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°C) 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.

i. **Aluminium**

- Aluminium is a lightweight, silvery white metal derived from bauxite ore, where it exists in combination with oxygen as alumina.
- Magnesium and manganese are often incorporated into aluminium to improve its mechanical strength (Page et al ., 2003).
- Aluminium is highly resistant to most forms of corrosion; its natural coating of aluminium oxide provides a highly effective barrier to the effects of air, temperature, moisture and chemical attack.
- The mechanical, physical and chemical properties of aluminum foil such as its barrier effect, deadfold properties and suitability for food contact enable a wide range of applications in many different products and sectors (Lamberti and Escher, 2007).
- The material is light but strong, can be formed and converted into complex shapes, has a high thermal and electrical conductivity, and can be recycled without decrease in quality.
- Aluminium foil is used for aseptic cartons, pouches, wrappings, bottle capsules, push - through blisters, laminated tubes, lids, trays and containers.

ii. Tinplate

- Tinplate has been used for preserving food for well over a hundred years.
- Produced from low-carbon steel (that is, black plate), tinplate is the result of coating both sides of black plate with thin layers of tin.
- The coating is achieved by dipping the sheets of steel in molten tin (hot- dipped tinplate) or by the electrodeposition of tin on the steel sheet (electrolytic tinplate).
- The benefit provided by the bare tin surface inside the can is protection of the natural flavor and appearance of the food, through oxidation of the tin surface in preference to oxidative degradation of the food.

iii. Tin - Free Steel

- This is also known as electrolytic chromium-coated steel or chrome-oxide-coated steel.

- Tin - free steel requires a coating of an organic material to provide complete corrosion resistance.

- Tin-free steel has good formability and strength, but it is much cheaper than tinplate.

PACKAGING METHODS:

1. ASCEPTIC PACKAGING:

- Process in which a food product, such as ultra high temperature (UHT) milk and its package is sterilized separately and then combined and sealed under sterilized atmosphere.

- It increases the shelf-life.

2. VACCUM PACKAGING

- It 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.

N_2 O_2 CO_2

3. MODIFIED ATMOSPHERE PACKAGING (MAP)

- Modified atmosphere packaging (MAP) is a procedure which involves replacing air inside a package with a predetermined mixture of gases prior to sealing it.
- The gases involved in modified atmosphere packaging, as applied commercially today, are carbon dioxide, nitrogen and oxygen.

i. 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.

ii. Nitrogen has no direct effect on microorganisms or foods, other than to replace oxygen, which can inhibit the oxidation of fats.

iii. Oxygen is included in MAP packages of red meat to maintain the red colour, which is due to the oxygenation of the myoglobin pigments.

SOME NOVEL PACKAGING METHODS:

1.BIODEGRADABLE PACKAGING:

- The present global concern about petrochemical - based plastic materials has generated much interest in biodegradable, or “ green” packaging materials.

- According to the ASTM,2003 guidelines, a “biodegradable plastic” is defined as a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi and algae.

- Biodegradable or green packaging must satisfy some basic requirements to be an ideal candidate for food packaging.
- These requirements include barrier properties (to water vapor, gases, light and aromas), optical properties (transparency), strength, welding and molding properties, printing properties, migration resistance, chemical and temperature resistance, the ability to satisfy disposal requirements, antistatic properties, and the ability to retain sensory properties.
- Bio-based polymers, or biopolymers, are obtained from renewable resources (Weber et al., 2002)
- These renewable resources consist of proteins (whey protein, soy protein, collagen, gelatin, wheat protein etc.), polysaccharides (starch, alginates, pectin, carrageenans and chitosan/chitin) and lipids (fats, waxes and oils) (Comstock et al., 2004).

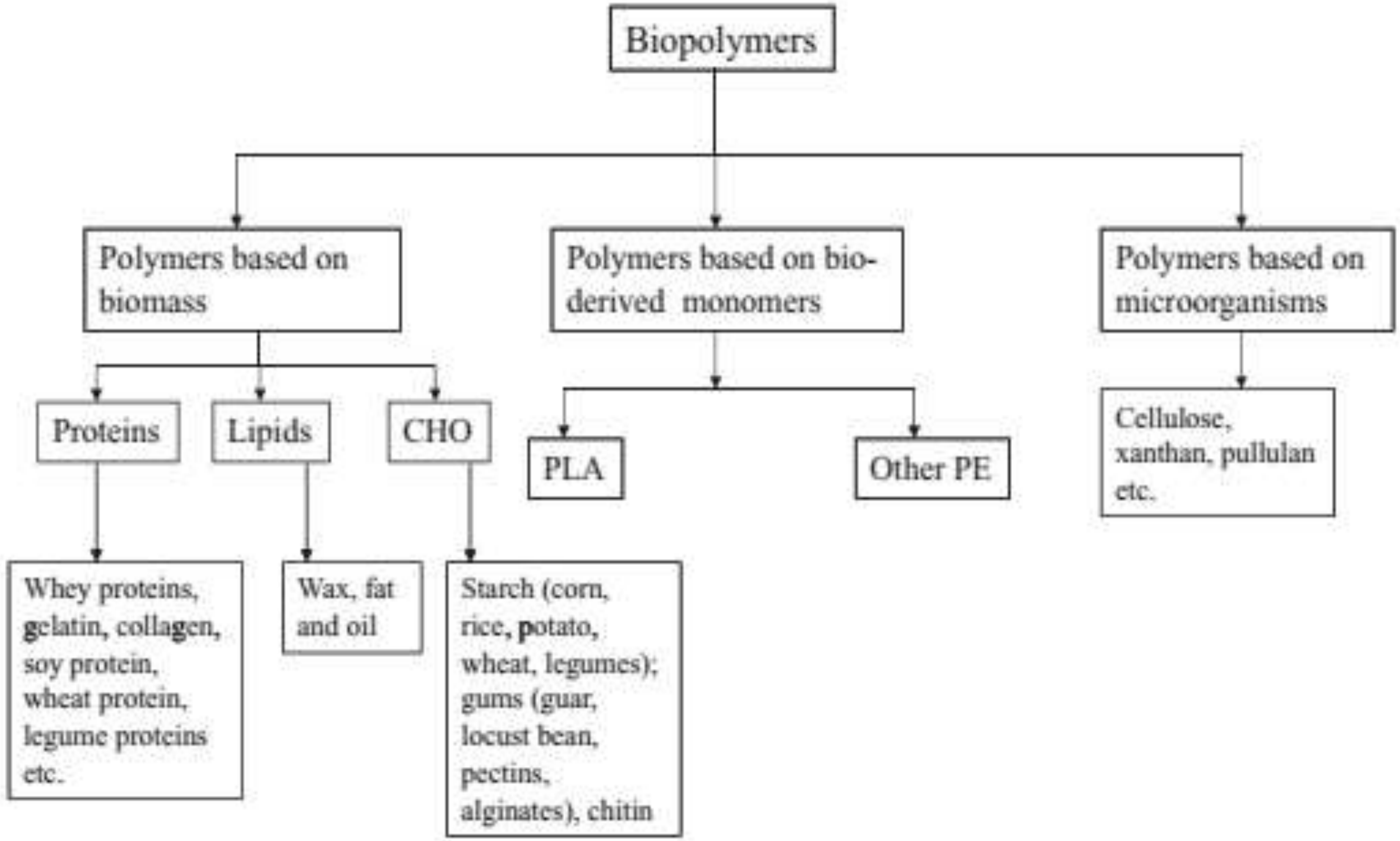

Figure 41.3 The various categories of bio-based materials. (CHO, carbohydrates; PLA, polylactide; PE, polyesters.)

- Polymers such as polylactide(PLA) have gained growing attention in the last decade as food packaging materials because they can easily be obtained from renewable resources, their production consumes quantities of carbon dioxide, they can be recycled and composted, and their physical and mechanical properties can be tailored through the polymer architecture (Sinclair, 1996 ; Siracusa et al., 2008).

2. ACTIVE PACKAGING

- Active packaging is an innovative concept that can be defined as a mode of packaging in which the package, the product and the environment interact to prolong shelf-life or enhance safety or sensory properties, while maintaining the quality of the product (Suppakul et al., 2003).

- It allows the active preservation of foods, according to their needs, by modification of the environment inside the package by removing undesired gases or by regulating the composition of the gas in the package headspace.

- Active systems can be classified according to their functionality as scavengers, regulators and emitters, and their action can be specific for several substances (O_2 , CO_2 , ethylene etc.).

- The internal atmosphere may be regulated by substances that absorb (scavenge) or release (emit) gases or vapors.

i. Oxygen Scavengers

- Oxygen can have considerable detrimental effects on foods.
- Oxygen scavengers can therefore help maintain food product quality by decreasing food metabolism, reducing oxidative rancidity, inhibiting undesirable oxidation of labile pigments and vitamins, controlling enzymic discoloration and inhibiting the growth of aerobic microorganisms.
- The most common oxygen scavengers take the form of small sachets containing various iron-based powders containing an assortment of catalysts.

- 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 that is labelled “Do not eat”.
- The main advantage of using such oxygen scavengers is that they are capable of reducing oxygen levels to less than 0.01%.
- Nonmetallic scavengers include those that use organic reducing agents such as ascorbic acid, ascorbate salts or catechol.

ii. Carbon Dioxide Scavengers/Emitter

- There are many commercial sachet and label devices that can be used to either scavenge or emit carbon dioxide.

- The use of carbon dioxide scavengers is particularly applicable for fresh roasted or ground coffees that produce significant volumes of carbon dioxide.

- Fresh roasted or ground coffees cannot be left unpackaged since they absorb moisture and oxygen and lose desirable volatile aromas and flavours.

- If coffee is hermetically sealed in packs directly after roasting, the carbon dioxide released builds up within the packs and eventually causes them to burst.
- To circumvent this problem, **two** solutions are currently used.
- The first is to use packaging with patented **one-way valves** that allow excess carbon dioxide to escape.
- The second solution is to use a **carbon dioxide scavenger** or a dual-action oxygen and carbon dioxide scavenger system.
- These dual-action sachets and labels typically contain iron powder for scavenging oxygen and calcium hydroxide which scavenges carbon dioxide when it is converted to calcium carbonate under sufficiently high humidity conditions.

iii. **Ethylene Scavengers**

- Ethylene (C_2H_4) is a plant hormone that accelerates the respiration rate and subsequent senescence of horticultural products such as fruit, vegetables and flowers.

- Many of the effects of ethylene are necessary, e.g. induction of flowering in pineapples and colour development in citrus fruits, bananas and tomatoes, but in most horticultural situations it is desirable to remove ethylene or to suppress its effects.

- Effective systems utilise potassium permanganate ($KMnO_4$) immobilised on an inert mineral substrate such as alumina or silica gel.

- $KMnO_4$ oxidises ethylene to acetate and ethanol and in the process changes colour from purple to brown and hence indicates its remaining ethylene-scavenging capacity.

- $KMnO_4$-based ethylene scavengers are available in sachets to be placed inside produce packages or inside blankets or tubes that can be placed in produce storage warehouses.

3. Edible Packaging

- Edible packaging is defined as a thin layer of edible material formed on a food as a coating or placed (preformed) on or between food components (Pagella et al., 2002).

- Natural polymers have been studied extensively for the development of edible packaging.

- A variety of polysaccharides (starch and hydrocolloids), proteins (whey proteins, soybean proteins and fish proteins) and lipids have been used, either individually or in mixtures, to produce edible films.

- Edible films and coatings have some advantages such as edibility, biocompatibility, barrier properties, absence of toxicity, the fact that they are nonpolluting, and low cost (Han, 2000).

- Moreover, biofilms and coatings, by themselves or acting as carriers of food additives (i.e., antioxidants and antimicrobials), have been considered particularly for food preservation because of their ability to extend the shelf - life (Franssen and Krochta, 2003).

4. Intelligent or Smart Packaging

- Intelligent, or smart packaging is basically designed to monitor and communicate information about food quality (Kerry et al., 2006).

- It is essentially an integrating method that deals with mechanical, chemical, electrical and/or electronically driven functions that enhance the usability or effectiveness of the food product in a proven way (Mahalik and Nambiar, 2010).

- Some common examples of intelligent packaging are Time–Temperature Indicators (TTIs), ripeness indicators, biosensors and radio frequency identification (RFID).

- In addition, self-heating and self-cooling containers with electronic displays indicating use-by dates and information regarding the nutritional qualities and origin of the product in numerous languages are available in smart packaging (Mahalik and Nambiar, 2010).

- These smart devices may be incorporated into packaging materials or attached to the inside or outside of a package.

- The FDA recognizes TTIs for fish products, so their importance may increase in the seafood industry.

5. NANO PACKAGING:

- Nanoscale innovation could potentially introduce many amazing improvements to food packaging in the form of barrier and mechanical properties, detection of pathogens, and smart and active packaging with food safety and quality benefits (Brody et al ., 2008).
- Nanotechnology enables designers to alter the structure of packaging materials on the molecular scale, in order to give the material the desired properties.
- With different nanostructures, plastics can be given various gas and water vapor permeabilities to fit the requirements of various foods.
- By adding nanoparticles, one can achieve packages with more resistance to light and fire, better mechanical and thermal performance, and less gas absorption.
- These properties can significantly increase the shelf - life and sensory characteristics of food products, and facilitate transportation and usage.
- The addition of nanosensors to food packages could be used to detect chemicals, pathogens and toxins in foods .


CONCLUSION





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