. propionate, benzoate and sorbate, bacteriocins, e.g. nisin,, spice and herb extracts, e.g. from rosemary, cloves, horseradish, mustard, cinnamon and thyme, enzymes, e.g. peroxidase, lysozyme and glucose oxidase, chelating agents, e.g. EDTA, inorganic acids, e.g. sulphur dioxide and chlorine dioxide, and anti-fungal agents, e.g. imazalil and benomyl. The major potential food applications for antimicrobial films include meats, fish, bread, cheese, fruit and vegetables.

Moisture Absorbers

Humidity management within food packaging is essential to a high quality end product. Moisture scavengers reduce water activity, thereby inhibiting spoilage microorganisms from negatively effecting the food inside. There are two types of moisture scavengers. Liquid absorbers usually come in the form of pads or sheets that have a hygroscopic layer that absorbs and holds moisture and are often used in high water activity items like meat, poultry, fish, and produce. Relative humidity regulators, commonly referred to as desiccants, absorb moisture and control humidity in the headspace of the package in the form of sachets or labels that are often used in foods with lower water activity like snack foods, cereals, nuts, and spices.

Flavour/Odor Adsorbers

The interaction of packaging with food flavors and aromas has long been recognized, especially through the undesirable flavor scalping of desirable food components. Two types of taints amenable to removal by active packaging are amines, which are formed from the breakdown of fish muscle proteins, and Aldehydes that are formed from the autoxidation of fats and oils. Volatile amines with an unpleasant smell, such as trimethylamine, associated with fish protein breakdown are alkaline and can be neutralized by various acidic compounds. The bags that are made from film containing a ferrous salt and an organic acid such as citrate or ascorbate are claimed to oxidize amines when they are absorbed by the polymer film. Odor and Taste Control (OTC) technology removes or neutralizes aldehydes.

Intelligent packaging

Intelligent packaging includes indicators to be used for quality control of packed food. They can be so-called external indicators, i.e., indicators which are attached outside the package (time temperature indicators), and so-called internal indicators which are placed inside the package, either to the head-space of the package or attached into the lid.

Time temperature indicator (TTI)

A time temperature indicator (TTI) can be defined as a simple device that can give the idea about easily measurable, time-temperature dependent change which affects the full or partial temperature history of a food product to which it is connected. The principles of TTI operation are based on mechanical, chemical, electrochemical, enzymatic or microbiological irreversible change.

Freshness indicators

Two types of changes can take place in the fresh food product i.e.

(i) Microbiological growth and metabolism resulting in pH changes, formation of toxic compounds, off-odours, gas and slime formation,

(ii) Oxidation of lipids and pigments resulting in undesirable flavours, formation of compounds with adverse biological reactions or discolouration.

A freshness indicator indicates directly the quality of the product. The indication of microbiological quality is based on a reaction between the indicator and the metabolites produced during growth of microorganisms in the product. An indicator that would show specifically the spoilage or the lack of freshness of the product, in addition to temperature abuse or package leaks, would be ideal for the quality control of packed products.

Pathogen indicators

Commercially available Toxin Guard is a system to build polyethylene-based packaging material, which is able to detect the presence of pathogenic bacteria with the aid of immobilized antibodies. As the analyte (toxin, microorganism) is in contact with the material it will be bound first to a specific, labelled antibody and then to a capturing antibody printed as a certain pattern. The method could also be applied for the detection of pesticide residues or proteins resulting from genetic modifications.

Shrink-wrap packaging

It is a system where heat shrinkable thermal plastic film is wrapped around an article or a group of articles and made to shrink around it by application of heat to achieve a skin light package. Canned food product, bottles, jars of all types can be shrink wrapped. Shrink wrapping saves packaging material cost. It also saves storage space. The package is lighter. Shrink wrapping saves transportation costs. Shrink wrapping give security. Strong see-through packaging provides full protection from pilferage as also store and transit damages. It can be used for all sizes, shapes and weights and hence it is versatile. Shrink wrap packaging offers protection from dust, moisture, breakage and easy to handle, easy to open and easy to use.

Utilization of agricultural waste

Agricultural and forest wastes like dried leaves of banana, coconut husk, areca husk, hemp, jute and banana fiber thread have been converted into packaging. The surface of the raw material is subjected to heat treatment in the machine to insure hygiene and microbiological safety. The physical strength of the container should also be improved by laminating the leaves with paper or plastic films in the machine itself.

UNIT – III

LAMINATION, COATING AND ASEPTIC PACKAGING

FOILS AND LAMINATES - CHARACTERISTICS AND IMPORTANCE IN FOOD INDUSTRY

Aluminum Foil

Aluminum foil is sheet metal of a very thin gauge. It is produced by the cold reduction process through which pure aluminum is pressed to reduce its thickness to less than 0.152 mm and annealed to give folding properties. Aluminum foil is used in the form of cups and trays, laminated foil pouches as alternatives to cans or jars, collapsible aluminum tubes for pastes, and aluminum barrels.

The advantages of foil as a packaging material

1. Good appearance
2. Excellent dead-folding properties
3. Ability to reflect radiant energy
4. Excellent barrier to moisture, gases, and odors
5. Nonabsorbent and nontoxic

Foil (> 0.015 mm thick) is totally impermeable to moist gases, light, and microorganisms. It is widely used for wraps (bottle caps [0.05 mm]), and trays for frozen and ready meals (0.06 mm). Foil trays are coated with vinyl epoxy compounds to make them suitable for microwave heating without damage to the magnetron. The disadvantages of aluminum foil are:

1. Low strength due to its thin gauges
2. Readily attacked by high-acid products
3. Not heat-sealable

To overcome these problems, the foil is often laminated on the outside paperboard (to increase its strength) and with low-density polyethylene on the inside to impart resistance to high-acid products and to develop heat-sealant characteristics. Aluminum is also used to metallize flexible films.

Composite Containers

- Recently due to the development of laminates with metalized films which are having similar properties to metal containers with less cost, the use of metal containers is decreasing. Therefore, cans made from a combination of paperboard, foil, and plastic are now used in place of metal cans.
- Kraft paper is the main component in the can body. The inside of the can is plastic (low-density polyethylene, polypropylene, or ionomer) often backed by the foil for added barrier

properties. End closures can be made of metal, plastic, paper, or a combination of these materials.

- Composite cans are manufactured by a spin convolute wound method, with spiral cans dominating the market due to their superior barrier characteristics.
- Composite cans are widely used to package shortening, powdered and dehydrated baby foods, aseptically packaged single-strength fruit juices, and frozen dough.

Barrier Properties of Packaging Materials

Many materials can be selected for packaging food products. When choosing the appropriate packaging material, the following factors should be considered:

1. Gas barrier properties
2. Moisture barrier properties
3. Antifog properties
4. Machinability
5. Mechanical strength
6. Sealability
7. Performance vs. cost

One of the most important characteristics is the barrier properties to both oxygen and moisture vapour, which varies greatly from material to material. High-barrier materials usually provide high barriers to both moisture and oxygen, e.g., glass, tin plate, and aluminum foil.

Laminating process

Laminating is the process through which two or more flexible packaging webs are joined together using a bonding agent. The substrates making up the webs may consist of films, papers, or aluminium foils. In general terms, an adhesive is applied to the less absorbent substrate web, after which the second web is pressed against it to produce a duplex, or two-layer, laminate.

Applications

Web laminating is used to improve the appearance and barrier properties of substrates.

Laminating machinery and laminating types

Laminating machinery can be classified according to the type of bonding agent used to produce the laminates. These types are:

- **Wet lamination:** Wet lamination uses solvent or aqueous-based adhesives and can only be used when one or more of the webs are permeable to the water or other solvent used thus allowing it to escape, where the bonding agent is still in a liquid state when the webs are joined together. It is commonly used to produce a paper-aluminium foil laminate that is widely used in flexible packaging.
- **Dry lamination:** where the bonding agent, dissolved into a liquid (water or a solvent), is applied to one of the webs, before being evaporated in the drying oven. The adhesive-coated web is laminated to the other under strong pressure and using heated rollers, which improves the bond strength of the laminate.
- **Wax lamination:** where the bonding agent is a wax or hot melt and is applied in a molten state onto one of the two substrates. This process allows the production of paper-paper or paper-aluminium foil laminates that are widely used for the packaging of biscuits and bakery products.
- **Solventless lamination:** where the adhesives used do not contain solvents. Solventless adhesive generally indicates a specific type of adhesive composed of two components reacting with each other and consequently not requiring drying.

The resulting laminated web is then rewound into a finished roll.

Flexible Packaging Laminating Process: Laminating is the process in which two or more flexible packaging webs are joined together using a bonding agent. These webs are comprised of films, papers or aluminum foils. To bond the webs, an adhesive is applied to the less absorbent substrate web, which is then pressed against the second web. This results in a two-layer laminate.

Functions of Flexible Packaging Laminates: Flexible packaging laminates have three main functions:

- **Mechanical Properties:** Improve the strength of the material by making it more resistant to tearing. Protect it during packaging, distribution and storage
- **Barrier Properties:** Protect it from outside deteriorating agents (light, moisture, gas), Prevent the loss of product qualities, such as freshness and aroma (food)
- **Substrate Sealability:** Closes the flexible packaging

Flexible Packaging Laminate Applications: Flexible packaging laminates are used for products that need to be protected or have shelf lives extended. Applications for food products include:

- Ready-to-eat such as snacks, ice creams, coffee
- Freezer-to-microwave
- Boil-in-bag pouches

ASEPTIC PACKAGING

Aseptic packaging is a packaging concept where product is packed under aseptic conditions. The history of aseptic packaging goes back to the early 20th century. A patent was filed for a process, termed an aseptic conservation process in Denmark, prior to 1913 by J. Nielson following Orla Jensen which was obtained in 1921. In 1950 another major advancement in aseptic packaging took place when the first aseptic filling plant was commercialised in the market by Dole which used superheated steam at 210ºC for sterilization. The most significant development in this field is the development of a commercially viable packaging plant for milk, i.e. the Tetra Pak system, following the development of the UHT process for milk. The system remains till today.

The production of a commercially sterile product by continuous UHT processing requires a means of packing which will ensure continued product sterility with the attainment of expected shelf-life. Such a requirement is fulfilled by aseptic packing. Aseptic processing and packaging denotes the filling of commercially sterilized and cooled products into pre-sterilized containers under aseptic conditions and sealing in an atmosphere free of microorganisms.

The basic operation in aseptic packaging consists of:

- Heating the product to sterilization temperatures (140-150°C for 0-few seconds).
- Maintaining the sterility of the products till they are cooled/packed.
- Filling into sterile containers and sealing aseptically.

The main characteristics of aseptic packing which are essential from a basic functional point of view are as follows.

- Low water-vapour transmission rate.
- Low gas transmission rates, especially to oxygen. This is important to preserve the colour, flavour and nutritional constituents in the products.
- Good physical or mechanical strength, sufficient to resist any physical damage during manufacture, handling and distribution.
- Good sealing characteristics to prevent the entrance of external contaminants.
- Capability to fit into automatic fabricating and filling equipment.
- Resistance to withstand the temperatures encountered during the filling of the product as well as during storage and distribution.
- Chemically resistant to the product packed and able to withstand sterilisation packing material with gas and liquid radiation.
- Resistance to microbes, insects and other types of biological hazards.
- Compatibility with the milk packed. The constituents and additives etc. of the package material should be inert with low migration levels in accordance with the appropriate codes of practice and standards of the country.
- Economical in cost in comparison to the packaged product and readily available in the market.

Packaging Materials Used in Aseptic Packaging

a. 1st generation material: Paper board/plastic /foil/plastic laminates.
b. 2nd generation: plastic containers.

Properties sought in a laminate for aseptic packaging

The packaging material or container is sterilized prior to filling and sealing in a sterile environment. Both the packaging material and seal are of sufficient strength and function to prevent recontamination of the product during storage and transport.

Various packaging materials are used for milk, from paper-based laminates or carton boards to bottles made from polyethylene or polypropylene. The common packing is typically a combination of polyethylene, paper and aluminium foil. The polyethylene forms a mono-layer protective coat on the outer surface of the carton, and a co-extruded double layer on the inner food-contact surface which aids in sealing. Between the polyethylene layers is a paper layer which provides strength, rigidity and printability and the aluminium foil layer serves as an oxygen barrier.

The general principle of a common aseptic packaging system is that cartons are formed from a roll of packaging material which passes through a sterilizing bath containing a 35% solution of hydrogen peroxide (H_2O_2) at 70-80°C. The packaging material then passes through rollers and a curtain of air at 125°C which evaporates the solution and also serves to increase the rate of sterilization. The film is formed into a continuous tube sealed along the longitudinal edge and the base of the carton is then formed by a transverse seal. Milk from an aseptic storage tank is filled into the carton, under aseptic conditions maintained by a heater and the carton is sealed by another transverse seal which also forms the base of the next carton. An appropriate cut along the transverse seal separates the cartons.

The complete carton forming, filling and sealing operation is carried out in a closed room, sterilized prior to use. This Aseptic packaging room is separate from other plant and supplied with a positive pressure sterilized air atmosphere.

Pre-formed cartons may be used for UHT milk, in which case the packaging is usually pre-sterilized, for example with ethylene oxide gas, and once again with a combination of H_2O_2 and sterile air at around 180°C, just prior to filling and sealing.
Pipelines valves and fittings that are coming in contact with sterile milk are pre-sterilized before use.

Tetra pack cartons

Tetra Pak aseptic cartons are made of three basic materials with 6 layers that together result in a very efficient, safe and light-weight package. Each material provides a specific function.

- Paper (80%): to provide strength and stiffness
- Polyethylene (15%): to make packages liquid tight and to provide a barrier to microorganisms.
- Aluminium foil (5%): to keep out air, light, and off-flavours - all the things that can cause food to deteriorate.

Combining each of these three materials has enabled Tetra Pak to produce a packaging material with optimal properties and excellent performance characteristics. Higher degree of safety, hygiene and nutrient retention in food

UNIT – IV

PACKAGING OF SPECIFIC FOODS

Choosing an Appropriate Packaging Material

In modern food business which is heavily dependent on the retailing sector, it is important to choose the best packaging for the food being marketed in the most cost-effective manner. Choice of an appropriate packaging material is governed by several factors such as:

− The specific sensitivities of the contents, e.g. moisture, oxygen, etc.

− Factors changing the contents viz. temperature, RH, pH, and the reaction mechanism involved.

− Weight and shape of container.

− Effect on filling and sealing speeds.

− Contamination of food by constituents of the packing material.

− Storage conditions- How long the product needs to be protected.

− Bio-degradability and recycling potential.

− Most of the food production has been in the rural pockets of the country, while the major markets are in the urban areas. So the need for its transportation over long distances has become a necessity.

− Dairy and fruit products being highly perishable products, utmost care is needed in their preservation during storage, handling and transportation.

− Food products spoil fast at high temperatures, in the presence of oxygen and other contaminating agents present in the atmosphere.

− There are many more peculiarities, which could be identified under the following headings for determining the packaging of processed food products.

-> Product range

-> Market

-> Consumer needs

-> Operating margins

Packaging and consumer needs

In deciding the type of packaging, consumer trends play a vital role. Some of the trends in the food industry in India are:

- Well-packed food products are associated with quality. - Packaging is expected to make food products safe.

- Increasing mobile lifestyle.

- Time has become a precious commodity.

- The younger generation is looking for health and wellness foods and beverages.

- The consumer is ready to try new products.

- Concern for freshness.

- Seeking a home-meal dining experience. The traditional family meal is fast becoming a rarity in urban India.

- For children, innovative or fun flavoured fortified foods and beverages.

Attributes that Consumers Appreciate

− Product quality and protection with a great emphasis on freshness.

− Easy to open, dispense, reseal and store.

− Appealing product presentation is gaining prominence.

− Durable and eco-friendly is being viewed together.

− Leak and spillage proof is a must for the producer as well as the consumer.

− Reusable packaging.

− Less hassles, more convenience.

− Selection from a wider choice of available sizes.

PACKAGING MATERIALS FOR DIFFERENT FOOD PRODUCTS

Food Product	**Normal Packaging material**
Milk	LDPE/LLDPE laminate
Milk powder	Tin cans with aluminium foil or Aluminium Foil/Poly laminate
Baby/malted food	Tin cans with aluminium foil or Aluminium Foil/Poly laminate
Ghee	LDPE/HDPE laminate or Nylon
Chocolate bars	Alu Foil/Poly laminate PET/Poly laminate
Confectioneries/candy	Paper wax PET/Poly

Ready-to-eat foods	PET or BOPP/Poly
Edible oil	3 and 5 layer nylon films
GEMS like products	BOPP/Poly
Vanaspati	LDPE/HDPE and Nylon based films
Biscuits	Wax coated Paper Glassine/Poly Alu Foil/Paper PET/BOPP/Poly Paper/Poly
Bread	Waxed Paper
Tea	PET/Poly Paper/Poly Alu Foil/Paper
Coffee	PET/Poly
Spices	PET/Poly
Salt	LDPE/LLDPE
Potato chips	Met.PET or Foil Poly
Juices	Foil/Poly
Extruded foods	PET or BOPP/Poly

LDPE : Low density Polyethylene

LLDPE : Linear LDPE

Poly : Polythene

Alu Foil : Aluminium foil

PET : Polyethylene teripthallate

BOPP : Biaxially oriented Polypropylene

PACKAGING OF SPECIFIC FOODS

Packaging materials for Cereals and Snack foods

1. Paper, Paperboard, and Printed Fiber board - Most cereals and snack foods are packaged with paper-based materials made from wood / fibers. Corrugated paperboards have unique characteristics including good strength properties, excellent shock absorbing ability, good aesthetic appearance, environmental advantages, and distinctive print properties. White board is suitable for contact with food and is often coated with low density polyethylene (LDPE), PVC (poly vinyl chloride) or wax. It is used for snack, chocolate, and frozen food cartons.

2. Plastic Films - Flexible plastic/films have been used for cereals in single packaging or multi-serving size packages with other packaging materials. Typically, the majority of snacks are in flexible bags. Biaxially oriented /films are most widely used for snack foods. Biaxially oriented polypropylene (BOPP) has qualities of toughness (against puncture and abrasion) and clarity, and is rendered heat sealable by coextrusion or coating with polyolefin copolymers. Films are also coated with other polymers or aluminum to improve the barrier properties or to impart heat sealability.

3. Metals - Metal containers have been rarely used for cereals and snack foods due to their cost, despite their perfect gas barrier properties, convenience, and extreme strength. However, composite containers are used for molded chips and nuts. The body of the container is made of LDPE-coated foil on spirally wound paperboard. The top and bottom ends of the containers may be made of metal or plastic. An aluminum pull-tab top and a reclosable plastic lid on the container form a reclosable canister.

Packaging materials for beer

1. Aluminum cans - The total barrier provided by a double-seamed aluminum can prevents ingress of O2 or egress of CO2. Any oxidation leading to off-flavors, off-colors, and haze is due to O2 remaining in the beer after the brewing process and any O2 added in the filling operation. Thus, the extension of shelf life of beer in cans appears to be dependent on reducing levels of O2 exposure from these two sources.

2. Glass bottles - As with aluminum cans, glass bottles prevent O2 ingress and CO2 egress. However, unlike aluminum can double-seam closures, bottle closures provide an opportunity for gas transmission through the closure lining. If no O2 is added to a bottle of beer during filling, the resulting shelf life for the beer would be 4–13 months for a maximum O2 ingress of 1 ppm. In order to decrease O2 ingress through the closure lining, with resulting increase in shelf life, various O2 scavengers have been developed and commercialized for bottle closures. It is recognized that pry-off crown closures provide a tighter seal than do twist-off crowns.

Packaging materials for carbonated beverages

1. Metal cans - Metal cans for beverages have an easy-open end consisting of a scored portion in the end panel and levering tab (formed separately) that is riveted into a bubble-like structure fabricated during pressing. The aluminum alloy used to manufacture easy-open ends for beverage cans is specially developed to give the required mechanical properties but is subject to environmental stress cracking (ESC) corrosion due to reaction with moisture. The score area is particularly susceptible because of the tensile stress to which this part of the end is subjected.
2. Glass bottles - Glass is attractive as it allows the consumer to see the product but offers little protection against the adverse effects of visible light on the product. Some protection of the product can be achieved by using coloured glass or wrap-round labels or by the application of a film to all or part of the outside of the bottle. The principal advantages of glass include its quality image; low-cost production tooling; brand differentiation through shape, design, and texture; product compatibility; impermeability; odor resistance; good transparency; tamper resistance; resealeability; recyclability; reuse opportunity; sleeving and decorative opportunities; protection against UV light; suitability for in-pack pasteurization; and good top-load strength and rigidity.

3. PET bottles - The O2 barrier performance of PET is low, but, with high levels of carbonation and the shelf life required for most carbonated beverages, it is regarded as acceptable. PET shows one of the highest CO_2 gas barriers for all plastics used for packaging and is an order of magnitude better than polyolefins or polycarbonates. PET shows less favourable retention of moisture than polyolefins and poorer resistance to heat than polycarbonates but overall has the most favourable balance of performance for carbonated beverages.

Packaging materials for milk powders

1. Metal cans - The main reason for using metal cans is their excellent physical strength, durability, absolute barrier properties to moisture, O_2, and light, absence of flavour or odour, and rigidity. Because bare steel is susceptible to corrosion, it is commonly electrolytically coated with a very thin layer of tin; in addition, an organic lacquer is applied to further protect the metal from corrosion and avoid metal–food contact. Milk powder has a long shelf life when packed in metal cans due to its excellent barrier properties. The exchange of moisture and O_2 and the influx of light are not possible. Powders with a higher fat content are more susceptible to oxidation, and most powders are susceptible to deteriorative effects such as lumping and caking from moisture ingress. With adequately constructed cans, a shelf life in excess of 5 years is realistic, particularly when FMP products have been gas-flushed with N_2 to minimize the amount of available O_2.

2. Multilayer pouches - Commonly, a laminated multilayer pouch for milk powder must comprise a barrier to water vapour, O_2 (at least for WMP products), and light. Aluminium foil is capable of providing such a barrier provided the foil does not have pin holes in it. Aluminium foil built into a flexible material provides a close-to-absolute barrier. Building into a flexible material is essential because the foil does not have any mechanical strength by itself and therefore needs protection from mechanical damage. A sandwich construction with two plastic layers—one on the inside, such as low-density polyethylene (LDPE), so that the pouch can be sealed and one on the outside, such as biaxially oriented polypropylene (BOPP) or poly (ethylene terephthalate) (PET), to provide mechanical protection and also carry information is commonly practised.

Packaging materials for Vegetables Oils

1. Metal - Tinplate containers have been used for a long time for oil packaging and are still well appreciated because of their many advantages. They provide total protection against light, O_2, water vapor, and microorganisms, and are resistant to several types of mechanical abuses. Aluminum is also employed as a packaging material for edible oils as it is light and very resistant to corrosion. In order to increase its mechanical resistance, aluminum alloys with small amounts of Mg, Mn, and Si/Mg are recommended.

2. Glass Bottles - Glass containers are widely used for bottling olive oils and virgin olive oils in particular. Transparent glass, however, leads to photo-oxidation of olive oil and a reduction of its shelf life. The use of coloured glass bottles prevents or slows down the oxidation process. Metal and glass are the only packaging materials that provide a virtually total barrier to moisture and gases. The word ―virtually is used because such containers require a closure that incorporates other materials such as polymeric sealing compounds in cans and in closures, through which O_2 can easily permeate and promote oxidation.

3. Plastic Bottles - PET is one of the most used plastics in food packaging covering a wide range of packaging structures. PET satisfies many important requirements: good aesthetic aspect (brilliance and transparency); suitability for colouring; good mechanical, thermal, and chemical resistance; low production cost; good barrier properties against CO_2; suitability for prolonged storage, easy recyclability, and low weight with respect to glass bottles. HDPE is largely used as a packaging material because of its tensile strength and hardness and good chemical resistance. Blow-moulded HDPE containers in the form of bottles, jars, and jerry cans are used for packaging edible oils. PVC is a popular packaging material for edible oils in many countries, mainly due to its transparency, adaptability to all types of closures, total compatibility with existing packaging lines, and potential for personalized design features.

4. Multilayer pouches - The adoption of multilayer pouches for oil storage has increased due to consumer preference for unit packages. Generally, limited quantities of edible oil are packed in flexible pouches (up to 500 g). Flexible pouches may be manufactured from laminates or multilayered films of different compositions and the pouches may be in the form of a pillow or stand-up pouch. The selection of a laminate or multilayer film is governed primarily by the compatibility of the contact layer, heat Sealability, heat seal strength, and shelf life required, together with machinability and physical strength parameters.

Packaging material for raw foods

Raw Meat

The adoption of preservative packaging for raw meats has led to major changes in the processing and marketing of such products. As a result of the widespread adoption of vacuum packaging for primal cuts of red meats, trade in red meat carcasses has declined to trivial proportions in many developed countries, and the international trade in chilled raw meats has greatly increased, with a consequent decline in trading of frozen meats. The enhanced stability of vacuum-packaged products has facilitated consolidation of meat-packing facilities. Most meat is offered to consumers in a freshly or recently cut form, with little further processing to suppress the normal microbiological flora present from the contamination received during the killing and breaking operations required to reduce carcass meat to edible cuts. Fresh meat is vulnerable to microbiological deterioration from microorganisms. These microorganisms can be as benign as slime formers to stink producers to pathogens such as E. coli. The major mechanisms to retard fresh meat spoilage are temperature reduction, often coupled with reduced oxygen during distribution, to retard normal spoilage microbial growth. Reduced oxygen also leads to fresh meat color being purple of myoglobin, a condition changed upon exposure to air which converts the natural meat pigment to bright cherry red oxymyoglobin characteristic of most fresh meat offered to and accepted by consumers. Reduced oxygen packaging is achieved through the mechanical removal of air from the interiors of gas barrier multilayer flexible material pouches closed by heat sealing the end after filling.

Fish and Sea foods

Varieties of fish are among the most difficult of all foods to preserve in their fresh state because of their inherent microbiological populations many of which are psychrophilic, i.e., capable of growth at refrigerated temperatures. Further, seafood may harbour a nonproteolytic anaerobic pathogen, Clostridium botulinum type E, capable of toxin production without signalling spoilage.

The high-quality shelf life of most seafood in chill storage is relatively short, being only a few days. Packaging for fresh seafood is generally moisture resistant but not necessarily against microbial contamination. Simple polyethylene film is employed often as a liner in corrugated fiberboard cases. The polyethylene serves not only to retain product moisture but also to protect the structural case against internal moisture. Seafood may be frozen in which case the packaging is usually a form of moisture resistant material plus structure such as polyethylene pouches or polyethylene coated paperboard cartons. Canning of seafood is much like that for meats because all sea foods are low acid and so require high pressure cooking or retorting to effect sterility in hermetically sealed metal cans.

Fruits and vegetables

Increasing demand for a wide range of harvested fruits or vegetables (raw and fresh-cut) has led to dynamic growth in sales and new market opportunities for the fresh produce sector. However, their preservation still constitutes one of the most challenging applications for the food industry. Fresh produce is a living, "breathing" entity fostering the physiological consumption of oxygen and production of carbon dioxide and water vapor. From a spoilage standpoint, fresh produce is more subject to physiological than microbiological spoilage, and measures to extend the shelf life are designed to retard such reactions and water loss. High gas permeability plastic films, micro perforated plastic films, plastic films disrupted with mineral fill, and films fabricated from temperature-sensitive polymers have all been proposed or used commercially.

Fresh-cut vegetables, especially lettuce, cabbage, and carrots have been a major product in both the retail and the hotel/restaurant/ institutional market. Cleaning, trimming and size reduction lead to greater surface-to-volume of the produce and to the expression of fluids from the interior to increase the respiration and microbiological growth rate. On the other hand, commercial fresh-cutting operations generally are far superior to mainstream fresh produce handling in cleanliness, speed through the operations, temperature reduction, and judicious application of microbicides such as chlorine. Uncut produce packaging is really a multitude of materials, structures, and forms that range from the old and traditional, such as wood crates, to inexpensive, such as injection-molded polypropylene baskets, to polyethylene liners within waxed corrugated fiberboard cases. Much of the packaging is designed to help retard moisture loss from the fresh produce or to resist the moisture evaporating or dripping from the produce (or, occasionally, its associated ice) to ensure the maintenance of the structure throughout distribution. Some packaging recognizes the issue of anaerobic respiration and incorporates deliberate openings to ensure passage of air into the package, for example, perforated polyethylene pouches for apples or potatoes.

Milk

Milk is a complex mixture of water, proteins, lipids, carbohydrates, enzymes, vitamins, and minerals. Due to its specific composition and a pH close to neutral, it is a highly perishable product with high spoilage potential that can result in rapid deterioration of quality and safety. Packaging protects milk and dairy products against environmental, physical, chemical, as well as mechanical hazards. It also protects the product from loss of desirable flavor compounds or pick-up of undesirable odors, and contamination from spoilage or pathogenic microorganisms, insects, or rodents during storage and distribution. An effective packaging system should fulfill numerous other requirements, including compatibility with the dairy product it contains recyclability or reuse, tamper evidence, nontoxicity, aesthetics, machinability, and functionality in terms of shape, size, and disposability.

Milk and its derivatives are generally excellent microbiological growth substrates and therefore potential sources for pathogens. For this reason, almost all milk is thermally pasteurized or heated short of sterility as an integral element of processing. Refrigerated distribution is generally dictated for all products that are pasteurized, to minimize the probability of spoilage.

In recent years, milk packaging has been upgraded to incorporate reclosure, a feature that has been missing from gable top polyethylene-coated paperboard cartons. Further, in recent years, the packaging environmental conditions have been upgraded microbiologically to enhance refrigerated shelf life. Aseptic packaging is employed to deliver ambient temperature shelf stable fluid dairy products. The most common processing technology is ultra high temperature short time thermal treatment to sterilize the product, followed by aseptic transfer into the packaging equipment. Fluid milk is generally pasteurized, cooled, and filled into bag-in-box pouches for refrigerated distribution.

UNIT – V

MECHANICAL AND FUNCTIONAL TESTS ON PACKAGE

The best package for any particular purpose is the one which would protect the contents against the hazards the package would undergo during its journey at the minimum cost. The simplest and the most efficient way of testing packages is to carry out field trials with a sufficient number of packages under the actual conditions of usage. Evaluation of package performance or package testing is a means of shortening this process and obtaining results in a shorter period with a reasonable degree of accuracy.

MECHANICAL TESTS

Bursting Strength

The popularity of bursting strength test depends not only on the ease with which the test is made but also on the combination of strength and toughness, which it measures and which serves as a measure of the serviceability of paper in various applications. It has some disadvantages i.e. it depends in a complicated way on the machine direction, tensile strength, stretch and size of the burst area. Bursting strength is measured by the pressure developed behind a circular rubber diaphragm when it is forced through the paper so as to burst it. A tester in which testing is done by hydraulic pressure communicated through the medium of glycerin or by compressed air to a pure gum rubber diaphragm in contact with the paper, shall be used. The diaphragm used in the equipment shall be such that it does not materially affect the bursting pressure and shall be between 0.35 mm and 0.45 m thick. The rubber sheet used shall be pure gum vulcanization containing not less than 95 % by volume of first quality smoked sheet rubber, the only ingredient in the mix, apart from rubber, shall be those necessary to effect correct vulcanized and resistance to premature aging at normal temperatures. The pressure required to bulge the diaphragm 5 mm above the top plane of the lower clamping surface of the rest instrument shall be not more than 0.07 kg/cm2 . For determination of bursting strength, first clamp the piece of packaging material firmly over the diaphragm without slippage during the test between two annular, planes, unpolished surface of 30 mm internal diameter. After clamping the test piece, run the machine so that the pressure increases at a uniform rate (0.75 kg/cm2 per second) until the test piece burst. Now, with the help of pressure gauge the pressure in kilograms per square centimeter at which the test piece burst. Take two reading with each sample sheet, one with the wire-side upper most and the other with the top- side uppermost. For calculating the burst factor the formula is as follows: Burst factor =Bursting strength (g/cm2)/substance (g/m2).

Tearing resistance

The tearing resistance is usually greater in the cross direction than in the machine direction. Ballistic type of tear-tester such as the ‗Elmendorf' is recommended. The machine is provided with two clamps, the one fixed and the other carried on a sector-shaped pendulum suspended from a column by means of a friction less bearing located near the apex of the load of pendulum recorded through a spring load friction pointer on the circumferential scale marked on pendulum. For determination of tearing resistance, accurately cut the piece with a template in such a way that two parallel slides from a centre tongue giving a double tear. At least one test piece in each direction shall be taken from each specimen. First holds outer tongues of the test piece in a fixed clamp and the centre tongue in the movable clamp. Release the pendulum and note the load necessary to continue to tear. The test may be made such that either the reading is not less than 25% and not more than 75% of the capacity of the instrument. The tearing resistance shall be tested separately for machine and cross direction. Record average, maximum and minimum of the reading in such direction separately and state the number of test piece used for each determination. Tear factor is used for comparing two papers with regards to their tearing strength and is calculated as follows: Tear Factor = Tearing resistance/ substance.

Impact strength of glass bottles

Impact strength in glass can be determined by two methods. First method is drop tester. In this method, the certain height at which glass breaks is determined. In second method the impact strength is determined by pendulum. In this, keep glass bottle at platform and gives oscillation at which point glass break. Whatever energy required to break the glass becomes impact strength. During recycling of bottles; thermal shock resistance decreases, because of pitting of bottle, then application and use of caustic soda, acid, hot water etc. due to these severe processes; thermal shock resistance decreases. To avoid this problem; silicates coating is done on bottles. When you treat with caustic soda, this coating is protecting other coating and the properties of glass remains as such for long time. Pressure at which beverages bottles withstand is 15 kg / cm2. By this experiment, one can determined the thermal shock resistance for glass bottles.

Thermal shock

Thermal shock test determination requires a basket for holding the bottles upright. Two water baths are also required. One contained hot water and other cold water. It may also have a device to control the desired temperature of the baths within +/- 1^{o}C, otherwise the temperature has to be controlled manually using thermometers. Each water bath may also be provided with a stirrer to keep uniform temperature. First adjust the coldwater bath to a temperature of 30+/-1 ^{o}C and the hot water bath at a temperature of 72+/-2 ^{o}C. Now fill a basket fully or partially with the empty sample bottles. When the bath has attained the prescribed temperature, immerse quickly the basket containing the bottles in the hot water bath in such a manner that the bottles become completely filled with hot water. Allow the bottles to soak for 15 minutes. After this transfer the basket with the bottle filled with water to the cold water bath so that the bottles are immersed in water up to the neck, taking care that no cold water enter the bottles. Keep the bottles immersed for 2 minutes. Then remove the basket from cold bath. The process of transfer from the hot to the cold bath shall be completed in 15+/-2 sec. Take every precaution to protect the apparatus from draughts. At last inspect each bottle for cracks or breaks.

Climatic tests

Salt Spray Test

Salt spray test is used to evaluate the resistance of the package to corrosion by salt spray. The package is placed for nearby 50 hours, to a wet, dense fog environment generated by the automation of a 20% water solution of sodium chloride. The solution shall maintain at a PH of 6.5 to 7.2, the temperature of the fog is maintained at 95oF.

Sand and Dust Tests

Sand and dust test is used to evaluate the resistance of a package to the penetration of sand and dust, to determine the erosive effects of blowing sand and dust. A standardize mixture of sand and dust of density 0.1 to 0.5 gm/cu.ft. is used to create an atmosphere for this. The temperature of this atmosphere is maintained at 77° F for a period of 6 hours and then increased to 160° F for another 6 hours.

Opacity

Opacity of all kinds of paper and paper products is determined by measuring the apparent light reflectance. The apparatus shall be capable of measuring the apparent light reflectance. The values of apparent light reflectance are relative to the apparent reflectance from magnesium oxide taken as 100%. The standard white backing shall have an apparent reflectance of 91.5% and the standard black blacking shall have an apparent reflectance of not more than 0.5%. Completely diffused illumination from incandescent lamps at a colour temperature of 2400 to 2800 Kelvin shall be used. The direction of viewing shall be not more than 20° from the normal to the surface of the specimen. Observations shall be made visually or by equivalent means such as a photo- electric with a filter adjusting its sensitivity to that of the human eye. Place the test piece first over the standard white backing, then over the standard black backing and then measure the apparent reflectance of the light. The ratio of reflectance over black backing to that over white backing expressed as a percentage is the contrast ratio. Calculate the average contrast ratio from determination on both sides of each test piece.

FUNCTIONAL TESTS

The basic function of the package is to protect and preserve the contents during transit from the manufacturer to consumer. Protection is required against spillage, dirt, ingress and egress of moisture, insect infestation, contamination by foreign material, tempering, pilferage etc. Identification techniques for different packaging materials are given below.

Visual Test: Fold the film several times to make number of layers. Observe the Colour of the film. E.g. Clear, Hazy Watery, White, Yellowish etc. Cellulose acetate, polyester, polystyrene and PVC – the colour of the film is crystal clear.

Polypropylene and polyethylene - Hazy

Tear Test: Fold the film and tear it on the fold. Try tearing the film from a straight edge. Nick the film.

Polystyrene – Easy to tear

Polypropylene and polyethylene – stretches before tearing

Polyester and poly vinyl chloride – resists tearing

Burning Test: Burn a film very carefully at the edge with help of a burner flame. Observe the edge of the film as it burns of the smoke.

Polyester – burns like wax, Sweet Odour

Polyethylene - Burns like wax without dripping, white smoke

Polystyrene - Marigold Odour, Black smoke

Solubility Test: Cut the film into small pieces. If necessary, crush the sheet material to increase the rate of solubility. Dissolve this film in a glass beaker using appropriate solvents. Amount of the solvent should not be less than 10 times the volume of the solid material. If needed, 25 times volume may also be used. Compare the Solubility.

Solubility of Plastic films for Identification

No.	**Film**	**Acetone**	**Amyl formate**	**Carbon tetrachloride**	**Cresylic acid**	**Cyclo hexanone**	**Dimethyl formamide**	**Ethyl acetate**	**Ethyl alcohol**	**Formic acid**	**Methyl alcohol**	**V**
1	Acrylic			**I**				**S**			**I**	
2	Cellophane	**I**										
3	Cellulose Acetate	**S**										
4	Cellulose Butyrate	**S**						**S**	**I**			
5	Cellulose Nitrate	**S**	**S**									
6	Cellulose Propionate	**S**										
7	Nylon			**I**	**S**	**I**		**I**		**S**		
8	Polycarbonate			**S**				**I**				
9	Polyester	**I**										
10	Polyethylene	**I**		**I**				**I**			**I**	
11	Polypropylene	**I**		**I**				**I**			**I**	
12	Polystyrene	**S**		**S**				**S**			**I**	

13	Polyvinyl Alcohol					**S**	**S**					
14	Polyvinyl Chloride	**S**		**I**				**I**				
15	Rubber Hydrochloride			**S**				**I**			**I**	
16	Saran	**S**		**I**		**S**	**S**	**I**				

I = Insoluble, S = Soluble

Determination of density: Weight a small amount of the material in a flask. If necessary, cut it into pieces. Add water up to the mark on the neck. Remove air bubble (if any) trapped with the film using vacuum. Weigh the flask containing water and film. Weigh the same flask filled with only water at the same temperature. The difference in weights may be used in calculating the density of the given film.

Melt Test: Light a match stick and let the stick to burn for few seconds. Extinguish it and make contact of the hot stick to the film.

Water Test: Place a drop of water on the flat surface of the film and observe. Compare the observations.

Shrink Test: Hold the film I" away from the flame of a match or a burner and observe.

Drip Test: Roll the film into a tape like and allow to burn. Observe the burning and dripping of the film.

Flame hot wire Test: Heat a copper wire on flame and allow it to touch to the film. Put the wire again into the flame and observe.

Identification of various films

No.	**Observation**	**Inference**
1	**Melt Test:** • Match does not push through readily (film resists melting)	• Plain Cellophane • NCC cellophane • PVDC coated cellophane

	• Hot end of the match readily pushes through the film • Film melts readily and does not resist penetration	• PE coated cellophane • PVDC (Saran) • Cellulose acetate • Polystyrene • Nylon
2	**Water Test:** • Drop flatters, spreads and softens the film • Drop does not spread. Wetting and softening of the film occurs only when it is dipped in acetone and wiped off as compared to the original (undipped) part of the film.	• Plain transparent cellophane • Nitrocellulose coated cellophane
3	**Shrink Test:** • Film shrinks violently and rapidly to deep wrinkles • Little shrinkage is observed	• PVDC, Cellulose acetate • Polystyrene • Polyester, Nylon
4	**Drip Test:** • Film burns with drip like melting wax leaving molten drops • Some drip • No molten drip but edges tacky when cooled.	• Polyethylene (PE) • Poly Vinyl Chloride (PVC) • Rubber Hydrochloride, Pliofilm
5	**Flame Hot Wire Test:** • Green colour of the flame. • Negative test, film unaffected by accetone	• Vinyl or rubber type of material • Polyethylene coated cellophane