Food packaging materials M.Sc 1st Year, 2nd sem

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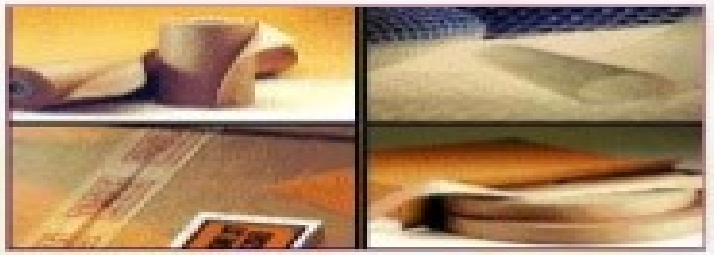
INTRODUCTION

- It can be considered as a combination of art, science and technology that is used in the transportation and selling of foods.

- The primary role of food packaging is to protect food products from the outside environment and from damage by abrasion, to contain the food, and to provide consumers with information about ingredients and nutrition (Dallyn and Shorten, 1998).

- The main requirement of food packaging is to maintain the safety, wholesomeness and quality of food.

DEFINITION



- Packaging can be defined as a method to protect and contain foods with the aim of minimizing the environmental impact of our consumption.

- The Packaging Institute International (PII) defines packaging as the 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: containment, protection, preservation, communication, utility and performance. If the device or container performs one or more of these functions, it is considered a package.

FUNCTION

- Packaging materials have the four basic functions of providing protection, communication, convenience and containment (Paine, 1981; Robertson, 1993).

- Traceability and tamper indication are said to be the secondary functions of increasing importance.

1. Protection:

- One of the main objectives of the packaging of food is to protect it against spoilage or deterioration due to physical damage, chemical changes or biological damage.

2. Communication:

- Any special instructions or information.

3. Convenience:

- Ease of access, handling, and disposal; product visibility; resealability.

4.Containment:

Hold the contents and keep them secure until they are used.

5.Traceability:

- Ability to track any food through all stages of production, processing and distribution.

6.Tamper indication:

- Food tampering is the intentional contamination of a food product, with intent to cause harm to the consumer or to a private company (Canadian Food Inspection Agency, 2010).
- There are several measures to detect tampering, including banding, special membranes, breakaway closures, special printing on bottle liners or composite cans such as graphics or text that irreversibly changes upon opening and special printing that cannot be easily duplicated (Marsh and Bugusu, 2007).

7.Packaging as a Marketing Tool:

- Packaging is an important tool for advertisement.
- Packaging protects the interests of consumers.
- The information on the packaging includes quantity, price, additives, ingredients, inventory levels, lot number, size and weight is very important for merchandising.

8.Socioeconomic Factors in Food Packaging:

- The use of food packaging is a socioeconomic indicator of increased spending ability of the population, an increase in the gross domestic product or an increase in food availability (Brody et al., 2008).
- Packaging technology must balance food protection with other social and environment issues, including energy and material costs, heightened social and environmental consciousness, and strict regulations on pollutants and disposal of municipal solid waste.

MASS TRANSFER & FOOD-PACKAGE INTERACTION

- The quality of packaged food is directly related to the attributes of the food and packaging material (Cooksey, 2007; Lee et al.,2008).
- The quality of most packaged food deteriorates owing to mass transfer phenomena (e.g., moisture absorption, oxygen permeation, flavor loss, absorption of undesirable odors, and the migration of packaging components) (Kester and Fennema, 1986).
- Migration may also result in mass transfer of an additive from the packaging material to the food.

- Several possibilities have been reported for the interaction between foods and packaging materials when they come into contact with each other (Gnanasekharan and Floros, 1997).

- These are the following:

(i) Migration of volatile and nonvolatile compounds from packaging materials to the packaged **food**, including unreacted monomers or additives present in the polymerized packaging material. [Diffusion]

(ii) Sorption of components from the food or from the environment into the **packaging material**. The kind of molecules sorbed is dependent upon the type of interface between the food and the packaging. Some common examples are the sorption of fatty matter, pigments and vitamins into the packaging. [Absorption]

(iii) Permeation of volatile compounds (flavors and water vapor) from the food through the packaging. [Permeation]

PACKAGING MATERIALS:

- The major categories of materials used for food packaging are glass, metals, paper and paperboard, and plastics.
- There are many multilayered packaging materials containing either layers of different plastics or combinations of plastics with paper/board, metal or glass.
- In many cases, a packaging material with two layers is chosen.

TYPES OF PACKAGING MATERIALS:

1. PAPER:

- Paper and paperboard are sheet materials produced from an interlaced network of cellulose fibers derived from wood by using sulfate and sulfite.

- The fibers are then pulped, bleached, and treated with chemicals and strengthening agents to produce the paper product.

a. Kraft Paper

- Kraft paper is made using a process that involves pulverizing the wood pulp and blending the material into large sheets of strong, brown wood filaments.
- It is an expensive option when it comes to paper products.
- The kraft process includes the use of sulfate in the conditioning of the wood pulp, which also helps to add to the overall strength of the finished paper.
- One of the most common uses of plain brown kraft paper is in the manufacture of paper bags for use in grocery stores.

b. Sulfite Paper

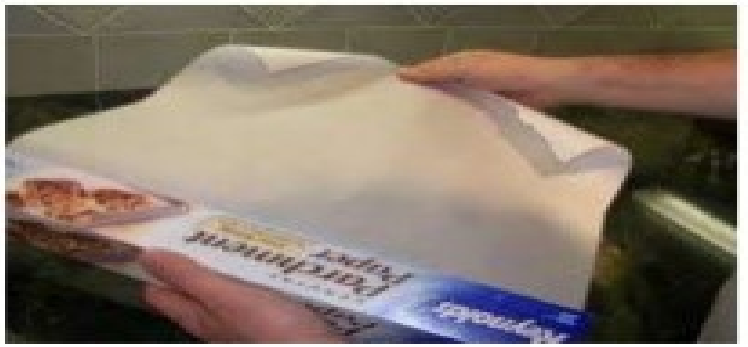
- Lighter and weaker than kraft paper.
- Sulfite paper is glazed to improve its appearance and to increase its wet strength and oil resistance.
- In the production process of sulfite paper, the wood pulp is treated with peroxide or hypochlorite and subjected to operations that yield a thick paper product.
- It can be coated for higher print quality, and is also used in laminates with plastic or foil.
- It is used to make small bags and wrappers for packaging biscuits and confectionery.

c. Greaseproof Paper

- Greaseproof paper is made by a process known as beating, in which the cellulose fibers undergo longer than normal hydration period that causes the fibers to break up and become gelatinous.
- These fine fibers thereafter pack densely to provide a surface that is resistant to oils but not to wet agents.
- Greaseproof paper is used to wrap snack foods, cookies, candy bars and other oily foods, a use that is being replaced by plastic films.
- Glassine is greaseproof paper with a highly smooth and glossy finish.
- It is used as a liner for biscuits, cooking fats, fast foods and baked goods.

d. Parchment Paper

- Parchment paper is produced from acid-treated pulp (passed through a sulfuric acid bath).
- The acid modifies the cellulose to make it smoother and impervious to water and oil, which adds some wet strength.
- It does not provide a good barrier to air and moisture, is not heat-sealable, and is used mostly to package bakery products with a high fat content.



2. PAPER BOARD

- Paperboard is thicker than paper, with a higher weight per unit area, and is often made in multiple layers.
- It is commonly used to make containers for shipping, such as boxes, cartons and trays and is seldom used for direct food contact.
- There are several different types of paperboard, including white board, solid board, fiber board and chipboard (Soroka,1999).

3. GLASS

- The production of glass containers involves heating a mixture of silica (the glass former), sodium carbonate (the melting agent), limestone or calcium carbonate and alumina (stabilizers) to high temperatures until the materials melt into a thick liquid mass, which is then transferred to molds.

- ADVANTAGES: Glass possesses very good barrier properties, so it maintains product freshness for a long period of time without impairing the taste or flavor, visibility of product, the ability to withstand high processing temperatures.

- DISADVANTAGES: Brittle, heavy and non-degradable.

4. PLASTIC

- Plastics are synthesized by condensation, addition or crosslinking polymerization of monomer units.
- In condensation polymerization, the polymer chain grows by condensation reactions between molecules and is accompanied by the formation of water or alcohol.
- The thermal and mechanical properties can be partially modified in order to manufacture retortable packages with plastics that have a high melting point, or thermosealable packages making use of plastics with a low melting point and to develop very flexible structures (sachets and wrappings), semirigid structures (trays and tubs) and rigid structures (bottles, closures and tanks).

- Polymers can be classified into two types according to their behavior on heating: **thermoplastic** and **thermosetting** polymers (Kondo, 1990).

1. **Thermoplastic polymers** soften and melt on heating and solidify again on cooling. They are easily molded and extruded into films, fibers and packaging. Examples include polyethylene, polypropylene and polyvinyl chloride.

2. **Thermosetting polymers**, in contrast, become hardened on cooling, and these plastics retain their shape and cannot return to their original form. They are hard and durable. Thermosets include polyurethanes, polyesters, epoxy resins and phenolic resins.

- Thermoplastics are less rigid than thermosets.

Types of plastic:

- Various types: polyolefins, polyesters, polyvinyl chloride, polyvinylidene chloride, polystyrene, polyamide and ethylene vinyl alcohol.

- Polyolefins and polyesters are the most common.

A. Polyolefins

i.Polyethylene(PE):

- Polyethylene is the simplest, most versatile and most inexpensive plastic.
- Synthesized by addition polymerization of ethylene.
- According to the its density, PE is classified into: very low-density polyethylene (VLDPE), low-density polyethylene (LDPE), medium-density polyethylene (MDPE), and high-density polyethylene (HDPE) (Kondo, 1990).
- However, LDPE and HDPE are the most commonly used forms in food packaging.

a. LDPE:

- Used in applications where heat sealing is necessary.
- LDPE shows excellent cold resistance (up to −70 °C), and therefore is used in frozen - food packaging.

b. HDPE:

- HDPE is stiff, strong, tough, resistant to chemicals, moisture, gas, easy to process, and easy to form.
- HDPE is a harder plastic and has a higher melting point than LDPE.

ii.Polypropylene (PP):

- It is harder, denser and more transparent than polyethylene.
- Has good resistance to chemicals and is effective at barring water vapor.
- The various forms of polypropylene have different melting points and hardnesses.
- Its high melting temperature (160 ℃) makes it suitable for applications where thermal resistance is required, such as hot-filled and microwavable packaging.
- Popular uses include yoghurt containers and margarine tubs.

B. Polyesters

- Polyethylene terephthalate (PET), polycarbonate (PC) and polyethylene naphthalate(PEN) are polyesters, which are obtained by condensation polymerization from ester monomers that result from reactions between a carboxylic acid and an alcohol.

- The most commonly used polyester in food packaging is PET.

i. Polyethylene Terephthalate (PET)

- PET is a thermoplastic polyester that is synthesized by the condensation of terephthalic acid and ethylene glycol.
- **Advantages:** Almost unbreakable, good barrier to gases (oxygen and carbon dioxide) and moisture thus food products stored in PET have a long shelf–life, good resistance to heat, mineral oils, solvents and acids but not to bases.
- PET is the packaging material of first choice for beverages and mineral waters.
- The main reasons for its popularity are its glass -like transparency, gas barrier properties that allow retention of carbonation, light weight and shatter resistance.

ii. Polycarbonate(PC)

- PC is formed by polymerization of a sodium salt of bisphenol acid with carbonyl dichloride (phosgene).
- Its gas barrier properties are moderate, but it provides a very good barrier against flavors and aromas (Kondo, 1990).
- PC is resistant to a wide range of temperatures (its melting point is 230° C and its brittle temperature is −100°C).

iii. Polyethylene Naphthalate (PEN)

- PEN is a condensation polymer of dimethyl naphthalene dicarboxylate and ethylene glycol.
- PEN is chemically similar to PET but **more temperature–resistant.**
- PEN shows excellent barrier properties for carbon dioxide, oxygen and water vapor, comparable to those of PET.
- It provides better performance at high temperatures, allowing hot refills, rewashing and reuse.
- PEN retains flavors and odors, and therefore it is well suited for manufacturing bottles for beverages such as beer.
- It is more expensive than PET.

C.Polyvinyl Chloride (PVC)

- Polyvinyl chloride (PVC) is obtained by radical polymerization or chain polymerization from vinyl chloride monomer (Kondo, 1990).
- PVC is heavy, stiff and ductile, and is a strong, amorphous, transparent material.
- It has excellent resistance to chemicals (acids and bases), grease and oil; good flow characteristics; and stable electrical properties.

D. Polyvinylidene Chloride (PVdC)

- Polyvinylidene chloride (PVdC) is an addition polymer of vinylidene chloride.
- It is heat-sealable and serves as an excellent barrier to water vapor, gases, and fatty and oily products.
- Major applications include the packaging of poultry, cured meats, cheese, snack foods, tea, coffee and confectionery.
- It is also used in hot filling, retorting, low-temperature storage and modified-atmosphere packaging.

E. Polystyrene(PS)

- Polystyrene (PS), an addition polymer of styrene.
- It is clear, hard and brittle with a relatively low melting point.
- PS is a colorless polymer used extensively for low-cost applications.
- It is available commercially in both pellet and sheet form.
- It can be mono-extruded, co-extruded with other plastics, molded or foamed to produce a range of products.
- Foaming produces an opaque, rigid, lightweight material with impact-protection and thermal-insulation properties.
- Typical applications of PS include protective packaging such as egg cartons, containers, disposable plastic silverware, lids, cups, plates, bottles and food trays.

F. Polyamide (Nylon)

- Nylon is a polyamide with an amide structure (– CO–NH–) in its main chain.
- Polyamide is synthesized by a condensation reaction between a diamine and a diacid, where the repeating units are held together by amide links.
- Nylon also offers good chemical resistance, toughness and low gas permeability.

G.Ethylene Vinyl Alcohol (EVOH)

- EVOH is a copolymer of ethylene and vinyl alcohol.
- It is an excellent barrier to oil, fat and oxygen.
- EVOH films show excellent gas barrier properties in dry conditions.
- However, EVOH is greatly affected by humidity and is therefore mostly used in multilayer co-extruded films in situations where it is not in direct contact with liquids.

5.METALS

- Metals are the most versatile of all forms of packaging.
- They offer the combination of excellent physical protection and barrier properties, formability, decorative potential, recyclability, and consumer acceptance.
- Metal containers are vacuum-sealed and thermally sterilized under low oxygen pressure.
- The decomposition of nutrients is kept to a minimum in metal containers, since metals are a perfect barrier to oxygen, light and moisture.
- The major limitations of metal containers are cost, the weight of the containers and the fact that they are difficult to crush.
- Aluminum and steel are the most predominantly used metals in food packaging.

Food Packaging Materials

Food is one product that needs careful packaging. This is because of the strict regulations and standards imposed in relation to health issues arising from wrong packaging. Accordingly, **food packaging materials** should be suitable to provide superior health protection and convenience to consumers as well as low impact on the environment. For your packaging needs, there are different materials to choose from for food and beverage:

Glass

This is a type of material that can be formed in various shapes and can be recycled without much change in mechanical properties. Although it needs high temperature in forming, glass packaging material has very good barrier properties and impermeability from gases and water vapor. It is mainly used for the production of bottles and jars, which can be pasteurized at high temperature. If there's one drawback of glass as a packaging material for food products, it's its brittleness. They easily break when subjected to insensitive handling.

Metal

It has been a base in packaging for a long time. It's mainly used in the production of cans, metallic trays, foils and bags for food products. Like glasses, metals have very good barrier properties but needs to be sterilized before packaging food and beverage. It can also be used for frozen and heated meals. Disadvantages of metals as food packaging include the high cost, corrosion for some types and opaqueness that consumers can't see what's inside.

Paper and Cardboard

These materials from wood are made mainly used for dry food such as sugar, salt, bread, flour and others. Paper is light, easy printable but permeable to air, water vapor and gases. They are very cheap materials and yet can be easily customized to various shapes and sizes. Paper as packaging material has very low impact on environment because of its highly sustainable property.

Plastic

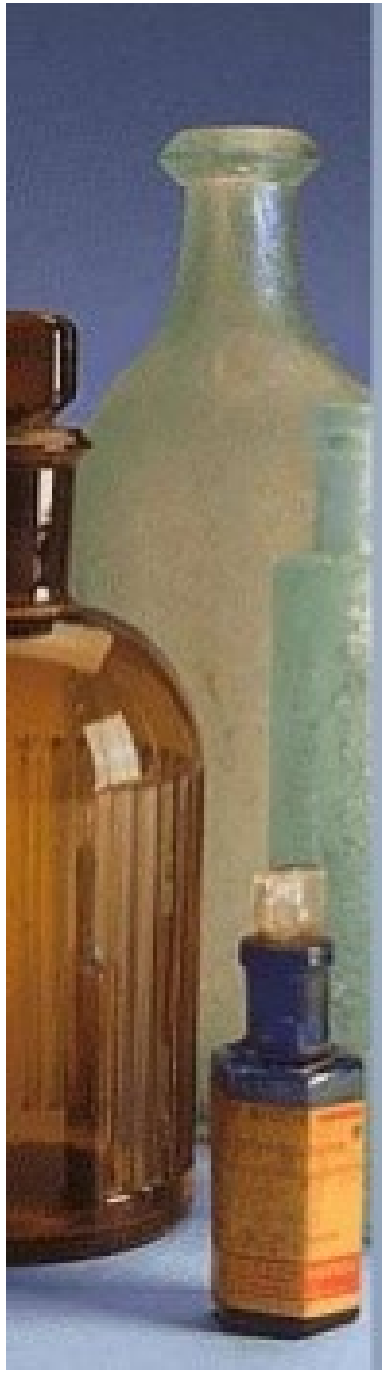
Plastic packaging for food products is becoming widely popular even for microwave operation. Plastic can be synthetic and biodegradable. Synthetic plastic is characterized by a low-cost production, good mechanical barrier properties, lightweight, elastic, can be recycled but non-biodegradable. Biodegradable plastics are specially processed for the materials to decompose at specific manners.

Mixed materials (laminates)

Packaging materials of this type is composed of few thin layers of different materials like metallic plastic and paper films. They also have very good barrier properties and laminate packaging is airtight that increases the shell life of products.

Active and intelligent packaging

Food packaging materials, which contain substances that prolong shelf-life. These substances are mainly oxygen and ethylene absorbers. They could also be compounds emitting or binding oxygen dioxide, regulating water, antioxidants and antibacterial substances.



Nanocomposites

They are new-generation packaging with specific properties which improve mechanical and barrier properties. They are usually applied to production of bottles or films with very low permeability for oxygen and water vapor. This one though is relatively expensive but can be recycled.

Food and beverages deserve the best packaging materials because of health concerns. Issues about economics should not compromise the quality of food packaging. People are becoming more health conscious and very discriminating about the food and drinks they bring in their stomach. Accordingly, food packaging materials should provide the utmost protection to the products for human consumption.