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ONLINE COURSE WARE

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Module I 8L

Lecture 1:

Definition:

Food packaging is defined as a co-ordinated system of preparing food for transport, distribution, storage, retailing, and end-use to satisfy the ultimate consumer with optimal cost (Coles et al., 2003). The package provides protection, tampering resistance, and special physical, chemical, or biological needs. It may bear a nutrition facts label and other information about food being offered for sale. Food packaging is an essential part of modern society; commercially processed food could not be handled and distributed safely and efficiently without packaging. The World Packaging Organization (WPO) estimates that more than 25% of food is wasted because of poor packaging (WPO, 2009). Thus, it is clear that optimal packaging can reduce the large amount of food waste. Moreover, the current consumer demand for convenient and high-quality food products has increased the impact of food packaging.

History:

- **Pre 20th Century Food Packaging**

Hundreds of years ago food was mostly grown and produced locally and therefore, there was no need for packaging. Of course, luxury goods like sugar were the exception and were imported on ships in sacks or barrels.

- **The Early 20th Century**

But as time went on, populations grew, industries advanced and transport of food became essential. The industrial revolution saw a large amount of innovations, including metal cans and cardboard boxes. Manufacturing processes vastly improved and there was a mutual belief among luxury goods suppliers that the quality of packaging should reflect the quality of their food inside. Quality at this time meant long lasting and durable, so packaging was designed to have multiple functions. A great example of this was tobacco packs being used as lunch and picnic tins. However, despite dual-use properties, packaging at this time was very rigid and quite expensive to produce, therefore many sought better ways to protect and display their lovingly crafted produce. The Great Depression saw the rise of the supermarket, which dramatically changed the face of food packaging as we knew it. Post World War Two, one-use materials were introduced into everyday life, such as foil and plastics. Gone were the days of local retailers weighing and hand-wrapping loose items, the introduction of stocked shelves was taking off and packaging was the store's 'silent salesman'.

Around this time, aniline printing technology (now known as flexography) was invented, which allowed realistic images to be printed on packaging. This rubber block printing technique was much more accurate than anything else previously used and therefore the food packaging industry saw considerably more elaborate designs quickly flooding the market. There were also many innovations with aluminium and plastic during this time, with cheaper, more flexible packaging materials becoming more common place.

- **The 1950s to 1980s**

Great strides were made during these three decades. The TV dinner was invented by Swanson for the busy working professional who served up their pre-prepared dishes in aluminium departmentalised trays. Polyethylene and polyethylene terephthalate were created for food bags and film covers too, whereas the design of aluminium cans was revolutionised with a simpler and more cost-effective design.

Despite being invented in the 50s, it wasn't until the mid-70s that the first barcode scanner was installed at a supermarket. Since then, barcodes have developed to become an everyday familiarity for many of us.

- **The 1990s to Today**

With the invention of the internet and digital technologies expanding greatly, global business became commonplace and no longer restricted to the mega brands. This meant there was more competition and packaging took on a more important role than ever, after all it was this that made your food item stand out amongst the rest on the shelf.

In 2008 labels and packaging began providing shoppers with even more information and resources by placing quick response (QR) codes on products. Easily scanned by a smart phone these direct the customer to an internet page holding anything from further product information, such as ingredients, to a competition run by the brand.

Throughout the early 21st century, many packaging companies and big food producers have grown a conscience and have begun looking for more ecological solutions to their packaging needs. Recyclable cartons and refillable jars have really taken off, and food retailers continue to come up with innovative solutions every day.

Lecture 2:

Functions of food packaging:

1. Containment: The term "containment" means, simply, to contain products to enable them to be moved or stored. All products must be contained for delivery from their point of production to their ultimate destination. Without packaging, products are likely to be lost or contaminated by the environment. The containment function significantly contributes to protecting and preserving products during their distribution.

2. Protection/preservation: There are two broad types of damage that fresh and processed foods sustain during storage and transportation. One is physical damage such as shock, vibration, compressive forces, etc. The other is environmental damage that occurs due to exposure to water, light, gases, odors, microorganisms, etc. A good packaging system will protect or reduce these types of damage to the package contents. For example, an essential aroma or flavor in coffee or juice may easily be evaporated or oxidized without optimum barrier packaging. However, in the case of fresh food products, the ideal protection is usually hard to achieve with packaging alone. Since temperature is a major influence on the degradation of food, it is more economical to control temperature through supply chain modification (refrigeration, freezing, etc.).

3. Communication: According to the Fair Packaging and Labeling Act (Federal Trade Commission, 1994), food packaging must identify the product, the net quantity of the contents, name/address of business of the manufacturer, packer, or distributor, as well as (usually) nutritional information. The communication function of packaging not only includes the information provided by the written text, but also elements of the packaging design such as package shape, color, recognized symbols or brands. Another aspect of the communication function is also important. The Universal Product Code (UPC) is widely used to facilitate rapid and accurate checkout in retail stores. Also, most warehouse and distribution centers track and manage their inventory using UPCs. Currently, by using radiofrequency identification (RFID) tags attached to secondary and tertiary packages, manufacturers are able to get better demand signals from customers and markets.

4. Utility: The utility function encompasses all the packaging attributes that provide added value and convenience to the users of the product and/or package. For example, an important social trend is the growing number of mothers in the workforce and smaller households (people living alone and married couples without children). Unquestionably, food products that offer simplification and convenience have grown in popularity with this group; examples include microwavable entrees, steam-in-pouch vegetables, oven-safe meat pouches, pump-action condiments, and so on.

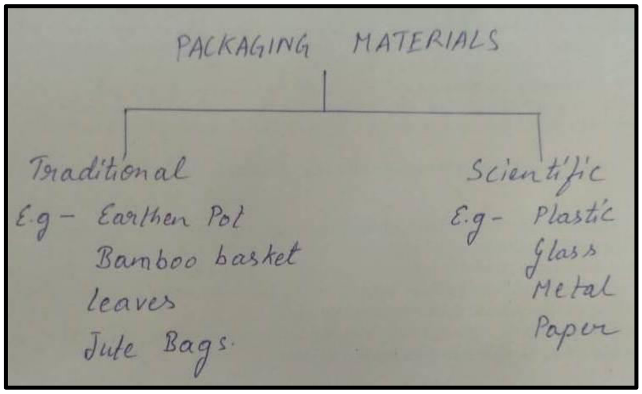
Lecture 3:

Different packaging materials for food industry:

Packaging Industry is mainly based on three types:

1. Raw material Manufacturing- Plastic granules are made.
2. Packaging Materials Converters- Plastic bottles are made from those plastic granules.
3. Packaging Users Industry- Products are filled in the Plastic Bottle and sealed.

Packaging materials can be broadly divided into two types:



Metal Cans

Metal is used in packaging in a variety of applications, from rack systems to tuna cans. For food packaging, four types of metal are commonly used: steel, aluminum, tin, and chromium. Steel and aluminum are commonly used in production of food cans, and are the primary materials for metal packaging. Food cans are most often made of steel, and beverage cans are usually produced from aluminum. Steel tends to oxidize when it is exposed to moisture and oxygen, producing rust. Therefore, tin and chromium are used as protective layers for steel. Tinplate is a composite of tin and steel made by electrolytic coating of bare steel with a thin layer of tin to minimize corrosion. If chromium is used to provide corrosion protection instead of tin, the resulting material is called electrolytic chromium-coated steel (ECCS) or tin-free steel (TFS). ECCS is less resistant to corrosion than tinplate but has better heat resistance and is less expensive.

1. Metal foil and containers- Aluminum foil is the most commonly produced metal foil. It is manufactured by passing aluminum sheet between a series of rollers under pressure. Pure aluminum (purity >99.4%) is passed through rollers to reduce the thickness to less than 150 μm and then annealed to provide dead-folding properties. Foil is widely used for wraps (9 μm), bottle caps (50 μm), and trays for ready-to-eat meals (50–100 μm). Aluminum foil has excellent barrier properties against gases and water vapor. Thus, it is also used as the barrier material in laminated films for packages, such as those in retort pouches. Collapsible aluminum tubes can be used for the packaging of viscous products. Typical applications include condiments packages such as mustard, mayonnaise, and ketchup.
2. Metallized films - also used in food packaging applications for their excellent barrier properties. The principle of metallization is to use a vapor deposition process to deposit an extremely thin layer of metal on another substrate (film). The typical thickness of the aluminum layer in metallized film is

400–500 Å. Oriented polypropylene (OPP) is the material most often used for metallized film applications. Nylon and PET are also common film substrates.

3. Coating- One of the major problems associated with metal packaging is corrosion. The inside of a can is normally coated to prevent interaction between the can and its contents. The outside of a can is also coated to provide protection from the environment. Coatings used in cans need to provide an inert barrier (must not impart flavor to the product), must usually resist physical deformation during fabrication, be flexible, spread evenly and completely cover the surface of the metal, and the coating must adhere well to the metal and be non-toxic (for food packaging).

   Two methods are used for the application of protective coatings to metal containers:

   1. Roller coating
   2. Spraying.

Lecture 4:

Plastics

Plastics are a special group of polymers that can be formed into a wide variety of shapes using controlled heat and pressure at relatively low temperatures, compared to metals and glass. Types of plastics and general properties

1. **Polyethylene (PE)**

Polyethylene, polymerized from ethylene, is the plastic most commonly used for food packaging. PE generally has flexibility, good moisture control, oil and chemical resistance, and good impact strength. PE is also an inexpensive plastic, so for applications where its performance is suitable, this plastic is usually the most economical choice.

2. **Polypropylene (PP)-** Polypropylene is polymerized from propylene gas, which is a relatively low-cost feedstock like ethylene (Soroka,2008a). As with the PE family, PP has good chemical and grease resistance. Barrier properties of PP are similar to those of HDPE; it is a good water vapor barrier but a poor gas barrier. The
3. **Polystyrene (PS)-** Polystyrene is a linear addition polymer of styrene resulting in a benzene ring attached to every other carbon in the main polymer chain. It is a material that is brittle and clear and has high surface gloss. The use of PS in food packaging is aesthetically appreciated, but the

material cannot generally be used when extended shelf life is required because of its poor water vapor and gas barrier properties.

4. **Polyvinyl alcohol (PVOH)/ethylene vinyl alcohol (EVOH)-** Polyvinyl alcohol is produced by hydrolysis of polyvinyl acetate, PVA. Due to the hydrogen bonding (OH) group in the structure, PVOH can provide an excellent gas barrier when it is totally dry. However, PVOH is readily water soluble and loses its gas barrier properties in humid conditions, which greatly limits its usefulness for food packaging. Also, pure PVOH is difficult to process and cannot be thermoformed or extruded. PVOH is non-toxic and biodegradable once dissolved. This material is generally used in water-soluble pouches such as those for laundry or dishwasher detergent.
5. **Polyester (PET)-** Polyethylene terephthalate (PET) is commonly produced by the reaction of ethylene glycol and terephthalic acid and has been one of the fastest growing food packaging plastics for the last several years. The properties of PET are attractive as a food packaging material; it has very high mechanical strength, good chemical resistance, light weight, excellent clarity, and reasonably high barrier properties. PET is also stable over a wide range of temperatures (−60 _C to 220_C). Thus, under some circumstances PET can be used for "boil-in-the-bag" products which are stored frozen before reheating or in dual-ovenable containers, since it has resistance to higher temperatures than many other plastics. PET is mostly oriented biaxially to improve its mechanical strength and gas barrier properties.
6. **Polyvinyl chloride (PVC)-** Polyvinyl chloride is produced from vinyl chloride monomers. PVC has high toughness and strength, good dimensional stability, good clarity, excellent oil barrier properties, and good heat sealability. Even though it has many beneficial properties, PVC is easily degraded at high temperature. It decomposes and gives off hydrogen chloride (HCl) around its melting temperature. Thus, unmodified PVC is almost impossible to process due to thermal degradation.

Lecture 5:

Paper

Paper and paperboard are the most commonly used packaging materials in the world. More than 95% of paper is made from wood, and the remaining sources are mainly agricultural by-products, such as straw (of wheat, rye, barley, and rice), sugar cane bagasse, cotton, flax, bamboo, corn husks, and so on.

Types of paper and their applications

1. ***Kraft paper-*** Kraft paper is the most used packaging paper and has excellent strength. It is made using the sulfate (kraft) chemical pulping process, and is usually produced from soft wood.
2. ***Bleached paper-*** Bleached paper is produced using bleached pulps that are relatively white, bright, and soft. Its whiteness enhances print quality and aesthetic appeal.
3. ***Greaseproof and glassine-*** Greaseproof is a dense, opaque, non-porous paper made from highly refined bleached kraft pulp. The prolonged beating during processing results in short fibers. Glassine derives its name from its glassy smooth surface.
4. ***Waxed paper-*** Waxed paper is produced by adding paraffin wax to one or both sides of the paper during drying. Many base papers are suitable for waxing, including greaseproof and glassine.
5. ***Vegetable parchment-*** Vegetable parchment is produced by adding concentrated sulfuric acid to the surface of the paper to swell and partially dissolve the cellulose fibers. It produces a grease resistant paper with good wet strength (meaning that it maintains its strength well when it is wet).

Paperboards and their applications

1. ***Whiteboard-*** Whiteboard is made with a bleached pulp liner on one or both sides to improve appearance and printability, and the remaining part is filled with low-grade mechanical pulp.
2. ***Linerboard-*** Linerboard is usually made from softwood kraft paper and is used for the solid faces of corrugated board.
3. ***Foodboard-*** Foodboard is used to produce cartons that are suitable for direct food contact. It is normally made using 100% virgin pulp but recently recycled pulp using an innovative barrier coating with a sustainable coating material is also being used.
4. ***Cartonboard (boxboard) -*** Cartonboard is used to make folding cartons and other types of boxes. Most often, this is a multilayer material made of more than one type of pulp, and often incorporating recycled fibers.
5. ***Chipboard-*** Chipboard is the lowest quality and lowest cost paperboard, made from 100% recycled fiber, and is not used in direct contact with foods. Outer cartons for tea and breakfast cereals are some examples.

Lecture 6:

Glass

Glass is defined as “an amorphous inorganic product of fusion that has been cooled to a rigid condition without crystallizing”. For food packaging, bottles or jars are the types of glass packaging most often used, bottles being the primary use. Glass is made primarily of silica, derived from sand or sandstone. For most glass, silica is combined with other raw materials in various proportions. For example, soda-lime glass, the glass typically used for food packaging, contains silica (68–73%), limestone (10–13%), soda ash (12–15%), and alumina (1.5–2%). Glass is inert to a wide variety of food and non-food products, very rigid and strong against pressure, transparent, and non-permeable (excellent barrier properties). However, glass has disadvantages due to its heavy weight and fragility.

For food packaging, the fragility has caused some safety concerns such as the possibility of the presence of chipped glass in food products. Glass for food packaging has declined over the last three decades, with glass losing market share to metal cans and, increasingly, to plastics.

Lecture 7:

Nano-composites

Nanotechnology has shown many advantages in different fields. As the uses of nanotechnology have progressed, it has been found to be a promising technology for the food packaging industry in the global market. It has proven capabilities that are valuable in packaging foods, including improved barriers; mechanical, thermal, and biodegradable properties; and applications in active and intelligent food packaging. Examples of the latter are anti-microbial agents and nanosensors, respectively. However, the use of nanocomposites in food packaging might be challenging due to the reduced particle size of nanomaterials and the fact that the chemical and physical characteristics of such tiny materials may be quite different from those of their macro-scale counterparts.

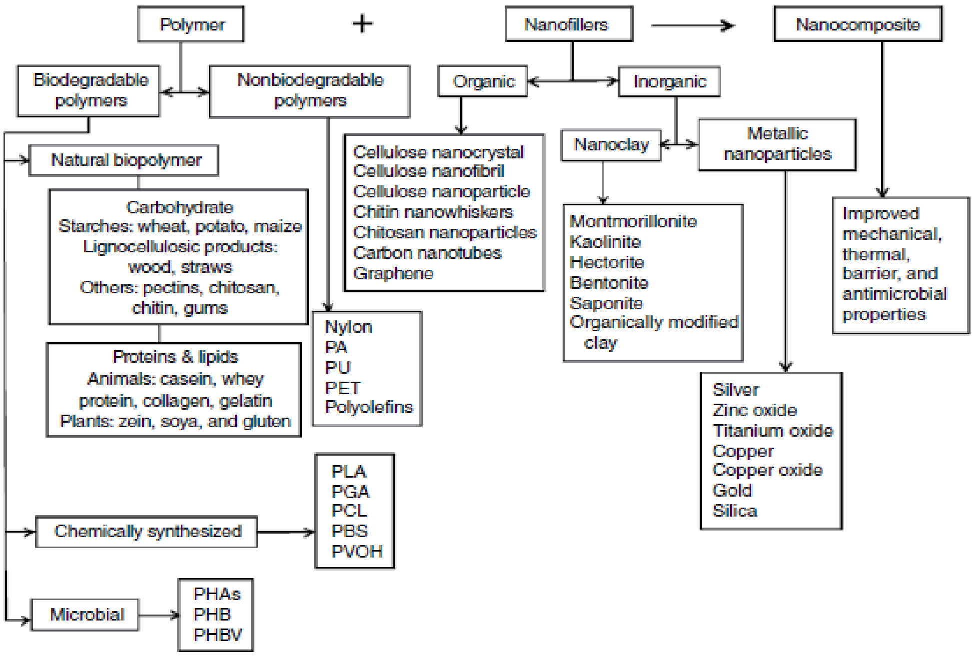


Fig: Composition and sources for the components of polymer nanocomposite

Types of Polymer Nanocomposite Packaging

The reinforcement of nanofillers in the polymer matrix has been explored for the significant enhancement in performance properties of nanocomposites for potential applications in food packaging, such as processed meat products, cheese, bakery products, confectionery, food grains, boil-in-bag foods, fruit juices and dairy products, and for the manufacture of carbonated beverage and beer bottles

Properties	Applications
Improved packaging performance (mechanical, thermal, barrier properties)	Shelf-life increase, down-gauging of film, package waste reduction
Thermal stability	Heat resistance, dimension stability
Optical property	Transparent packaging, UV-light barrier packaging
Biodegradation	Enhanced biodegradation, environment-friendly
Active packaging	Self-life extension, oxygen scavenger, antimicrobial packaging
Intelligent packaging	Interaction with the environment, self-cleaning, self-healing, indication of deterioration
Delivery and controlled release	Nutraceuticals, bioactive compounds
Monitoring product conditions	Temperature time indicator (TTI), freshness indicator, leakage indicator, gas detector
Nanosensor	Food quality indication, sensing, and signaling microbiological and biochemical changes
Nanocoating	Surface reinforcing of base packaging material
Antimicrobial	Active antimicrobial and antifungal surfaces
Information on product	RFID, nano-barcode, product authenticity, traceability

Fig: Properties and potential application of polymer nanocomposite in food packaging

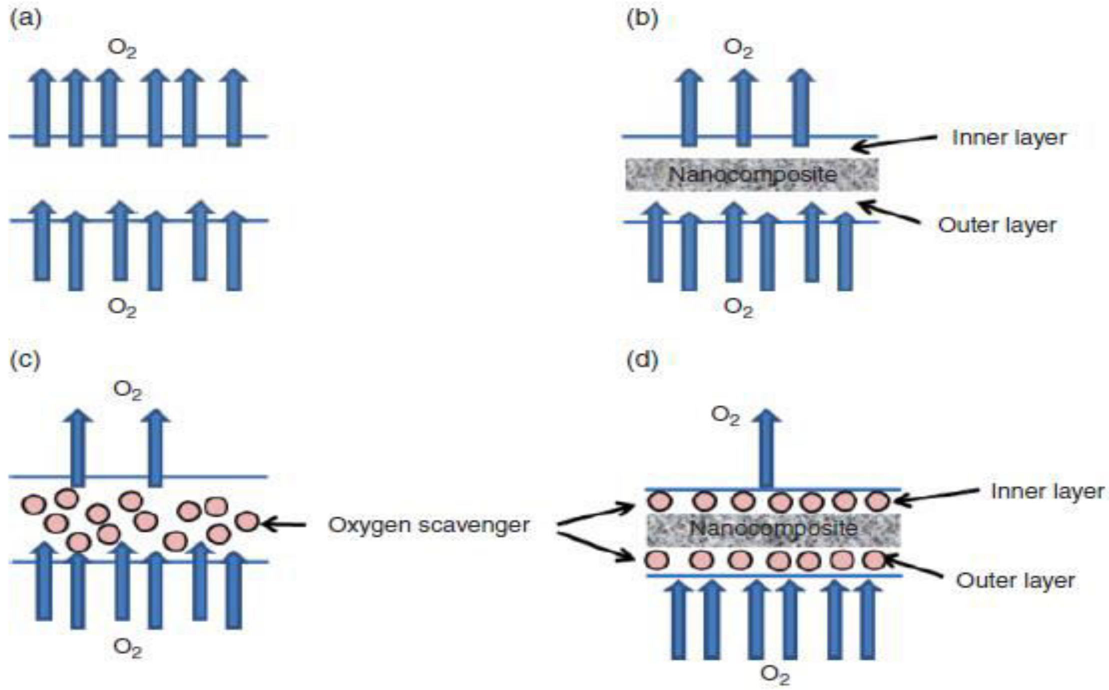


Fig: Diagrammatic representation of the structures of multilayer nanocomposite for oxygen (O2) barrier packaging: (a) neat polymer film without barrier, (b) nanocomposite layer as passive barrier, (c) oxygen scavengers as active barrier, and (d) mixture of active (oxygen scavenger) and passive (nanocomposite) barrier

Lecture 8:

Edible packaging

Introduction:

With the exception of paper-based products, food packaging materials have traditionally been based on nonrenewable materials. With the advent of time, the packaging industry saw a revolution which shifted its focus to bio-based packaging materials essentially plant-derived products and by-products. While it could be argued that fossil resources are bio-based and renewable, it takes more than a million years for biomass to be converted into oil that is used as feed stocks to produce plastics. Since the rate of consumption is much greater than the rate of replenishment, mass imbalance is produced in the carbon cycle. In contrast, bio-based polymers made from materials such as corn starch can be produced and then converted back into biomass in similar time frames.

Edible Packaging Materials: Edible packaging consists of edible films, sheets, coatings and pouches. Eg. Polysaccharides like starch, gum, chitosan, hemicellulose; Lipids; Proteins (Soy or Whey).

Advantages of Edible Packaging Material :

1. They can be consumed with the packaged product, leaving no residual packaging to be disposed of.
2. Even if the films are not consumed, they could still contribute to the reduction of environmental pollution since they are likely to degrade more readily than petrochemical-based polymers and are produced exclusively from renewable, edible ingredients.
3. They can enhance the organoleptic properties of packaged foods provided that various components such as flavorings, colorings and sweeteners are incorporated into them.
4. They can supplement the nutritional value of foods (this is particularly true for films made from proteins).
5. They can be used for individual packaging of small portions of food, particularly products that currently are not individually packaged for practical reasons such as peas, beans, nuts and strawberries.
6. They can be applied inside heterogeneous foods at the interfaces between different layers of components and tailored to prevent deteriorative intercomponent moisture and solute migration in foods such as pizzas, pies and candies.
7. They can function as carriers for antimicrobial and antioxidant agents and be used at the surface of foods to control the diffusion rate of preservative substances from the surface to the interior of the food.
8. They can be very conveniently used for microencapsulation of food flavoring and leavening agents to efficiently control their addition and release into the interior of foods.
9. They could be used in multilayer food packaging materials together with inedible films, in which case the edible films would be the inner layer(s) in direct contact with the food.

Environmental Aspects:

Development of bio-based packaging materials is predicated on a widely held belief that such materials will have lower environmental impacts than existing petrochemical-based materials. Without this advantage, there is less incentive for industry to adopt bio-based packaging materials apart from the obvious advantage of replacing nonrenewable with renewable raw materials, thus leading to a more sustainable packaging industry.

Module II 8L

Lecture 1:

MECHANICAL STRENGTH OF DIFFERENT PACKAGING MATERIALS

1. **PLASTICS:**
   - **TENSILE PROPERTIES:** The four properties of tensile and yield strength, elongation and Young's modulus are considered here. The same equipment is used for measuring each of them. The basic principle of tensile testing is to measure the capability of the film to be drawn out or stretched.
   - **BURSTING STRENGTH:** The bursting strength of a film is the resistance it offers to a steadily increasing pressure applied at right angles to its surface under certain defined conditions.
   - **IMPACT STRENGTH:** The impact properties of polymeric materials are directly related to the overall toughness of the material, toughness being the ability of the polymer to absorb applied energy.
   - **TEAR STRENGTH:** The usual tests for measuring tear strength actually measure the energy required for tear propagation rather than for tear initiation, as it is difficult to start a tear in most plastics films.
2. **EDIBLE, BIO-BASED AND BIODEGRADABLE FOOD PACKAGING MATERIALS:**
   Polysaccharides such as cellulose exhibit good mechanical properties. A number of materials are incorporated into edible films to enhance structural, mechanical and handling properties. Mechanical strength can also be influenced by missing different categories of biopolymers with each other. The mechanical properties are determined by the MW of the polymer, chain architecture (linear vs. branched) and degree of crystallinity.
3. **PAPERS:**
   Papers in general lack in providing an excellent mechanical strength.Khwaldiaet al. (2010) reviewed the barrier, mechanical and other properties of biopolymer-coated paper anddiscussed existing and potential applications for bioactive coatings on paper packaging materials. Kraft papers have high mechanical strength as compared to other types of papers. Layered structure and higher thickness impart very high mechanical properties to paperboards which are often used as secondary and tertiary packaging materials.

4. METALS:

These provide excellent mechanical strengths. The formability of tinplate finds a very useful application in the food industry. Protective coatings of epoxy on cans impart high mechanical properties.

- STRESS CORROSION CRACKING: Stress corrosion is the acceleration of corrosion in certain environments when metals are externally stressed. Because the conditions that cause cracking in one metal may not cause cracking in another, it is very difficult to predict where attack will occur.
- SULPHUR STAINING OR SULPHIDE STAINING: It is characterized by blue-black or brown marks on the inside of tinplate or tin-free steel cans. In lacquered cans, this headspace phenomenon occurs during processing

5. GLASS:

Because of its amorphous structure, glass is brittle and usually breaks because of an applied tensile stress. It is now generally accepted that fracture of glass originates at small imperfections or flaws, the large majority of which are found at the surface. The principles of fracture analysis are:

1. Internal pressure resistance
2. Vertical load strength
3. Resistance to impact
4. Resistance to scratches and abrasions.

Lecture 2:

<u>Ways to evaluate and test the mechanical strength of different packaging materials</u>

1. Glass Containers:

The techniques used can broadly be defined as chemical, physical and visual. Chemical testing by spectrophotometry, flame photometry and X-rayfluorescence is used to check raw materials and the finished glass. Small changesin the proportions and purity of raw materials can have a significant effect onprocessing and physical properties.Physical tests include checking dimensional tolerances, tests for colour, impactstrength, thermal shock resistance and internal pressure strength.

2. Metal cans:

Table 5.1 Summary of quality assurance checks on in-coming containers at food packers

External inspection of can bodies	Internal inspection of can bodies	Inspection of can ends
Dimensions	Cleanliness	Dimensions
Seam defects on makers end (three-piece cans)	Internal lacquer: presence, continuity and adhesion	Compound: presence and distribution
Welds (non-drawn cans)	Oil	Defective curl
Fractured plate		Damaged
Pin holed (especially for embossing)		Fractured
Damaged		Distorted
Defective flange		Corrosion
External lacquer: presence, continuity and adhesion		Easy-open score: dye penetration
Rust		Easy-open tab
Print quality of lithographed cans		

3. Plastic:

Transparency of the plastic helps in visual inspection both during the processing and after the processing, especially in retorting steps.

1. **Optical Property Testing:** Optical properties are related to both the degree of crystallinity and the actual polymer structure. There are a number of optical properties of importance with thermoplastic polymers including clarity, haze, color, transmittance, reflectance, gloss and refractive index.
2. **Mechanical Strengths can be evaluated by:**
    1. Tensile strength
    2. Bursting strength
    3. Impact properties
    4. Tear Strength
    5. Stiffness Test

Lecture 3:

Printing of packaging

Printed food packaging is used to provide information to the final consumer and plays an important role in the presentation and advertising of foodstuffs. Some of this information is legally required, such as weight, vendor details, information about composition, presence of allergens and nutritional details, etc. In addition, printing is carried out for decorative and protective purposes. There are exceptional instances where printing inks are applied to the inner side of the packaging or on inserts, e.g. for promotional purposes, and intentionally have direct food contact. Direct food contact inks represent a special case and comprise less than 1% of food packaging applications. Such inks are subject to different requirements and will not be treated in this report.

Characteristics and properties of printing inks:

- Ink production: The requirements related to colour and gloss are only met if the pigments used are dispersed as finely as possible.
- Printability: Continuous improvement of the ink formulations is required to satisfy requirements of increasing press speed, use of new substrates, etc.
- Substrate: Inks need to be customised for their best performance for each substrate they are printed on.
- Finishing: Finishing processes include coating, foil embossing, laminating, gluing, etc. and each has different requirements.
- Packaging: The choice of ink will be influenced by the packaging processes employed, e.g. heat sealing, speed of packaging machines, necessary slip, packing at low temperatures, etc.
- Storage of goods: Temperature and humidity have an impact.
- Package contents: The characteristics and properties of the food have an impact on ink choice (and subsequent formulation).
- Recovery of packaging: Inks are to be considered in the recovery processes for potential impacts in the recovered materials.

Composition of printing inks: Composition of printing inks can be described in terms of their generic components, irrespective of the printing process.

The main constituents of printing inks are:

- Colourants: insoluble organic and inorganic pigments, soluble dyes
- Vehicle: transport medium for carrying pigments through the press and fixing or binding them to the substrate. Vehicles comprise binders (polymers/resins) and different solvents
- Additives

Lecture 4:

Barcodes and other markings in packaging

Bar Codes: A bar code is defined as a series of parallel bars and spaces arranged according to the encoding rules of a particular specification in order to represent data (Barthel, 2009). Its purpose is to represent information in a form that is machine readable, typically by scanning devices that are programmed to analyze the structure of the bars and spaces and transmit the encoded data in electronic format to a computer. Since 2005, the European Article Number (now International Article Number) / Universal Product Code (EAN/UPC) symbology has been managed by the global organization GS1. The GS1 System of Standards are built and maintained through the GS1 Global Standards Management Process (GSMP), a worldwide collaborative forum. The need to encode more information into a smaller space leads to the development of 2D symbologies and there are now over 20 different 2D symbologies available. The other type are known as data matrix codes and consist of black and white "cells" or modules arranged in either a square or rectangular pattern.

A **barcode** (also **bar code**) is an optical, machine-readable representation of data; the data usually describes something about the object that carries the barcode. Traditional barcodes systematically represent data by varying the widths and spacings of parallel lines, and may be referred to as linear or one-dimensional (1D). Later, two-dimensional (2D) variants were developed, using rectangles, dots, hexagons and other geometric patterns, called *matrix codes* or *2D barcodes*, although they do not use bars as such.

Here are things your label will need:

• A UPC Barcode – You will need to contact the GS1 organization to get a barcode.

• Create a Brand/Product Identity – Do you have a name for your product?

• Ingredients in Weight Order* It takes your recipe and breaks down the basic ingredients.

• Nutrition Facts (Information Panel)

• Allergens Warning (milk, eggs, fish, shellfish, tree nuts, peanuts, wheat & soy)

• Net Weight (on primary display panel parallel to product name)

• Optional Positive Health Claims (must comply with special guidelines)

• Location of Manufactured or Distributed By

Another type of matrix code is the **QR (for Quick Response)** code that is machine readable and designed to be read by smart phones; it was invented in Japan in 1994. A QR code contains information in both the vertical and horizontal directions, whereas a bar code contains data in one direction only.

Radio frequency identification (**RFID**) is part of the family of Automatic Identification and Data

Capture (AIDC) technologies that includes 1D and 2D bar codes. RFID uses an electronic chip, usually applied to a substrate to form a label, that's affixed to a product, case, pallet or other package. The information it contains may be read, rewritten and/or recorded.

Lecture 5:

Interaction between packaging and food materials

Changes in food packaging have meant that the ways foods interactwith packaging have likewise changed. Interactions between foodsand packaging can be classified into four types:

- Migration or the Transfer of Components of the Package to the Food during Storage or Preparation: Migration can have both quality and toxicological significance. Very often, the components that migrate from plastics are odor active and can adversely affect the flavor of foods. Migration may also result i n the transfer of potentially toxic substances to foods.
- Permeation of the Food Container to Fixed Gases and Water Vapor: Unlike glass or metal containers, fixed gases and water vapor canpermeate packages made from plastics or thin foils.
- Sorption and/or Permeation by Organic Vapors: Continuous polymer films are permeable to organic vapors in a similar manner to fixed gases. Transfer of organic vapors across polymeric food packaging could have two adverse consequences. First, packaged foods that are exposed to undesirable volatile odors during storage or shipment might pick up the odor. The classical case occurs when diesel odors or the aroma of laundry soaps are absorbed by foods because of improper storage or shipping. The second type of problem can occur when the desirable aroma compounds associated with a particular food are diminishedby being adsorbed into or permeated through the package.
- The Forth Interaction Between Foods and Food Packaging Results From the Transparency of Many Food Packages to Light. Light, particularly i n the shorter wave lengths, can catalyze adverse reactions such as oxidation in foods. This may lead to discoloration, loss of nutrients, or the development of off -odors.

Lecture 6:

Flavour scalping in food packaging and other similar processes

SCALPING: The term scalping is used to refer to the uptake of components of the food such as flavor, aroma and pigments by plastic packaging. Sorption properties are largely determined by the characteristics of the package, the properties of the flavor molecules, food matrix composition and environmental conditions. As well as loss of aroma, sorption of organic molecules can also affect the mechanical properties of polymer films such as a reduction in seal and tensile strengths, and an increase, Oxygen permeability by two to four times.

Some examples concerning polymeric films:

1. Loss of Antioxidants from High-Density Polyethylene: – Antioxidants are incorporated into plastic films in order to protect them from degradation. It is well established that antioxidants are lost from polymeric films and sheets during storage. A small amount of this antioxidant is lost through decomposition reactions while the bulk of it is lost by whatis commonly assumed to be a diffusion controlled process.
2. Oxygen and Water Vapor Transport through Polymeric Film: –During storage undesirable transport phenomena as permeation of moisture, oxygen and organic vapors through the polymeric film do occur and their knowledge and control become critical. These transport processes are affected by the thermodynamic compatibility between the polymer and the penetrant and the structural and morphological characteristics of the polymeric material.

Lecture 7:

Cost considerations in food packaging

Packaging cost is a significant factor in pricing a product. Packaging is an integral part of the materials supply chain. It protects goods from damage, allows efficient distribution through channels, informs the consumer and helps to promote material in a market.

The important items of packaging costs are listed here under:

(i) Corrugated Container Costs- the cost of design and selection of a properly sized and specified cardboard box.

(ii) Protective Packaging Material Costs- the cost of design and selection of the void-filling material required to provide adequate protection to transport the product safely to customer.

(iii) Protective Packaging Material Labour Cost – the cost of labour wages

(iv) Overhead Cost – those fixed costs divided among each employee associated with the shipping process (monthly benefits/health insurance/vacation time, etc, usually 20 per cent).

(v) Return Cost – the additional labour and material costs plus overhead costs associated with receiving, inspecting, and evaluating to both the customer and shipping carrier when an item is returned or replaced because of damage due to inadequate protective packaging.

(vi) Shipping Cost – the cost of shipping an item using a carrier,

(vii) Repair Cost – the costs in labour, material (extra parts), postage plus overhead.

(viii) Discard Cost – the cost in labour and fees required to dispose of non repairable products.

(ix) Insurance Cost – the premium paid on each and every item shipped when using an inferior protective packaging material that has a history of unacceptable damage,

(x) Inventory Cost – both the space, labour and material cost associated with the storage and replenishment of protective packaging materials.

Factors Against the Reduction of Packaging Cost

It should be noted here that there are certain factors working against the attempt of reduction of packaging as listed here below.

(i) Increasing the number of individuals living alone who need to keep their goods in packed condition,

(ii) Increasing numbers living alone,

(iii) The cost of goods damaged in transit,

(iv) Increasing purchase of imported goods.

(v) Increasing demand from retailers for tamper evident and anti-theft packaging,

(vi) Changing shopping habits – like home delivery,

(vii) Decreasing time spent on shopping and increasing demand for convenience and

(viii) Increasing in travel leading to rising demand for convenience packaging.

Cost Reduction by Improvement in Packaging:

Packaging is defined as a science and as an art. It is more of an art when company dealt with consumer products and more of a science when company dealt with industrial products. While talking about cost improvement, there is a lot of conflicting requirements. A packaging designer is like a Jack of all trades. One has to look at the requirements of improvements in packaging while everything cost reduction. The transporter, for instance, looks for convenience in loading and unloading operations in terms of speed and time, and may not be too concerned about damaging the insides. Also the geometry of the product affects the container. Then comes the storage and handling at the warehouses, docks, airports while in transit. So there is a need to communicate how the box is to be stored, which side is up and so on. There is an international cargo marking accepted by all countries and this must be used on the box to help communication. Naturally, it was handled and stored roughly and some damages took place. The cost will depend on how much importance industries to safety, aesthetics, handling, storage, etc. Generally, 80 per cent of the packing costs go towards meeting customer convenience and requirements and the remaining 20 per cent is used in other aspects of logistics. Eco-friendly, easy-to-dispose packing material must be used. The packaging technology and innovations pave way for tremendous development in the entire packaging sector. It must not lead to cost escalation. The opinion of the packaging units is that the most essential factor in reduction of packaging cost with the mean scores of 3 to 4 points confronted by the units are 'research on reduction cost by redesigning', 'reducing multi layering', 'recycling', 'storage space optimization', 'process improvement', 'supply chain cost management', and 'reusing' these factors influences more in packaging cost 170 reduction. The second category of factor with the mean score of less than 2 is 'materials substitution'.

Lecture 8:

Environmental consideration in selecting food packaging materials

OXO-BIODEGRADABLE (OBD) POLYMERS

OBD plastic is typically polyolefin plastic to which has been added a prodegradant (very small [catalytic] amounts of metal salts) to accelerate the reaction of the plastic with atmospheric O2. Transition metal ions such as iron, cobalt and manganese are the most widely reported prodegradant additives currently in use. OBD plastics are designed to address the problem caused by plastic waste that gets, deliberately or accidentally, into the open environment where it could lie or float around for decades. If collected during its useful life it can be reused and recycled but if not collected, it self-destructs without human intervention, leaving no harmful residues. As long as the plastic has access to O2 (as it does in a littered state), these additives catalyze the natural degradation process to speed it up so that the OBD plastic will degrade. Once degraded to small enough particles, they can interact with biological processes to produce water, CO2 and biomass. The process is shortened from hundreds of years to months for degradation and, thereafter, biodegradation depends on the microorganisms in the environment.

Oxo-biodegradation is defined as "degradation identified as resulting from oxidative and cell mediated phenomena, either simultaneously or successively." The first stage is an abiotic process and involves the reaction of O2 in the air with the polymer resulting in hydroxyl (OH), carbonyl (C=O) and carboxyl

(COOH) groups being introduced into the polymer chain; this leads to further oxidation resulting in the formation of smaller molecular fragments. The main factors that influence abiotic oxidation are heat and sunlight.

Biobased packaging materials are by definition made from renewable raw materials and can be classified according to their origin and method of production. However, not all of these materials are biodegradable (e.g., biopolyethylene made from sugar) and it excludes biodegradable packaging materials produced from petrochemical-based materials (e.g., poly(butylene adipate-co-terephthalate) [PBAT]). Biodegradability is not dependent on the origin of the raw materials but only on the chemical composition of the polymers, and, therefore, biodegradable polymers can be made either from renewable or petrochemical-based raw materials. Therefore, for some purposes, it is helpful to classify biodegradable packaging materials according to their origin and method of production. Biobased and/or biodegradable packaging materials can be classified into four main categories according to their method of production:

- Category 1: Polymers directly extracted from biomass such as starch, cellulose and chitin
- Category 2: Polymers produced by classical chemical synthesis from biomass monomers such as polylactic acid (PLA) and biopolyethylene (bioPE)
- Category 3: Polymers produced directly by natural or genetically modified organisms such as the polyhydroxyalkanoates (PHA)
- Category 4: Polymers whose monomers are obtained from petrochemical-based monomers such as poly(caprolactone) (PCL), poly(butylene succinate-co-adipate) (PBSA) and PBAT

Degradable refers to a material capable of undergoing a significant change in its chemical structure under specific environmental conditions, resulting in a loss of structural integrity and other properties. Degradation is a process that takes place in all materials, the speed depending on the environment. It is important to distinguish between degradability (mechanical disintegration) and biodegradability (metabolism) because not every polymer that can no longer be seen after a few weeks because it has disintegrated into small pieces has actually been biologically degraded. Two general mechanisms are usually considered for degradable plastics: photodegradation and biodegradation.

Biodegradation is a process whereby microorganisms such as bacteria, fungi and algae consume a substance as a food source so that its original form disappears and it is completely converted into water, CO2 and biomass.

Module III 8L

Lecture 1:

Methods of packaging with metals

1. 2 PIECE CANS:

Drawn and Ironed: The D&I (also known as *drawn and wall ironed* [DWI]) tinplate or aluminum container is made from a circular disc stamped from a sheet or coil of uncoated plate, formed into a shallow cup with effectively the same side wall and base thicknesses as the starting material

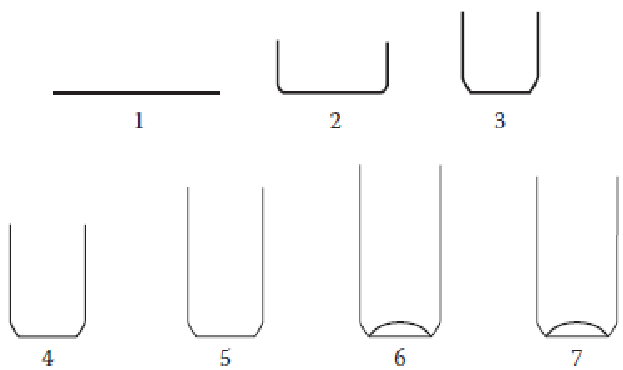


FIGURE 7.7 Sequential stages in the production of two-piece D&I cans: (1) disc cut from coil, (2) drawn into shallow cup, (3) redrawn into smaller diameter cup, (4, 5 and 6) wall thinning by ironing (diameter remains constant) and (7) finished can trimmed to required height.

Drawn and Re-drawn: The novelty of the DRD process is the use of multistage drawing to produce a can with a higher height-to-diameter ratio. This process is essentially identical to the initial stages of the D&I technique, except that the final height and diameter of the container is produced by sequentially drawing cups to a smaller diameter that is, causing metal to flow from the base to the wall of the container rather than ironing the container wall. As a consequence, the wall and base thickness, as well as the surface area, are identical to the original blank. This contrasts to the D&I can where the wall thickness is much less than the base thickness.

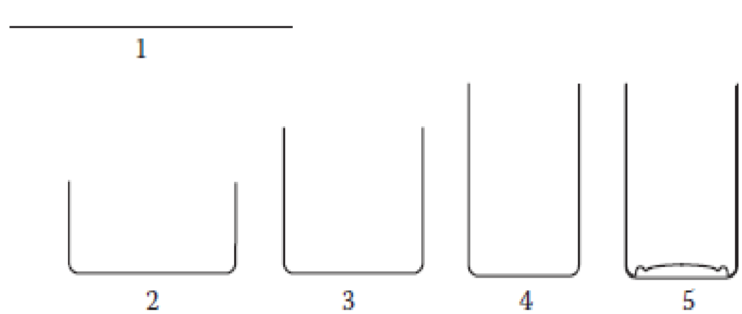


FIGURE 7.8 Sequential stages in the production of DRD cans: (1) body blank, (2) drawn cup, (3 and 4) diameter decreases as cup is redrawn and (5) finished trimmed can with profiled base.

3 PIECE CANS:

SEAMING OPERATION:

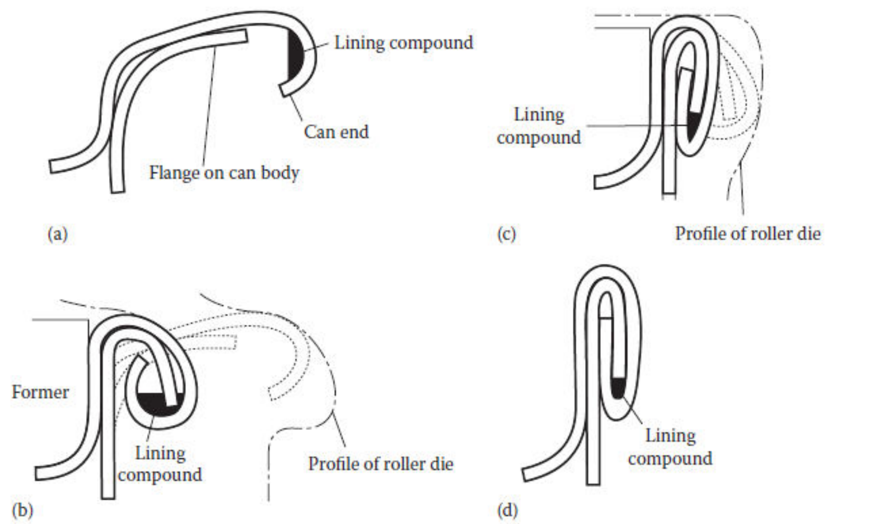


FIGURE 7.5 Double seaming of metal ends on to metal containers: (a) end and body are brought together, (b) first seaming operation, (c) second seaming operation and (d) section through final seam.

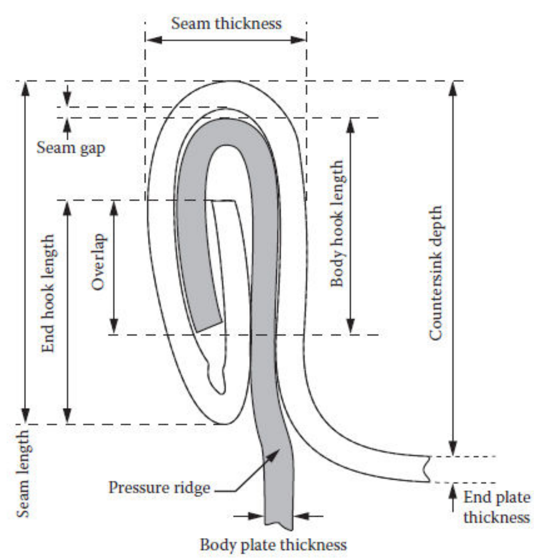


FIGURE 7.6 Main components of a double seam.

Lecture 2:

Methods of packaging with glass

FORMING PROCESSES: The glass is carried from the working end of the furnace to the forming machine in a channel-like structure called a **forehearth,** which is fired by a number of small burners, the aim being to ensure uniform temperature distribution throughout the depth of the glass. At the end of the forehearth is a gob-forming mechanism consisting of a rotating sleeve and vertical plunger. The glass exits in a continuous, viscous stream which is cut by rapidly moving, horizontal steel blades to form what isknown as a "gob" (i.e., a mass or lump of molten glass).Two basic types of processes are used to make: the blow and blow and the press and blow.

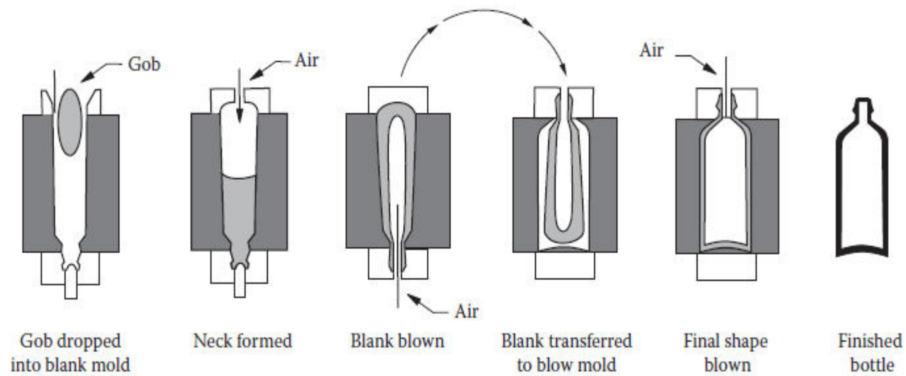


FIGURE 8.3 "Blow and blow" process for glass container manufacture.

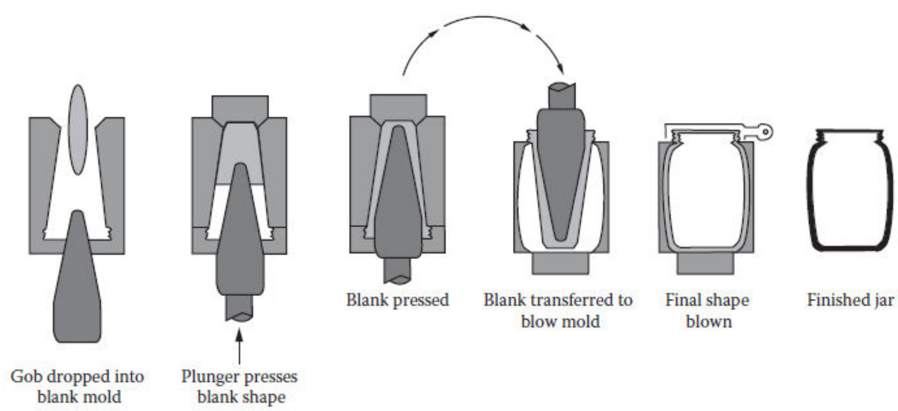


FIGURE 8.4 Wide mouth "press and blow" process for glass container manufacture.

Lecture 3:

Methods of packaging with plastics

PLASTIC FILM AND SHEET FOR PACKAGING:

Generally, films are by definition less than 100μm thick. Film is used to wrap product, to overwrap packaging, to make sachets, bags andpouches, and is combined with other plastics and other materials in laminates,which in turn are converted into packaging.

- In the cast film process, the molten plastic is extruded through a straight slot die onto a cooled cylinder, known as the chill roll.
- In the blown, or tubular, film process, the molten plastic is continuously extruded through a die in the form of a circular annulus, so that it emerges as a tube.

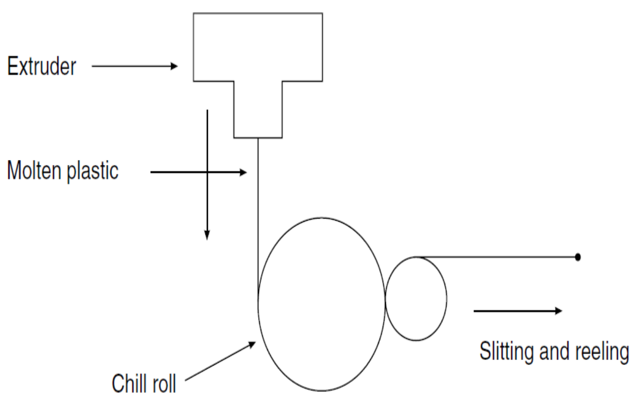


Figure 7.2 Production of cast film.

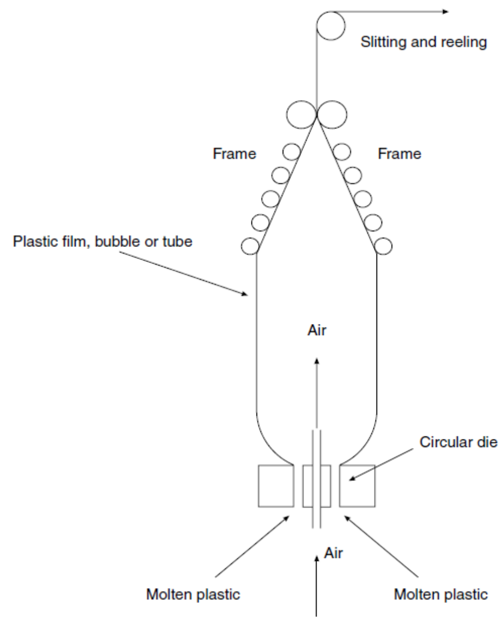


Figure 7.3 Blown film manufacture.

BLOW MOULDING:

Blow molding is a process to produce hollow objects. It was practiced with glass from ancient times, and the basic techniques used by the plastics industry have been derived from those developed by the glass industry. In blow molding, a molten tube of thermoplastic (known as a parison) is surrounded by a cooled mold having the desired shape. A gas (usually air but occasionally N2) is introduced into the tube causing the molten mass to expand against the walls of the mold where it solidifies on cooling. The mold is then opened and the bottle or jar ejected.

There are two techniques of plasticizing resin (i.e., making the material flow) and forming the parison:

1.Extrusion- which produces a continuous parison that has to be cut; this is the most common method used.

2.Injection molding- where the parison is formed in one mold and then transferred into another mold for blowing.

THERMOFORMING, FILLING AND SEALING:

There are many food applications for rigid and semi-rigid thermoformed containers. Examples include a wide range of dairy products, yoghurts etc. in single portion pots, fresh sandwich packs, compartmented trays to segregate assortments of chocolate confectionery and trays for biscuits. Thermo forming can be combined with packing on in-line thermoform, fill and seal machines. These machines can incorporate aseptic filling and sealing.

Lecture 4:

Potential of bio-composite materials for food packaging

During the last decade, joint efforts by the packaging and the food industries have reduced the amount of food packaging materials. Nonetheless, used packaging materials are still very visible to the consumer in the context of disposal. Environmental issues are becoming increasingly important to the European consumer. Consequently, consumer pressure may trigger the use of biobased packaging materials as an alternative to materials produced from non-renewable resources. Biologically based packaging is defined as packaging containing raw materials originating from agricultural sources, i. e. produced from renewable, biological raw materials such as starch and bioderived monomers. These materials are not necessarily biodegradable. Consequently, this review is not limited to biodegradable packaging. To date, biodegradable packaging has commanded great attention, and numerous projects are under way in this field. One important reason for this attention is the marketing of environmentally friendly packaging materials. Furthermore, use of biodegradable packaging materials has the greatest potential in countries where landfill is the main waste management tool. Biobased packaging materials include both edible films and edible coatings along with primary and secondary packaging materials.

Lecture 5:

Packaging regulations

On January 3, 2019, The Food Safety and Standards Authority of India (FSSAI) announced new regulations with respect to food packaging. The Food Safety and Standards (Packaging) Regulations, 2018 replace the packaging provisions of the Food Safety and Standards (Packaging and Labelling) Regulations, 2011. New labeling regulations were published separately. Food businesses will have until July 1, 2019 to comply with the new regulations. The new regulations include both general and specific requirements for packaging materials. In particular, they prescribe an overall migration limit of 60 mg/kg or 10 mg/dm2 and specific migration limits for certain contaminates in plastic packaging materials. The regulations also specify that food packaging materials must now comply with Indian Standards (IS) listed in Schedules I, II, and II for paper and paperboard materials, metal and metal alloys, and plastic materials, respectively. Previously, compliance with the standards was voluntary. They are available for purchase through the Bureau of Indian Standards (BIS). In comments on the draft Food Safety and Standards (Packaging) Regulations (notified to the World Trade Organization (WTO) on November 6, 2017), the European Union requested that BIS make the standards available free of charge, noting that non-Indian companies are required to pay higher prices than Indian companies. The EU also pointed out that the Standards are "not very recent" and requested that the Indian authorities permit newer materials if they can be shown to have an equivalent or better safety profile, as compared to materials permitted by the Standards. In addition, the EU requested information on the mechanism for submitting requests to BIS to establish new specifications. The final regulations allow the use of relevant International Standards where Indian Standards are not available. India's new packaging regulations ban both the use of recycled plastics in food packaging and the use of newspaper and such other materials for packing or wrapping of food articles. They also reference specific Indian Standards for printing inks for use on food packages. Schedule IV of the regulations is a list of suggested packaging materials for different food product categories.

Lecture 6:

Disposal of packaging materials

Packaging has been with us for thousands of years in one form or another. Nature developed food packaging well before man, even to the extent of the outer surface being an indicator to show when the product is ready to eat. Today food packaging is used, or abused, to provide prepared food for the sophisticated consumer.

Modern packaging can be defined as a means of ensuring the safe delivery of a product to the consumer in a sound condition at minimal overall cost. To put packaging materials in perspective, 66% of all packaging is used for food. In developed countries, where packaging is used with a food processing system, food waste is approximately 2-3%. In developing countries, where no such packaging systems exist, food waste may be as high as 30-50%. Today's consumer wants to buy food which is ready to eat, or needs a minimum of preparation, and is good value for money. To be able to supply these demands requires the use of different types of packaging for different applications. Packaging is also used by the manufacturer to make his product stand out on the shelf in the supermarket so that the consumer will select his product rather than that of his competitor. This means that pack design has an important part to play in the perception of packaging by the consumer. Packaging becomes waste when its original functional has been fulfilled. These functions are containment, protection, preservation, identification and convenience. Packaging is a lot less objectionable than the organic putrecible matter of which it has taken the place. Packaging can provide hygiene and an insurance against illness and disease. The average consumer is confused by some of the issues regarding packaging. We, as an industry, should attempt to put a balanced view to try to educate the consumer so that misunderstandings and conflicts between packaging materials are minimized.

Packaging materials can readily be classified into two categories:

1. Renewable resource, and
2. Non-renewable resource.

Lecture 7:

Biodegradable packaging materials

Biodegradables mean anything that must be degenerated and compostable under the suitable conditions of temperature, moisture, and oxygen leaving behind no toxic or harmful residues. Thus the biodegradable packaging materials are those that undergo the process of degradation by naturally occurring organisms, such as bacteria, yeast, or fungi (Sorrentino et al., 2007), and can be used as humus or fertilizer when composted (Siracusa et al., 2008). Currently, various kinds of biodegradable and compostable polymers, such as starch, cellulose, chitosan, and lignin, are commercially available. Even some synthetic polymers are mixed with minute amounts of biopolymers for making them biodegradable. The best biodegradable materials are derived from the renewable and bio-based sources called biopolymers. The main function of biodegradables like any other packaging materialist oprotectthe contents from surrounding and maintain its quality throughout the storage life. Therefore, other characteristics like mechanical (tensile strength, tear and burst strength, etc.) and barrier properties, such as permeability of vapors, gases, light, etc., are equally important. The biopolymers are effective barriers against vapors and gases. But their mechanical and barrier properties can be improved by blending two or more biopolymers. Several active components or additives like antimicrobials, color, nutrients, antioxidants, etc. can be incorporated for increasing their performance (Clarinval and Halleux, 2005). Thus, the biopolymers serve as an eco-friendly alternative for the use of nonrenewable and non-biodegradable plastic based packaging materials. The study of recyclable and biodegradable polymers is an interesting and growing area in packaging science but immense research is required for improving their performance, thermal, mechanical, and physical characteristics, and commercial use, which might be possible in a few years. The few developments of biodegradable polymers are mentioned as follows:

1. LDPE-starch blend were commercialized under the trade name Ecostar® in1993(Siracusa et al., 2008).
2. Alexandre and Dubois (2000) manufactured the biopolymer-layered silicate nano-composites that have remarkably enhanced the physical characteristics including higher gas barrier attributes, tensile strength, and thermal stability.
3. Khankrua et al. (2013) employed the silica nano particles to increase the onset and inflection temperature of thermal degradation in PLA, polybutylenesuccinate (PBS) as well as poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV) nano-composites. However, the mechanical properties were slightly improved at low concentration of silica and worsen at the higher levels of silica due to the agglomeration of silica in the polymer matrix.

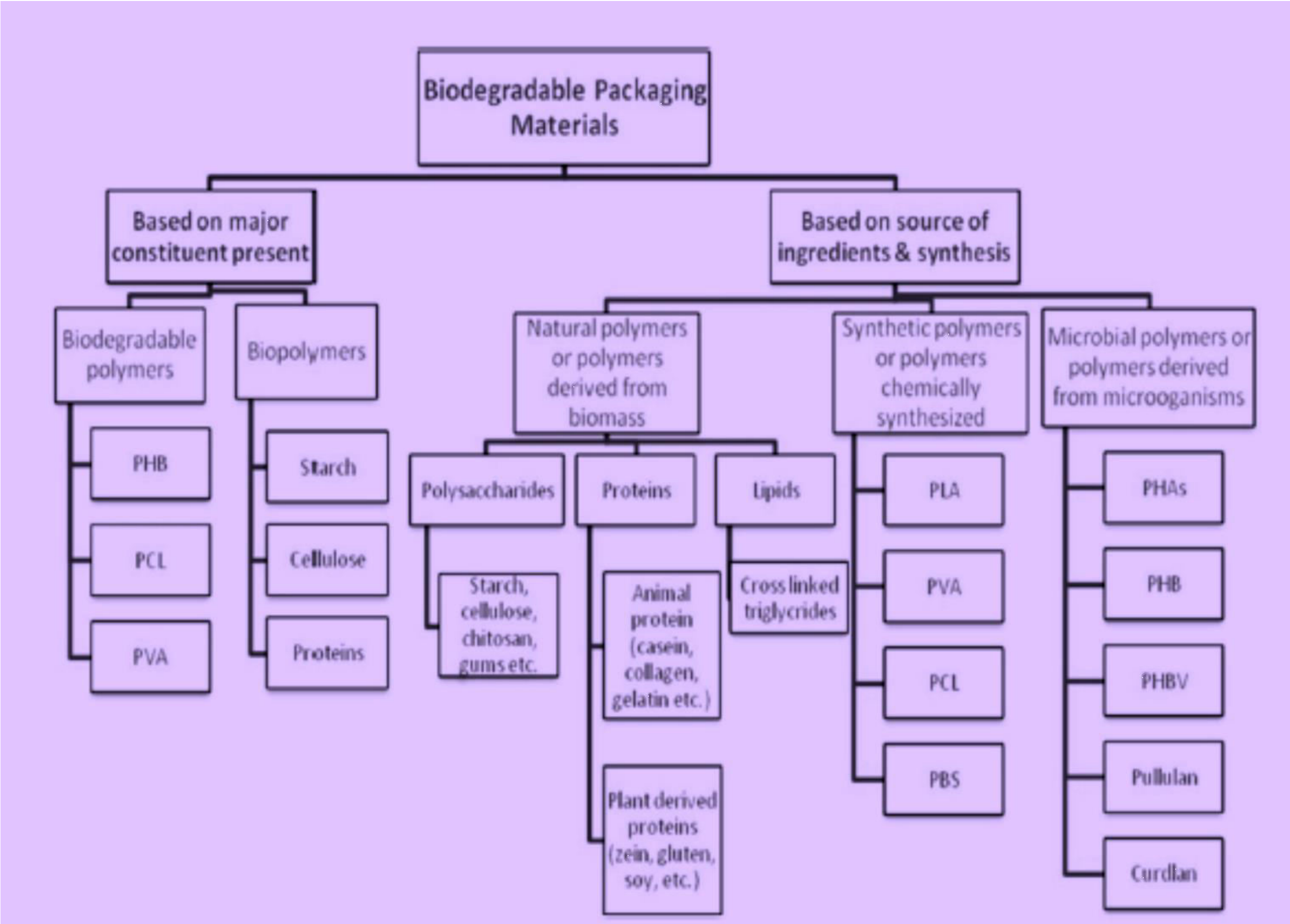


Fig. 1 Classification of biodegradable packaging materials based on the major constituents present and the origin of ingredients and their synthesis. PBS, polybutylene succinate; PCL, polylactic acid; PHA, polyhydroxyalkanoate; PHB, polyhydroxy butyrate; PLA, polylactic acid; PVA, polyvinyl alcohol. Reproduced from Clause, J.W., 2000. Bio-based packaging material for food Industry. European Concerted Action Project, pp. 13–50. ISBN: 87-90504-07-0.

Lecture 8:

Importance of packaging materials as tool for food preservation

Food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf life, and maintain or increase the quality and safety of food. Indoing so, packaging provides protection from3 major classes of external influences: chemical, biological, and physical.

Chemical protection minimizes compositional changes triggered by environmental influences such as exposure to gases (typically oxygen), moisture (gain or loss), or light (visible, infrared, or ultraviolet). Many different packaging materials can provide a chemical barrier. Glass and metals provide a nearly absolute barrier to chemical and other environmental agents, but few packages are purely glass or metal since closure devices are added to facilitate both filling and emptying. Closure devices may contain materials that allow minimal levels of permeability. For example, plastic caps have some permeability to gases and vapors, as do the gasket materials used in caps to facilitate closure and in metal can lids to allow sealing after filling. Plastic packaging offers a large range of barrier properties but is generally more permeable than glass or metal. Biological protection provides a barrier to microorganisms (pathogens and spoiling agents), insects, rodents, and other animals, thereby preventing disease and spoilage. In addition, biological barriers maintain conditions to control senescence (ripening and aging). Such barriers function via a multiplicity of mechanisms, including preventing access to the product, preventing odor transmission, and maintaining the internal environment of the package. Physical protection shields food from mechanical damage and includes cushioning against the shock and vibration encountered during distribution. Typically developed from paperboard and corrugated materials, physical barriers resist impacts, abrasions, and crushing damage, so they are widely used as shipping containers and as packaging for delicate foods such as eggs and fresh fruits. Appropriate physical packaging also protects consumers from various hazards. For example, child-resistant closures hinder access to potentially dangerous products. In addition, the substitution of plastic packaging for products ranging from shampoo to soda bottles has reduced the danger from broken glass containers.

Module IV 8L

Lecture 1: Testing of packaging materials: Rigid packaging

I]. Metal Containers

II]. Glass Container

Lecture 2: Testing of packaging materials: Semi-rigid packaging

I]. Plastic:

PARENTERAL AND NON-PARENTERAL PREPARATIONS:-

1. **Leakage test:** Fill ten containers with water. Fit with intended closures and keep tem inverted at room temperature for 24 hour. There are no signs of leakage from any container.

2. Collapsibility Test: This test applicable to containers. Which are to be squeezed in order toe remove the contents. A container by collapsing inwards during use yields at least 90% of its nominal contents at the required rate of flow at ambient temperature.

3. Clarity of aqueous extract: Select unlabelled, unmarked and non-laminated portions from suitable containers, taken at random sufficient to yield a total area of sample required taking into account the surface area of both sides. Cut these portions into strips none of which has a total area of more than 20 cm2. Wash the strips free from extraneous matter by shaking them with at least two separate portions of distilled water for about 30 seconds in each case, then draining off the water thoroughly.

4. Transparency test: Fill five empty containers to their nominal capacity with diluted. suspension as described in IP 1966. The cloudiness of the diluted suspension in each container is detectable when viewed through the containers as compared with a container of the same type filled with water.

5. Water vapour permeability test: Fill five containers with nominal volume of water and heat seal the bottles with an aluminum foil-poly ethylene laminate or other suitable seal. Weigh accurately each container and allow standing (without any overwrap) for 14 days at a relative humidity of 60+5% and a temperature between 20 and 25 ^{0}C re-weigh the containers. The loss in weight in each container is not more than 0.2%.

PHYSICO-CHEMICAL TESTS:-

The following tests are based on the extraction of the plastic material, and it is essential that the designated amount of the plastic be used. Also, the specified surface area must be available for extraction at the required temperature.

1. Appearance
2. Light absorption
3. pH
4. Non-volatile matter
5. Residue on ignition
6. Heavy metals
7. Buffering capacity
8. Oxidisable substances

BIOLOGICAL TESTS

The USP has provided its procedures for evaluating the toxicity of plastic materials. Essentially the tests consist of three phases:

1. Implantation test: Implanting small pieces of plastic material intramuscularly in rabbits.
2. Systemic injection test: Injecting eluates using sodium chloride injection, with and without alcohol intravenously in mice and injecting eluates using poly ethylene glycol 400 and sesame oil intraperitoneally in mice.
3. Intracutaneous test: Injecting all four eluates subcutaneously in rabbits. The reaction from test samples must not be significantly greater than nonreactive control samples.

II]. PAPER, PAPERBOARD, AND CARDBOARD

1. Tear strength
2. Bursting strength
3. GSM Test
4. Stacking Ability
5. Water vapour permeability test

Lecture 3: Flexible containers and retort pouches in food packaging

The retort pouch is a flexible package, hermetically sealed on three or four sides and made from one or more layers of plastic or foil, each layer having a specific functionality. The choice of barrier layers, sealant layers and food contact layers depends on the processing conditions, product application and desired shelf life. Typical processing conditions involve temperatures of 121°C for times of up to 30 min (60 min for the large [3.5 kg] catering packs). One of the attractions of the retort pouch compared to the metal can is the thin profile of the package (12–33 mm for 200–1000 g pouches), enabling retorting times to be reduced by up to 60%, final quality to be improved, as well as rapid reheating prior to consumption. Other advantages include the ease of carrying, reheating and serving, as well as weight and space saving. Finally, disposal of the used pouch is much simpler than for the metal can as it can be easily flattened.
A typical three-layer pouch structure would consist of an outer layer of 13 μm PET for strength and toughness; a middle layer of 9–18 μm aluminum foil as a moisture, light and gas barrier and an inner layer of 70–100 μm CPP for heat sealability, strength and compatibility with all foods. An additional inner layer of 15–25 μm BON-6 is used when a longer shelf life is required. Traditionally, a three-sided seal pouch was used for MREs and other commercial products, but this has been superseded by a multilayer four-side-seal pouch. Stand-up pouch designs having a gusseted bottom have also been commercialized. Traditionally, a three-sided seal pouch was used for MREs and other commercial products, but this has been superseded by a multilayer four-side-seal pouch. Stand-up pouch designs having a gusseted bottom have also been commercialized. Transparent retort pouches can be produced by replacing the aluminum foil layer.
Unlike the metal can, retort pouches are susceptible to rupture or seal separation during retorting if the internal pressure exceeds the external process pressure. This is most likely to occur at the start of the cooling cycle when the product is at its hottest. The use of superimposed air pressure to counter balance the buildup in internal pressure in the pouch and control pouch integrity is necessary.

A recent development has been the incorporation of zippers into the pouch to make it easier to open and reseal. Conventional zippers are made of LDPE that will not withstand retort temperatures, forcing zipper manufacturers to design zippers made from PP resins and match them with compatible pouch film. Aesthetic considerations have also had to be addressed. Because food migrates to the edges of the pouch during retorting, a secondary barrier to shield the zipper and prevent food from crusting around it had to be designed.

Lecture 4: Sealing of packaging materials

SEALING OF PLASTIC AND GLASS CONTAINERS:

Closures are required to perform some or all of the following functions without affecting, orbeing affected by, the contents of the container:

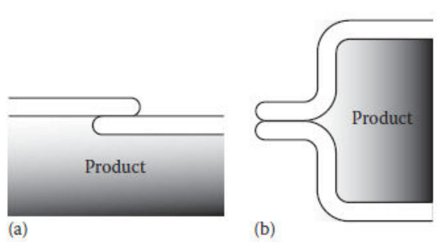
1. Provide an effective hermetic (air-tight) seal to prevent the passage of solids, liquids or gases into or out of the container.
2. Provide easy opening and (when only part of the contents is used at one time) resealing of the container.
3. Provide evidence of inviolability (i.e., that unlawful access to the contents or their exposure to the atmosphere has not occurred).

Closure and sealing techniques vary for different food packaging. In general, closures for plastic and glass that are used with food containers can be classified as:

- Closures to Retain Internal Pressure – these use crown corks, Roll-On Tamper-Evident with aluminum, etc.
- CLOSURES TO CONTAIN AND PROTECT CONTENTS
- CLOSURES TO MAINTAIN VACUUM INSIDE CONTAINER (USUALLY FOR VACUUM PACKED PRODUCTS)

HEAT SEALING FOR PLASTIC CONTAINERS

HEAT SEALING INVOLVES WELDING THERMOPLASTIC POLYMER SURFACES TOGETHER IN ORDER TO PRODUCE SEALS OR JOINTS OF SUFFICIENT STRENGTH TO WITHSTAND STRESSES IN THE DISTRIBUTION AND CONSUMER ENVIRONMENT. THERE ARE TWO TYPES OF SEALS. A FIN SEAL IS FORMED WHEN THE INSIDE SURFACE OF THE FILM IS SEALED AGAINST ITSELF. A LAP SEAL IS FORMED WHEN THE INSIDE SURFACE OF THE FILM IS SEALED AGAINST THE OPPOSITE (OUTSIDE) SURFACE OF THE FILM. THESE ARE COMMONLY USED IN LONGITUDINAL OR VERTICAL FORM-FILL-SEAL MACHINES.



Two major types of heat seals: (a) lap seal and (b) fin seal.

Apart from these there are other types of heat sealing techniques. One such example is the Induction Sealing which is a noncontact method of heat sealing made by exposing a metal (generally aluminum foil) coated with a thermoplastic sealant to a high frequency, electromagnetic field generated by passing an alternating current through a coil.

PEELABLE SEALS:

Peelable seal technology provides retention of package integrity yet allows consumers to access the contents without tearing or otherwise destroying the package. There are three basic peel mechanisms for achieving peelable heat seals – adhesive, cohesive and delamination peel.

Lecture 5:

Manufacturing of labels for packaging materials

Purpose of packaging labels:

- **Information transmission** – Packages and labels communicate how to use, transport, recycle, or dispose of the package or product. With pharmaceuticals, food, medical, and chemical products, some types of information are required by government legislation. Some packages and labels also are used for track and trace purposes. Most items include their serial and lot numbers on the packaging, and in the case of food products, medicine, and some chemicals the packaging often contains an expiry/best-before date, usually in a shorthand form. Packages may indicate their construction material with a symbol.
- **Marketing** – Packaging and labels can be used by marketers to encourage potential buyers to purchase a product. Package graphic design and physical design have been important and constantly evolving phenomena for several decades. Marketing communications and graphic design are applied to the surface of the package and often to the point of sale display. Most packaging is designed to reflect the brand's message and identity.

Packaging may be of several types. For example, a **transport package** or **distribution package** can be the shipping container used to ship, store, and handle the product or inner packages. Some identify a **consumer package** as one which is directed toward a consumer or household.

Custom packaging is an evolutionary use of modern materials. Thermoforming and vacuum forming allow for expanded capabilities for large trays, displays, and specialty needs. Thermoforming is a method which uses vacuum, heat, and pressure to form the desired material into a shape determined by its mold. This type of packaging is often used by the cosmetic and medical industry.

Packaging may be described in relation to the type of product being packaged: medical device packaging, bulk chemical packaging, over-the-counter drug packaging, retail food packaging, military materiel packaging, pharmaceutical packaging, etc.

It is sometimes convenient to categorize packages by layer or function: "primary", "secondary", etc.

- 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.
- Secondary packaging is outside the primary packaging, and may be used to prevent pilferage or to group primary packages together.
- Tertiary or transit 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.

These broad categories can be somewhat arbitrary. For example, depending on the use, a shrink wrap can be primary packaging when applied directly to the product, secondary packaging when used to combine smaller packages, or tertiary packaging when used to facilitate some types of distribution, such as to affix a number of cartons on a pallet.

Symbols used on packages and labels

Many types of symbols for package labeling are nationally and internationally standardized. For consumer packaging, symbols exist for product certifications (such as the FCC and TÜV marks), trademarks, proof of purchase, etc. Some requirements and symbols exist to communicate aspects of consumer rights and safety, for example the CE marking or the estimated sign that notes conformance to EU weights and measures accuracy regulations. Examples of environmental and recycling symbols include the recycling symbol, the recycling code (which could be a resin identification code), and the "Green Dot". Food packaging may show food contact material symbols. In the European Union, products of animal origin which are intended to be consumed by humans have to carry standard, oval-shaped EC identification and health marks for food safety and quality insurance reasons.

Bar codes, Universal Product Codes, and RFID labels are common to allow automated information management in logistics and retailing. Country-of-origin labeling is often used. Some products might use QR codes or similar matrix barcodes. Packaging may have visible registration marks and other printing calibration and troubleshooting cues.

Lecture 6:

SHRINK PACKAGING AND STRETCH WRAPPING:

SHRINK FILMS: Shrink films are composed of three basic categories: polyolefins, PVC and PVdC copolymer. With the exception of PVdC copolymer film, which can be shrunk in hot water, most of the other shrink films require temperatures above 100°C to obtain a suitable degree of shrinkage. The range of temperature over which a film will shrink is important. The lower the shrink temperature, the simpler and less expensive is the shrink process.

STRETCH FILMS: The main polymers used in stretch/cling films are LDPE, LLDPE, VLDPE, PVC, EVA copolymer and PP, the choice depending on such factors as appearance (i.e., requirements for clarity, sparkle and so on) and the protection required (gas and moisture barrier, and/or physical protection in preventing pallet loads from disintegrating).

Lecture 7:

Transportation of packaging materials

Goal: Ensure food is packaged and transported in a way that:

- Protects it from the likelihood of contamination
- Keeps it at a temperature to maintain safety and suitability
- Provides customers with accurate information about the food.

Material used for transportation:

1. CFB Boxes- Corrugated fiberboard is the most widely used material for fruit & vegetable packages because of the following characteristics:

- Light in weight
- Reasonably strong.
- Flexibility of shape and size
- Easy to store and use
- Good pointing capability
- Economical

2. Wooden Boxes- Materials used for manufacture of wooden boxes include natural wood and industrially manufactured wood based sheet materials.

3. Sacks- Sacks are traditionally made of jute fibre or similar natural materials. Most jute sacks are provided in a plain weave. For one tonne transportation of vegetables, materials of 250 grams per square meter or less are used. Natural fibre sacks have in many cases been replaced by sacks made of synthetic materials and paper due to cost factors, appearance, mechanical properties and risk of infestation and spreading of insects.

Other important factors for transportation:

1. **Palletisation-** Pallets are widely used for the transport of fruit & vegetable packages, in all developed countries. The advantages of handling packages on pallets are:
   - Labour cost in handling is greatly reduced.
   - Transport cost may be reduced.
   - Goods are protected and damage reduced.
   - Mechanized handling can be very rapid.
   - Through high stacking, storage space can be more efficiently used.
   - Pallets encourage the introduction of standard package sizes.

   In designing export packages, their handling on pallets for shipping or for transport and storage within the importing country, is an important factor. The most common pallet size is 1200 mmx1100 mm.
2. **Ventilation of Packages-** Reduction of moisture loss from the product is a principal requirement of limited permeability packaging materials. A solution to moisture loss problems from produce appeared with the development and wide distribution of semi permeable plastic films. Airflow through the ventilation holes allows hot fruit or vegetable to slowly cool and avoid the buildup of heat produced by the commodity in respiration. Holes are also important in cooling the fruit when the packages are placed in a cold storage, especially with forced air-cooling. Ventilation holes improve the dispersal of ethylene produced.
3. **Cushioning Materials-** The function of cushioning materials is to fix the commodities inside the packages and prevent them from mixing about in relation to each other and the package itself, when there is a vibration or impact. Some cushioning materials can also provide packages with additional stacking strength. The cushioning materials used vary with the commodity and may be made of wrapping papers, Fibreboard (single or double wall), Moulded paper pulp trays, Moulded foam polystyrene trays, Moulded plastic trays, Foam plastic sheet, Plastic bubble pads, Fine shredded wood, Plastic film liners or bags.

Lecture 8: Active and intelligent packaging

Active Packaging: Active packaging is defined as packaging in which subsidiary constituents have been deliberately included in or on either the packaging material or the package headspace to enhance the performance of the package system.

This type of packaging usually involves an interaction between the packaging components and the food product beyond the inert passive barrier function of the packaging material. The major active packaging technologies include oxygen scavengers, moisture absorbers, antimicrobial agent releasers, ethylene scavengers, flavor/odor absorbers, and temperature control packaging. In order to apply this technology, the major deteriorative factor(s) for food products should be understood. For example, the shelf life of a packaged food is affected by numerous factors such as acidity(pH), water activity (aw), respiration rate, oxidation, microbial spoilage, temperature, etc. By carefully considering all of these factors, active packaging can be developed and applied to maintain the quality of the product and/or to extend its shelf life.

ACTIVE PACKAGING SYSTEMS:

1. **Oxygen scavengers:** Oxygen scavengers are the most commercially applied technology in the active packaging market. By scavenging oxygen molecules in the package headspace, oxidative damage to food components such as oil, flavors, vitamins, color, etc. can be prevented. In addition, reduced O_2 concentration in the package retards the growth of aerobic bacteria and mold. The basic principle of oxygen scavenging is related to oxidation of the scavenging agents (either metallic or non-metallic based materials) to consume oxygen. The most common Oxygen scavengers used in the food industry are sachets with iron powder, which are highly permeable to oxygen. By using iron powder, the O_2 concentration in the headspace can be reduced to less than 0.01% while vacuum or gas flushing typically achieves 0.3–3.0% residual O_2 levels. The metal-based oxygen scavengers normally cannot pass the metal detectors on the packaging lines and cannot provide transparent packages if they are directly incorporated into packages. Non-metallic O_2 scavengers, such as ascorbic acid or glucose oxidase, can be used as an alternative choice. However, the use of non-metallic O_2 scavengers is not widespread. O_2 scavengers can be incorporated into plastic film/sheet when there are market concerns about accidental consumption of sachets or when an O_2 scavenger needs to be used for liquid foods. In this case, the O_2 scavenger impregnated layer is typically sandwiched between film layers. The

outside layer provides high oxygen protection and the inner layer prevents direct contact between the scavenger-containing matrix layer and the food.

$$Fe + \frac{3}{4}O_2 + 1\frac{1}{2}H_2O \rightarrow Fe(OH)_3$$

2. Moisture absorbers: Moisture in packages is a major cause of food deterioration such as microbial growth-related spoilage and product softening. Moisture-absorbing sachets are used in food packaging for humidity control. Several desiccants such as silica gel, calcium oxide, and activated clays and minerals are typically contained in sachets. Drip-absorbent pads and sheets are also used to absorb liquid in high aw foods such as meats, fish, poultry, fruits, and vegetables. A superabsorbent polymer is sandwiched by a microporous non-woven plastic film such as polyethylene or polypropylene. Polyacrylate salts, carboxymethyl cellulose (CMC), and starch co-polymers are typically used as the absorbent polymer.

3. Ethylene scavengers: Ethylene (C2H4) works as a plant growth regulator which accelerates the respiration rate and senescence of fruits and vegetables. Removing ethylene from the environment can extend the shelf life of horticultural products. One of the most common ethylene scavengers is made from potassium permanganate ($KMnO_4$) immobilized on an inert mineral substrate such as alumina or silica gel. Activated carbon-based scavengers with various metal catalysts are also used as effective ethylene scavengers. In recent years, packaging films and bags have been commercialized based on the reputed ability of certain finely dispersed minerals to absorb ethylene (such as clays, zeolites, coral, ceramics, etc.) (Rooney, 2005).

$$3C_2H_4 + 12KMnO_4 \rightarrow 12MnO_2 + 12KOH + 6CO_2$$

4. Flavor/Odor Absorbers and Releasers: The commercial use of flavor/odor absorbers and releasers is controversial due to concerns arising from their ability to mask natural spoilage reactions and hence mislead consumers about the condition of packaged food. Eg. FDA-approved flavors were sealed into a thin layer of plastic on the inside of the bottle cap. Before the seal is broken, the fragrance infused the water with a fruity scent. When a consumer opened the bottle breaking its seal, the fragrance was released into the air, and traveled along the back of the throat to the nasal passage, enhancing the fruity taste. Active packaging can also be used to remove undesirable taints or odors from packaged food and several such absorbers were released last century to absorb volatile amines from the

breakdown of fish muscle, as well as aldehydes from the autoxidation of fats and oils. However, there is no evidence that they are still commercially available.

5. Antioxidant Packaging: Antioxidants have been incorporated into plastic films (particularly polyolefin) to stabilize the polymer and protect it from oxidative degradation.

6. Antimicrobial agent releasers: Typically, surface contamination during food handling and transportation is one of the most common sources of food-borne illness, and lower amounts of antimicrobial agents are required to control the surface microbial contamination/ growth if they are incorporated into or onto packaging material rather than directly added into the food itself. There are two mechanisms for antimicrobial action: one is controlling microbial growth by slow and controlled release (or migration) of the antimicrobial agents over the product shelf life. The other type is controlling microbial growth by contact without release of the antimicrobial agents, which are immobilized on the surface of the package. An example of a commercial application of an antimicrobial packaging is silver ion-based film. This film is an effective antimicrobial agent with very low human toxicity and it has been used in food containers.

7. Microwave Susceptors: Packaging materials that absorb microwave energy and convert it to heat are called susceptors.

8. Temperature-controlled packages (Self-Heating And Self-Cooling Packages): Temperature-controlled active packages generally include self-heating and self-cooling systems. The fundamental concepts for self-heating are not new. An exothermic chemical reaction between CaO (quicklime) and a water based solution generates heat. The challenging part of this system is optimizing the reaction and the thermal design of the container to provide an efficient, safe, and cost-effective package. Self-heating packages are commercially available for coffee, tea, and ready-to-eat meals. Self-cooling cans use endothermic chemical reactions; the latent heat of evaporating water is often used to produce the cooling effect. One example is dissolution of ammonium nitrate and chloride in water to cool the product.

Intelligent Packaging:

Intelligent packaging is defined as packaging that contains an external or internal indicator toprovide information about aspects of the history of the package and/or the quality of the food.Intelligent packaging systems can be classified into three categories:

- Indicate product quality, for example, quality indicators, temperature and time–temperature indicators and gas concentration indicators.
- Provide more convenience, for example, during preparation and cooking of foods.
- Provide protection against theft, counterfeiting and tampering.

Time – temperature indicators such as chemical, physical, physicochemical, biochemical, etc. are in use. Gas concentration indicators generally used in MAP. Radio Frequency Identification (RFID) is the use of radio frequencies to read information at a distance with few problems fromobstruction or disorientation on a small device known as a tag or transponder that can be attachedto an object (commonly a pallet or corrugated box) so that the object can be identified and tracked. Biosensors are also used.

Question Bank

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following questions:

i) The principle ingredient of glass is

a) Calcium oxide

b) Alumina

c) Silica

d) Potash Alumn

ii) Common lubricant system for tin plate uses

a) Dioctyle sebacate

b) Linseed oil

c) Grease

d) Wax

iii) The surface of tin free steel contains

a) Chromium oxide

b) Chromium

c) Steel

d) Oil

iv) Two piece cans can be prepared by

a) Double seaming

b) DWI

c) Welding

d) Soldering

v) Biodegradable film can be produced from

a) LDPE

b) Chitosan

c) PP

d) PVC

vi) Packaging material used for packaging of fats and oils is

a) HDPE

b) LLDPE

c) Nylon

d) PP

vii) Ideal shipping container for biscuit is

a) Paperboard

b) Flexible Pouch

c) Glass Jar

d) Aluminum Container

viii) Role of nylon laminates is basically to give

a) Stiffness and printability

b) Strength and oil resistance

c) Clarity

d) Low moisture permeability

ix) Idea packaging material for instant tea is

a) Paper

b) PET

c) Aluminium foil

d) LDPE

x) Full form of PET stands for

a) Polyester terephthalate

b) Polyester trimethyle

c) Polyethylene terephthalate

d) None

xi) Benzophenone is actually

a) Bibenzyl alcohol

b) Diphenyl ketone

c) Propyle benzene

d) Phenyl propane

xii) Which of the following natural pigments acts as corrosion accelerator pf metal cans?

a) Xanthophyll

b) Chlorophyll

c) Myoglobin

d) Anthocyanin

xiii) Safety concern for vacuum packed sausage is caused by

a) *Salmonella enteritidis*

b) *Listeria monocytogenes*

c) *Clostridium botulinum*

d) *Bacillus cereus*

xiv) Glass as packaging materials were first industrialized in which of the following civilizations?

a) Egypt

b) China

c) India

d) None

xv) Hydrapulper is used to produce which one of the following during paper manufacturing?

a) Pulp

b) Stock

c) Sheet

d) All of the above

xvi) Most common application of carbon monoxide in MAP of food is for

a) Red Meat

b) Shell Fish

c) Fresh fruit

d) None

xvii) Active packaging for foods provides

a) Oxygen, Nitrogen, Carbon-di-oxide

b) Oxygen and NO

c) Oxygen, Carbon di oxide and odour scavenger

d) Carbon di oxide, NO_2 and odour scavenger

xviii) Environmental Stress Cracking is a failure for

a) Polymers

b) Metals

c) Paper

d) None

xix) Which of the flowing is the strongest paper manufactured

a) Grease-proof paper

b) Kraft

c) Parchment

d) None of the above

xx) Which of the following is a type of laminating adhesive used in food packaging?

a) Blends of paraffins

b) Vinyl acetate

c) Both of the above

d) None of the above

xxi) What is the full form of LLDPE?

a) Linear Low Density Polyethylene

b) Linear Low Density Polystyrene

c) Labeled Low Density Polyethylene

d) None of the above

xxii) Inner layer of laminates for food pouches preferably consists of

a) LDPE

b) PP

c) Nylon film

d) All of the above

xxiii) For greater strength pure aluminum is alloyed with

a) Magnesium

b) Zinc

c) Copper

d) Chromium

GROUP - B
(Short Answer Type Questions)

2. Define Packaging and explain primary, secondary and tertiary packaging. (2+1+1+1)
3. What function does packaging material play in conserving the environment? (5)
4. Give some examples of co-polymers of Ethylene which can be used as packaging materials?What is Environmental Stress Cracking? (2+3)
5. What are the advantages of edible packaging materials? (5)
6. What is addition polymerization? Briefly explain atactic and isotactic polymers. (3+2)
7. What are Oxo-Biodegradable (OBD) Polymers? What are the advantages of using nano-composite materials in food packaging? (3+2)
8. What are grease-proof papers? Briefly explain the term 'glassine'. Write the use of kraft paper. (2+2+1)
9. What are the uses of paper-boards as a packaging material for food? What is the function of corrugation in fiber-boards? Why do we laminate papers? (2+2+1)
10. Give some examples of additives in plastics. Why is PET a very good choice for packaging of beverages?What are the stages of performing shrink-wrapping of food? (2+1+2)

GROUP - C

(Long Answer Type Questions)

11. What is modified atmosphere packaging (MAP)? What are the packaging films commonly used for MAP? Is there any difference on controlled atmosphere packaging and MAP? Discuss the roles of O_2, N_2 and CO_2 in MAP. Name some equipment used for performing MAP.
(3+2+2+6+2)
12. Discuss the difference between tin-plates and tin-free steel (TFS). What are the disadvantages of using TFS? Briefly explain the role of aluminum as a packaging material. How is aluminum foils made? Write some applications of aluminum foils. (3+2+4+2+4)
13. Comment on the advantages of using glass as a food-packaging material. Briefly discuss the methods of forming process for manufacturing glass jars and bottles. (7+8)
14. What type of packaging items will you choose for the following food items –
    a) Milk and Dairy products
    b) Fats and oils
    c) Red Meat

What are form-fill-seal cartons? How does irradiation help in aseptic packaging?
(6+5+4)

15. What are the common sorbants, permeating and migrating substances – generally relevant in interactions between food and packaging materials? Highlight their adverse consequences. How do different factors affect food-packaging interactions? Explain with examples on how we can reduce such problems? (3+3+5+4)
16. Give some examples of different polyolefin used in food packaging industry. Discuss the properties of polypropylene as a food packaging material. What is the major difference between LDPE and LLDPE? What is polystyrene? Give some uses of polystyrene as packaging material.
(3+5+2+2+3)
17. What do you mean by intelligent packaging? Give some examples. Discuss the role of radio frequency identification in intelligent packaging of food. How can we improve the printability of a packaging material? (4+3+3+5)
18. What is meant by 'Tetra pack'? Discuss the scalping phenomenon. What are disposable packaging materials? What are the optical tests that are performed for packaging materials?
(5+3+2+5)
19. Why is it important to have a good closure to the food container? What are the different types of closures that are in use? What are the different types of heat sealing used in packaging industry? What are the differences between adhesive and cohesive types of peel-able seals usedin food packaging?
(2+5+5+3)