

Packaging of Dairy Products



PACKAGING OF DAIRY PRODUCTS

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Index

Lecture	Page No
Module 1: Introduction and History of Packaging Development	
Lesson 1. History of Package Development	5-10
Lesson 2. Importance of packaging	11-20
Module 2: Packaging Materials	
Lesson 3. Selection of Packaging Materials	21-23
Lesson 4. Characteristics of Paper, corrugated paper, fiber board and wood	24-30
Lesson 5. Characteristics of Glass	31-34
Lesson 6. Characteristics of Metals and Metallic Containers	35-41
Lesson 7. Characteristics of Plastics	42-47
Lesson 8. Sources of different plastic materials and process of manufacture	48-58
Lesson 9. Forms of different plastic materials - 1	59-70
Lesson 10. Forms of different plastic material-2	71-78
Lesson 11. Forms of different plastic materials – 3	79-85
Lesson 12. Newer forms with combination of two or more ingredients	86-96
Lesson 13. Foils and Laminates – Characteristics and Importance in Food Industry	97-101
Lesson 14. Characteristics of Retort Pouches	102-104
Module 3: Package Forms	
Lesson 15. Forms of packages used for packaging of food and dairy products	105-130
Module 4: Legal Requirement	
Lesson 16. Safety requirements of packaging materials and product information	131-139
Module 5: Packaging of Milk And milk Products	
Lesson 17. Pasteurized Milk	140-144
Lesson 18. UHT-Sterilized milk	145-147
Lesson 19. Aseptic packaging	148-151
Lesson 20. Fat Rich Dairy Products - Butter and Ghee	152-156

Lesson 21. Coagulated and Desiccated Indigenous Dairy Products and their Sweetmeats	157-162
Lesson 22. Concentrated and Dried Milks Including Baby Foods	163-170
Module 6: Modern Packaging Techniques	
Lesson 23. Vacuum and Modified Atmosphere Packaging (MAP)	171-174
Lesson 24. Eco Friendly Packaging	175-183
Lesson 25. Active Packaging	184-190
Module 7: Principles and Methods of Package Sterilization	
Lesson 26. Different Methods of Package Sterilization, Importance of such methods and Principles	191-194
Module 8: Coding and Labeling of Food Packagaes	
Lesson 27. Different Methods of Coding and Standards of Labeling of food packages	195-224
Module 9: Aseptic Packaging	
Lesson 28. Scope of Aseptic Packaging and Pre-Requisite Conditions for Aseptic Packaging. Description of Equipments (Including Aseptic Tank) and Machines	225-227
Lesson 29. Micro-processor Controlled Systems Employed for Aseptic Packaging- Package Conditions and Quality Assurance Aspects of Aseptic Packaging	228-229
Module 10: Microbiological Aspects of Packaging Materials	
Lesson 30. Microbial Standards, Packaging material as Sources of Contamination	230-232
Module 11: Disposal of Waste Package Materials	
Lesson 31. Disposal Methods of Waste Packages	233-236
Module 12: Packaging System	
Lesson 32. Description of Equipments and Machines of Different Packaging Systems	237-243

Lesson-1

History of Package Development

1.1 INTRODUCTION AND HISTORY OF PACKAGE DEVELOPMENT

1.1.1 Changes in packaging to meet society's needs

1. Packaging is not a recent phenomenon.
2. Packaging is an activity closely associated with the evolution of society and, can be traced back to human beginnings.
3. The nature, degree, and amount of packaging at any stage of a society's growth reflect the needs, cultural patterns, material availability and technology of that society.
4. A study of changing roles of packaging and forms over the centuries is a study of the growth of civilization.
5. Social changes are inevitably reflected in the way we package, deliver and consume goods.

1.1.2 The origins of packaging

1. We don't know what the first package was, but we can certainly speculate.
 2. Primitive humans: nomadic hunter / gatherers lived off the land. Social groupings restricted to family units.
 3. They would have been subject to the geographical migrations of animals and the seasonal availability of plant food.
 4. Primitive people needed containment and carrying devices and out of this need came the First "package" which might be
 - a) A wrap of leaves
 - b) An animal skin
 - c) The shell of a nut or gourd
 - d) A naturally hollow piece of wood
-
1. Early packaging materials were Fabricated sacks, baskets and bags, made from materials of plant or animal origin; wood boxes replaced hollow logs; a clay bowl, the fire-dried clay pots (pottery and ceramic trade).
 2. The discovery of glass: About 1500 B.C., the earliest hollow glass objects appeared in Mesopotamia and Egypt.
 3. In China, Ts'ai Lun is credited with making the first true paper from the inner bark of mulberry trees. The name "paper" given to the Chinese invention made of matted plant fibers.
 4. Paperboard cartons and corrugated fiberboard boxes were first introduced in the late 19th century.

5. In 768, the oldest existing printed objects (Japanese Buddhist charms); in 868, the oldest existing book (the *Diamond Sutra*) printed, found in Turkistan.
6. Iron and tin plated steel were used to make cans in the early 19th century.
7. Packaging advancements in the early 20th century included Bakelite closures on bottles, transparent cellophane overwraps and panels on cartons, increased processing efficiency and improved food safety.
8. As additional materials such as aluminum and several types of plastic were developed, they were incorporated into packages to improve performance and functionality.

1.1.3 The Industrial Revolution and Modern Food Packaging

The Industrial Revolution started in England in about 1700 and spread rapidly. It is the change that transformed people with peasant occupations and local markets into an industrial society with world-wide connections. This new type of society made great use of machinery and manufactured goods on a large scale for general consumption.

1.2 DEFINITIONS OF PACKAGING

1. Packaging is described / defined in various ways:
2. Packaging is best described as a coordinated system of preparing goods for transport, distribution, storage, retailing, and use of the goods.
3. Packaging is a complex, dynamic, scientific, artistic, and controversial business function.
4. Packaging is science, art and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the process of design, evaluation and production of packages.
5. Packaging is an act of providing outer covering to an object or an act of putting the product in container or enclosing the object.
6. Packaging is a technique of using appropriate forms of container and components so as to protect, carry, identify and merchandize the content.
7. Packaging may be defined as the protection of materials of all/any kind by means of container so designed as to prevent damage to the contents by outside influences.
8. Packaging is a means of ensuring safe delivery of the product to the ultimate consumer in sound condition at minimum cost.
9. Packaging is a techno-economic function aimed at minimizing costs of delivery while maximizing sales (and hence profits).
10. Dictionary meaning: To package i.e. to put (a commodity) into protective wrapper or container for shipment / transport or storage.
11. Package means a covering wrapper or container which attracts the eye of the customer and at the same time protects the merchandize.
12. Packaging is described as a complex, dynamic, scientific, artistic and controversial segment of business. It is certainly dynamic and constantly changing. New materials need new methods, a new methods demand new machinery, new machinery results in better quality and better quality opens up new markets which require changes in packaging. The cycle is repeating.

Packaging Of Dairy Products

13. Packaging is an all-embracing term and covers the operation of cleaning, giving protective coating, weighing and filling, closing, labeling, surface designing, printing, cartooning and bracing, containerizing, marketing and may also include material handling.
14. Packaging is defined as “the enclosure of products, items, or packages in a wrapped pouch, bag, box, cup, tray, can, tube, bottle, or other container to perform the following functions: containment; protection or preservation; communication; and utility or performance.” If the device or container performs one or more of these functions, it is considered a package. This definition implies that packaging serves more than one function; i.e., it is multifunctional.

Packaging functions range from technical ones to marketing oriented ones as shown in the following Table-1.1:

Table 1.1: Functions of Packaging

Technical Functions		Marketing Functions	
contain	measure	communicate	promote
protect	dispense	display	sell
preserve	store	inform	motivate

Technical packaging professionals need science and engineering skills, while marketing professionals need artistic and motivational understanding.

1.3 CHANGING NEEDS AND NEW ROLES

1. All historical changes have had an impact on the way products are bought, consumed and packaged
2. Packaging is important to food supply because food is organic in nature (an animal or plant source) and one characteristic of such organic matter is that it has a limited natural biological life.
3. Most food is geographically and seasonally specific.
4. In a world without packaging, we would need to live at the point of harvest to enjoy these products, and our enjoyment of them would be restricted to the natural biological life span of each.
5. It is by proper storage, packaging and transport techniques that we are able to deliver fresh potatoes and Apples, throughout the year and throughout the world.
6. We are free of the natural cycles of feast and famine that are typical of societies dependent on natural regional food-producing cycles.
7. Central processing and pre-packaged food has the advantage that it allows value recovery from what would normally be wasted and the By-products of the processed-food industry form the basis of other sub-industries
8. The economical manufacture of durable goods also depends on sound packaging. A product's cost is directly related to production volume, distribution and packaging.

9. Humankind's global progress is such that virtually every stage in the development of society, packaging is present somewhere in the world today.

1.3.1 The United Nations and packaging

- a. The less-developed countries do not have adequate land to raise enough food.
- b. Food goes beyond its natural biological life, spoils, is lost, is infested with insects or eaten by rodents, gets wet in the rain, leaks away or goes uneaten for numerous reasons, and is lost all of which can be prevented by sound packaging principles.
- c. No industry can recover secondary value from food by-products and a poor economy can not afford wastages.
- d. Packaging is perceived to be a weapon against world hunger.

1.4 STATUS OF PACKAGING IN INDIA

1.4.1 Indian Packaging Industry

1. Early 1950's showed slow pace but 1980-85 onwards greater change was witnessed.
2. The market volume of the Indian packaging industry amounts to about Rs. 77,570 crore and has constantly grown by approximately 15 percent year per year.
3. It is expected that the pace of growth will accelerate to between 20-25 percent per year.
4. The highest demand for packaging and the associated equipment come from the food processing industry at 50 percent and from the pharmaceutical industry at 25 percent.
5. The Indian packaging industry contributes nearly 2 per cent to the country's overall GDP.
6. Food and beverages which will apply mainly packaging are using some 60-65 per cent of all packaging materials.
7. Rapid urbanization increased spending power of large growing middle class, growing number of working women, changing life style/standard of living, liberalization and organized retail sector are the catalysts to the growth of packaging.
8. According to the 'India Food Report 2008' published by Research and Markets. The Indian food market is estimated to total about Rs. 8,82,350 crore
9. Food retail turnover is expected to grow from the current Rs 3,39,365 crore mark to 7,27,212 crore by 2025.
10. There are about 600-700 packaging machinery manufacturers, 95 percent of which are in the small and medium sector located all over India.
11. Indian packaging machinery imports are around Rs 606 crore (20-25 percent) while the Indian packaging machinery exports are rapidly growing.
12. Germany and Italy are the largest suppliers of packaging machinery to India but focus is now shifting to Taiwan and China.

Packaging Of Dairy Products

13. Indian companies are now placing increasing emphasis on attractive and hygienic packaging. This promises enormous potential for the future
14. Today consumer is showing greater awareness towards food packaging for assurance on quality, quantity and hygiene of foods.
15. Potential benefits offered by unit packaging in retailing are also well realized.
16. Self service groceries, super markets (especially in urban sector) increased the demand for retail packs.
17. Changes in purchasing power, family sizes, frequency of shopping, inflation, changed food habits lead to changes in packaging material and pack sizes.
18. Every sector of user industry has become package conscious and the need for scientific, functional and aesthetic packaging is being realized.
19. Nationwide marketing becoming common trend for processed foods.
20. Expanding electronic media unprecedented audience reach (Paper, radio, TV) widen market of packaged food.
21. Thus dramatic change is observed bringing overall revolution in packaging concept, style and forms.
22. New concepts like aseptic packaging, system packaging, thermoforming, in-pack sterilization of foods have taken industrial footing in Indian market.

1.4.2 The Modern Packaging Industry

1.4.2.1 The broad industry divisions

1. “Converters”: to take various raw materials and convert them into useful packaging materials or physical packages (cans, bottles, wraps). To this point, packaging becomes a materials application science. The company forming the physical package will also print or decorate the package.
2. Package “users”: the firms that package products are also regarded as part of the packaging industry and are divided into a number of categories and each of these can be further subdivided.
3. The “supplier”: manufacturers of machines for the user sector and the suppliers of ancillary services, such as marketing, consumer testing and graphic design, are also important sectors of the packaging industry.

1.4.2.2 Professional packaging associations

1. **IoPP**: Institute of Packaging Professionals, Illinois, USA
2. **PAC**: Packaging Association of Canada, Toronto
3. **PMMI**: Packaging Machinery Manufacturers Institute, Reston, VA, USA
4. **FPA**: Flexible Packaging Association, Linthicum, MD, USA
5. **WPO**: World Packaging Organization, Stockholm, Sweden

1.4.2.3 Other organizations having a major impact on packaging activities

1. **ISO**: International Organization for Standards, Geneva, Switzerland
2. **ASTM**: American Society for Testing and Materials, Pennsylvania, USA
3. **TAPPI**: Technical Association of the Pulp and Paper Industry, Norcross, GA, USA

- 4. ISTA : International Safe Transit Association, Michigan, USA
- 5. FSSAI: Food Safety and Standards Authority of India, New Delhi

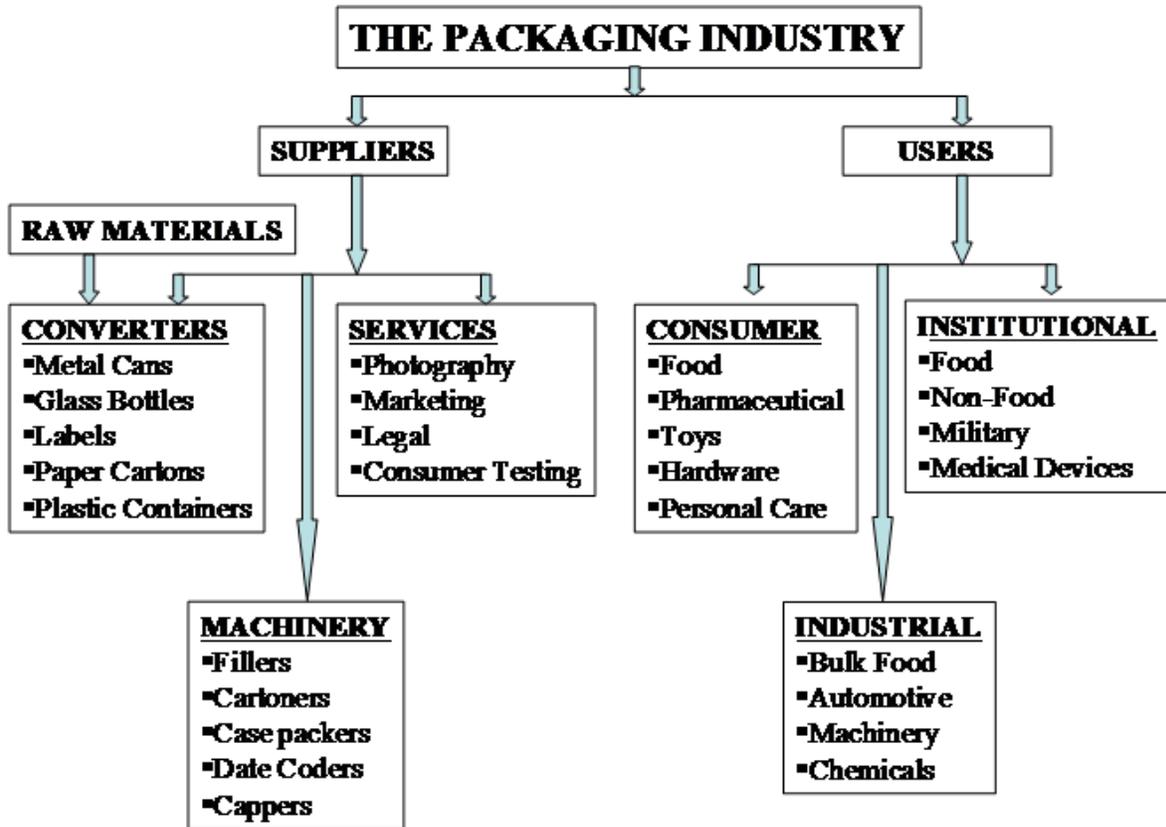


Fig-1.1: The packaging industry can be divided into those that use packaging for their products and those that supply to these users



Lesson-2

Importance of packaging

2.1 INTRODUCTION

This lesson deals with basic functions of packaging and importance of packaging in food industry.

2.2 FUNCTIONS OF PACKAGING

The functions of a package are “to preserve the quality and freshness of food, to add appeal to the food to attract consumers, and to facilitate its storage and distribution.” The basic functions required of a package can be grouped under five major categories.

2.2.1 To Contain the Product

The primary function of any package is to contain the food and facilitate handling, storage, and distribution all the way from the manufacturer to the ultimate user or even the time the rest portion is utilized by the consumer. However, there are usually various levels of packaging. A primary package is one that comes into direct contact with the contained product, e.g., metal cans, glass jars, and plastic pouches. By law, a primary package must not yield any substance that may be injurious to the health of the consumer. Further development to facilitate handling is to bundle a series of primary packages together, and this lead to the concept of secondary packages. Examples of secondary package is corrugated box in which tins of apple juice are packed. As methods of handling and transportation have become more sophisticated, these secondary packages are often palletized and secured by strapping with metal or, more commonly, by shrink- or stretch-wrapped film to give yet another level of packaging,i.e tertiary packaging. In turn, these pallet loads may be packed into large metal containers, i.e., quaternary packaging for transportation over long distances by air, land, or sea. The secondary, tertiary and quaternary packaging are also known as packing. The following are considered in this regard.

1. Adequate size and shape (biscuit package, tubs for detergent)

2. Proper constructional features. No leakage, spillage, diffusion, i.e. loss prevention.
3. Package: Must contain the commodity in natural form (biscuits packed in Pillow pack, prevent damage)
4. No subsequent damage after packaging during handling transportation and storage.
5. Thus package must be strong enough to contain the commodity as it is.
6. Optimum compatibility (nontoxic, non soluble with product... No physical, chemical or biochemical changes/alteration... i.e. inert to the product.)
7. Containment or agglomeration - Small objects are typically grouped together in one package for reasons of efficiency. For example, a single box of 1000 pencils requires less physical handling than 1000 single pencils. Liquids, powders, and granules need containment.

2.2.2 To Protect the Product

One of the most important function of any container is to protect the product contained against any form of loss, damage, deterioration, spoilage, or contamination that might be encountered throughout the distribution chain. Packaging can prevent physical damage, e.g., bruising caused by vibrational shocks during transportation or stacking in a warehouse. Proper packaging will also prevent material loss, e.g., potatoes from a weak sack or juice from a leaky can. Packaging can also protect products against moisture loss or gain, dust, and light, especially UV light, which causes deterioration of some light-sensitive products. It can also protect the package contents against temperature fluctuations in the transit of chilled and frozen foods. Packaging can also be used to control the availability of oxygen to fruits and vegetables and to protect against loss of flavor or fragrance and help products retain their nutritional value. Proper packaging may also protect the product against microbial spoilage by bacteria, yeasts, and molds. It can also protect against microbiological spoilage of stored products due to rodents and insects.

Packaging protects the product against damages which may be due to different hazards viz. (a) Mechanical, (b) Environmental (c) Microbial and Biochemical hazard. (d) Social Hazards.

Table 2.1: Hazard, damage and protection of packaging materials

SN	Storage	Hazard	Damage	Protection
I	Handling and transportation	Drop, shunting, shocks, vibrations, stack load, compression etc.	Breakage, loss of shape, dusting, seepage	Cushioning, blocking.
II	Storage	Stack load, compression, Attack by rodents and insects	Crushing, distortion sticking, spillage, contamination, spoilage	Adequate compression strength of package. resistance and repulsiveness to insects
III	Environment during storage transportation and distribution	Biological or otherwise	Contamination	Toughness of packaging material (to resist penetration).
		High/low humidity moisture/water.	Physical, chemical and biological deterioration due to loss/gain of moisture	Efficiency of closure providing. Water vapour barrier properties.Package desiccant etc.
		O ₂	Oxidative rancidity	O ₂ BARRIER VACUUM – O ₂ N ₂ /CO ₂ flushing packaging in impermeable package
		Light U.V. rays	Vitamin Destruction, Off flavour development, Oxidative	Use of opaque or colour like Yellow, red, brown, etc. for packaging material.

			rancidity, Bleaching of pigments	
Storage	Temperature		Change of state, Increase of moisture ingress Increased rate of deterioration	Heat insulation Use of poor conductor Use of reflective insulation
	Time		Gradual and slow changes occur and staling and other deteriorative changes occur	Early/immediate marketing (FIFO) Proper schedule of dispatching order providing Heat insulation Use of Barrier material

Barrier protection - A barrier from oxygen, water vapor, dust, etc., is often required. Permeation is a critical factor in design. Some packages contain desiccants or Oxygen absorbers to help extend shelf life. Modified atmospheres or controlled atmospheres are also maintained in some food packages. Keeping the contents clean, fresh, and safe for the intended shelf life is a primary function of the package.

2.2.3 Medium of communication

An important function of any food package is to identify the product and its origin; to inform the consumer how to use the contents; to provide any other information needed or required; and very importantly, to attract the user and encourage purchase of the product. Package design has been an important and constantly evolving phenomenon for many years. Marketing communications and graphic design are applied to the surface of the package and in many cases the point of sale/display. The information a package can convey to the consumer may include the following:

Packaging Of Dairy Products

1. Product manufacturing and best buy dates
2. Proper storage conditions
3. Cooking instructions
4. Size and number of servings or portions per pack
5. Nutritional information per serving
6. Manufacturer's name and address
7. Cost
8. Suggested recipes
9. Country of origin
10. Information transmission - Packages and labels communicate how to use, transport recycle, or dispose of the package or product.

2.2.4 Means of minimizing costs:

An important factor often overlooked is that packaging actually reduces costs for the consumer. Packaging reduces food costs by reducing the cost of processing. Foods can be processed where they are grown, waste is treated at the processing plant, and shipping weights are reduced, thereby lowering the cost of transportation. The handling of packages in quantity is important for the economics of bulk storage, warehousing, transport, and distribution. Proper packaging facilitates efficient and mechanized handling, distribution, and marketing of products, thus reducing the high labour costs that would have to be absorbed into the price of the product. Thus, packaging not merely contains the product, but it is a process of bringing goods from the production point to the point of use in a most beneficial manner. This involves all aspects of handling, storage, preservation, distribution, advertising, sales promotion, display dispensity, preparation and various other facts of industry.

2.2.5 Means of selling product:

The packaging and labels can be used by marketers to encourage potential buyers to purchase the product. Packaging is often referred to as the "silent salesman." Robertson (1992) concisely summarized the multifunctions of packaging when he stated that "a package must protect what it sells and sell what it protects." Packages can have features which add convenience in distribution, handling, display, sale, opening, reclosing, use, and reuse. According to Jelen (1985), primary packages should have the following characteristics to facilitate the sale of products:

1. Sanitary
2. Non toxic
3. Transparent
4. Lightweight
5. Tamper evident
6. Easy to pick up and handle
7. Easy to fit into cupboards, shelves, refrigerators, etc.
8. Easy to open and dispense from
9. Easy to reclose
10. Returnable, recyclable, or reusable
11. Safe and presents no hazards in the way of broken glass or sharp jagged metal edges
12. Display the product
13. Glamorize: Create an illusion of something very precious, by decoration, embossing techniques and exotic closures, but it should not deceive the people.

The desirable polyfunctional properties of packaging materials are summarized in Table 2.2.

Table 2.2: Functional Requirements of Packaging Materials

No.	Functional Property	Specific Factors
1	Gas permeability	§ O ₂ , CO ₂ , N ₂ , H ₂ O vapor
2	Protection against environmental factors	§ Light, odor, microorganisms, moisture
3	Mechanical properties	§ Weight, elasticity, heat-sealability, mechanical sealability, strength (tensile, tear, impact, bursting)
4	Reactivity with food	§ Grease, acid, water, color
5	Marketing-related properties	§ Attractiveness, printability, cost
6	Convenience	§ Disposability, repeated use, resealability, secondary use
7	Aroma	§ Aroma compound barrier property

Source: Jelen, P. 1985. Food packaging technology. In *Introduction to Food Processing*, Reston Publishing, Reston, VA, pp. 249–266.

2.3 OTHER FUNCTIONS OF A PACKAGE:

1. **Dispensing:** Consumers: Product not used all at once, remove a portion...without destroying/damaging the remaining product/container.
2. **Preserve:** Remaining product in container-Protection and preserve it for extended/desired period.
3. **Measuring / Portion control:** Single serving or single dosage package has a precise amount of contents to control usage. Bulk commodities (such as salt) can be divided into packages that are a more suitable size for individual households. It also aids the control of inventory: selling sealed one-liter-bottles of milk, rather than having people bring their own bottles to fill themselves.
4. **Security** - Packaging can play an important role in reducing the security risks of transport. Packages can be made with improved tamper resistance to deter tampering and also can have tamper-evident features to help indicate tampering. Packages can be engineered to help reduce the risks of package pilferage: Some package constructions are more resistant to pilferage and some have pilfer indicating seals. Packages may include authentication seals to help indicate that the package and contents are not counterfeit. Packages also can include anti-theft devices, such as dye-packs, RFID tags, or electronic article surveillance tags, that can be activated or detected by devices at exit points and require specialized tools to deactivate. Using packaging in this way is a means of loss prevention.

2.4 PACKAGING TYPES:

2.4.1 Terms used:

1. **Package:** It cuts contact between material and outside influences. Package material comes in direct contact with the product (Packaging).
2. **Pack:** Secondary container. *Packing material never comes in contact with product.*
3. **Packing:** Number of containers/packages put together in big container is called pack...Process of packing.

Packaging may be looked at as several different types. For example a **transport package** or **distribution package** is the package form 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. It is sometimes convenient to categorize packages by layer or function: "primary", "secondary", etc.

1. **Primary packaging** is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents (viz. butter in parchment paper).
2. **Secondary packaging** is outside the primary packaging – perhaps used to group primary packages together (viz. paper board pack containing butter wrapped in veg. parchment paper).
3. **Tertiary packaging** is used for bulk handling, warehouse storage and transport shipping. The most common form is a palletized unit load that packs tightly into containers (viz. Boxes containing 20-25 or 50 butter packs are put together).

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 combining smaller packages, and tertiary packaging on some distribution packs.

Table 2.2: Differences between packaging and packing

No.	Packaging	Packing
1	Comes in direct contact with the product	Never in direct contact
2	Called primary packaging material	Secondary / Tertiary / Quaternary
3	Should be food grade, non-toxic, tasteless, odourless, lowest possible migration	No strict requirements
4	Packaging- a must e.g. Ice cream party pack, Bulk pack, Ghee	May be done/may not be done. Packaging then packing e.g. CFB, cartons, etc. Bulk biscuit packs.
5	Materials used: Plastics / glass / metal / treated paper or their combination	CFB / Plastic board boxes, wood, metal, etc. Shrink/ stretch wrapping
6	Objectives: Mainly to contain, carry, protect. Help in selling, legal aspects, marketing / sale, technical, transportation	Mainly ease in transportation and protection of packages
7	Generally attractive. Not a must: Biscuits & rolls in a pack. E.g Kellogs flakes, toffee. The exposed portion must be attractive.	Generally not attractive. But if retail pack, secondary packing exposed to consumers...then attractive: say Butter carton

Packaging Of Dairy Products

8	Recycled material never used.	Much preferred.
9	Selection of packaging material: Physico-chemical properties of product are considered.	Generally stress / strength properties, puncture resistance / burst strength, folding endurance, environmental factors considered.
10	Keeping quality is determined by packaging material.	Generally not so.
11	Single unit packaging.	Generally multi unit packaging. Sometimes single unit also. Butter carton, Bag in box...Here packing materials should be more attractive / effective than packaging material.

Reasons for selecting a particular style/type of packaging are vast and varied, numerous and changing. Product and packaging are becoming so interdependent that one cannot separate/consider one without another. Greatest part of food is spent in some form of package.

2.5 REQUIREMENTS FOR PRODUCING SUCCESSFUL PACKAGE:

Four sets of facts are necessary to be known for producing a successful package:

2.5.1 Facts about the product:

1. The nature of the product, the material from which it is made and the manner in which it can deteriorate.
2. Its size and shape.
3. Its weight and density: eg. Powder – Bulk Density ... size of tins
4. Its weakness-which parts will break, move about, become bent or scratch or abrade the box easily.
5. Its strengths: which part will withstand loads or pressures and which might be suitable for loading the product in the pack.
6. The effect of moisture and temperature changes on the product and whether it will absorb moisture or corrode.
7. Compatibility: whether the product is likely to be affected by any of the possible packaging materials, which items can be packed together, with protection if necessary and which items must not be packed together under any circumstances.
8. How far stripping down may be carried out to reduce the package size to a minimum such that the customer can handle them.(Generally for merchandize foods like kitchen machine, blender etc.)

2.5.2 Facts about the transport hazards:

1. The type of transport-road, rail, sea or air.
2. The degree of control over the transport. Is it private or public transport?
3. The form of transport- bulk, freight container, Unitized load, postal, passenger train, etc.
4. The mechanical conditions and duration of storage (manufacturer State Distributor District Distributor ... Taluka / CityRetailer. The longer the journey or handling more strength is required in packaging & packing materials leading to higher cost).
5. The nature and intensity of mechanical and climatic hazards in transport, storage, retailing and use. Packaging / packing material has to withstand wide range of temperatures and relative humidity
6. Whether handling aids are available for loading and off-loading at all points between maker and user. (Viz. Lifts, Trolleys, Slip conveyers etc.)
7. The importance of minimum volume in relation to transport costs. Over packaging must be prevented.

2.5.2.1 Hazards may be:

1. Mechanical: Impact (vertical, horizontal), stationary package impacted by another, vibration, compression, Racking or deformation, piercing, puncturing, tearing etc.
2. Climatic hazard: (High / low temperature / pressure) light, liquid/water (fresh / polluted), dust, and water vapour, R.H.
3. Biological: (Microorganisms, fungi, moulds, bacteria, beetles, moths, flies, ants, termites, mites, rodents (rats and mice), birds.

2.5.2.2 Contamination by other goods:

1. By materials of adjacent packs
2. By leaking contents of adjacent packs
3. Radioactivity.

Packaging is considered as 5th P of Management

1. Protection
2. Preservation
3. Presentation
4. Promotion
5. **Packaging**
6. Portability
7. Pollution Free

Lesson-3

Selection of Packaging Materials

3.1 INTRODUCTION

The food processor has a variety of packaging materials to choose from for food packaging, specifically, paper, glass, metal, and plastics. The choice of the proper packaging material will be made by the food processor based on the requirements:

1. Composition of the food (solid or liquid)
2. Physical, chemical, and microbiological and deteriorative reactions that might occur
3. Storage conditions and time of storage
4. Socioeconomic situation of the anticipated customer or market
5. Desired package attractiveness
6. Cost of the packaging material
7. Packaging technology selected
8. Specific functional properties of the packaging material

There are several reasons for selecting or rejecting a particular packaging material over another, as summarized in the following Table: 3.1

Table 3.1: Reasons for Selection and Rejection of Specific Packaging Materials

Paperboard	Glass	Steel	Plastics
Selection			
Easily machined and folded	Product visibility	Strong, stiff	Fabricability
Easy to bond	Impervious, inert	Malleable	Variety of forms
Composites well	Image of high quality	Retortable	Tough, lightweight
Printability	Ovenable, Reusability	Permanence, Reusability	Wide range of properties
Rejection			

Chances of water absorption	Shatters, Scratability	Corrodes	Thermal limit
Penetrable	High weight-to-strength ratio	Limits shapes	Permeable
Image	Limited shapes	Appearance	Absorbs flavors
Tears, punctures	Large sizes	Flavor distortion	Distortion and creep

3.2 TYPES OF PACKAGING MATERIALS

A variety of packaging materials, each with specific functional properties, is commercially available for packaging fruit products. These include wood, cloth, paper, glass, metal, and plastic (Table 3.2).

Table 3.2: Commonly Used Packaging Materials

No.	Materials	% Consumption		Examples of Use
		India	Global	
1	Paper and paper board	40	29	Bags, boxes, cartons
2	Glass	16	8	Bottles, jars
3	Metal	5	19	Cans, aluminum foil
4	Plastics	15	39	Overwraps, bags, cups, bottles
5	Wood	--	--	Crates, pallets
6	Cloth	--	--	Sacks
7	Laminates	--	--	Multilayered plastics, cartons
8	Others	24	5	---

3.3 CHARACTERISTIC OF AN IDEAL PACKAGE

1. Compatible with product.
2. Protection from Mechanical hazards especially transportation. climatic hazards, microorganisms : Packaging do not harbour bacteria, restrict their growth....Flavour gain/loss/salts/difference in temperature.
3. Fit into a production line.
4. Advertising potential.
5. Attractive appearance.
6. Easy to handle during...Production, storage and Distribution
7. Moisture proof/resistance.
8. Sufficient mechanical strength to withstand drop, vibration, compression etc.
9. Acid, alkali resistance.
10. Grease & oil resistance.
11. Resistance to photo-chemical changes in product.
12. Resistance to insects and rodents.
13. Fire proof resistant to smoke, fume and water.
14. Pilfer proof (malpractice).
15. Inert: No effect on flavour/aroma.
16. Not injurious to health.
17. Economic.
18. Easy availability.
19. Protect against climatic hazards.
20. Protect against microorganisms. It should not harbour microbes rather restrict their growth by controlling growth factor like.



Lesson-4

Characteristics of Paper, corrugated paper, fiber board and wood

4.1 INTRODUCTION

This chapter deals with characteristics of paper, corrugated paper board, fibre board and allied products.

4.2 PAPER AND PAPER BOARD

4.2.1 Characteristics

1. Paper and board are very popular packaging materials. Paper is thin material mainly used for writing upon, printing upon or for packaging. It is produced by pressing together moist fibers, typically cellulose pulp derived from wood, rags or grasses, and drying them into flexible sheets.
2. Paper is a versatile material with many uses. Whilst the most common is for writing and printing upon, it is also widely used as a packaging material, in many cleaning products, in a number of industrial and construction processes.
3. Paper pulp is produced from wood chips by acid or alkaline hydrolysis. The pulp is suspended in water and beaten with rotating impellers and knives to split the cellulose fibers longitudinally. The fibers are then refined, pressed and passed through heated rollers to reduce the moisture content and then through finishing rollers to give the final surface properties to the paper. Alkaline hydrolysis produces sulphate pulp and acid hydrolysis produces sulfite pulp.

4.2.2 Paper Types, thickness and weight:

1. The thickness of paper is often measured by caliper, which is typically given in thousandths of an inch. Paper may be between 0.07 millimetres (0.0028 in) and 0.18 millimetres (0.0071 in) thick.
2. Paper is often characterized by weight. In using the ISO 216 paper sizing system, the weight is expressed in grammes per square metre (g/m^2 or usually just gsm or grammage) of the paper. Printing paper is generally between 60 and 120 gsm. Anything heavier than 160 gsm is considered card. The weight of a ream therefore depends on the dimensions of the paper and its thickness.

4.3 PAPERBOARD

4.3.1 Paperboard is material with a higher thickness than paper, usually over 0.25 mm or 10 points or grammage over 150 g/cm^2 . It can be either single or multi-ply and

Packaging Of Dairy Products

is most often used in packaging and graphic printing. It is sturdier than paper but is thinner than corrugated board. Paperboard is widely used in today's society and is used to package many popular items, most notably food products and cigarette, ice-cream packaging. It can be easily cut and formed, is lightweight, and is strong; paperboard is popular in many industries as a packaging option.

4.3.2 Production:

Pulp (virgin or recycled) is used to create one or more layers of board which can be coated for a better surface and/or improved visual appearance.

4.3.2.1 General Steps of Paper Making Process

1. **Pulping**
2. **Washing**
3. **Settling**
4. **Squeezing of slurry**
5. **Pressing**
6. **Drying, Calendaring and Sizing**

4.3.2.2. Raw Materials:

1. **Hard wood:** 0.05 inches (length) e.g. Birch which has short fibres. It is generally more difficult to work with however does provide higher strength.
2. **Soft wood:** 0.13 inches (length) e.g. Pine and spruce which have typically long fibres.
3. **Recycled:** Recycled material is collected and sorted and usually mixed with virgin fibres in order to make new material. This is necessary as the recycled fibre often loses strength when reused and gets this from the added virgin fibres. Mixed waste paper is not usually de-inked for paperboard manufacture and hence the pulp may contain traces of inks, adhesives, and other residues which together give it a grey colour.
4. **Others:** Straw, Hemp, Cotton, Flax

4.3.2.3. Pulping:

1. **Mechanical Pulping:** Mechanical pulping is a two stage process which results in a very high yield of the wood being converted.
2. **Chemical Pulping:** Chemical pulping uses chemical solutions to convert wood into pulp but yields around 30% less than mechanical pulping. It involves

different processes like Soda process, Sulfate/Kraft process, Sulfito process, Semi chemical or Combination process.

4.3.2.4. Bleaching

Pulp used in the manufacture of paperboard can be bleached to increase colour and purity. Virgin pulp is naturally brown in colour because of the presence of lignin. Recycled paperboard may contain traces of inks, bonding agents and other residue which causes a grey colouration. Although bleaching is not necessary for all end uses, it is vital for many graphical and packaging purposes.

4.3.2.5. Plies

Multi ply paperboard generally has higher creasing and folding performance than single ply as a result of layering different types of pulp in a single product. In cases, where the same kind of pulp is being used in several layers, each separate layer is treated and shaped individually in order to create the highest possible quality. The benefits of multi ply paperboard are for example its higher creasing and folding performance.

4.3.2.6 Coating

In order to improve whiteness, smoothness and gloss of paperboard, one or more layers of coating are applied. Coatings are usually made up of: a pigment, which could be china clay, calcium carbonate or titanium dioxide, an adhesive or binder and water.

4.3.3 Grades of paper board

The DIN Standard 19303 "Paperboard - Terms and grades" (2005-09) defines different grades of paperboard based on the surface treatment (first letter), the main furnish (second letter) and the colour (non-D grade) or bulk (D grade only).

Table 4.1: Grades of paper boards

First letter (surface treatment)	Second letter (main furnish)	Number
A = cast-coated G = pigment coated	Z = bleached virgin chemical pulp C = virgin mechanical pulp	(all except D grades): 1 = white reverse side

Packaging Of Dairy Products

U = uncoated	N = unbleached virgin chemical pulp T = recycled/secondary fibre with white, cream or brown reverse D = recycled/secondary fibre with grey back	2 = cream reverse side 3 = brown reverse side (D grades only): 1 = bulk ≥ 1.45 cm^3/g 2 = bulk < 1.45 cm^3/g , > 1.3 cm^3/g 3 = bulk ≤ 1.3 cm^3/g
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Example: GC1 would be a "pigment coated", "virgin mechanical pulp" board with a "white reverse side". Often the used paperboard type would be FBB, which is coated on both sides.

4.3.4 Classifications of Paper board

Based on the production process and the source of the pulp, different types of paperboard are produced. The common industry abbreviations are:

1. FBB (Folding Box Board)
2. SBB (Solid Bleached Board)
3. SUB (Solid Unbleached Board)
4. WLC (White Lined Chipboard)

Various types of paper and paperboard containers used as food packaging are shown in Table 4.2.

Table 4.2: Types of Paper Commonly Used as Packaging Material

No.	Product	Characteristics	Example
1	Kraft paper	Brown, unbleached paper. Good strength and resistant to bursting	Heavy duty bags and sacks A layer in multilayer paper board for increased strength. Viz. Aseptic packaging material in India
2	Bleached paper	White paper, may be glossy. Less strength than	White bags, wrapping paper

		unbleached paper	
3	Vegetable Parchment paper	Translucent paper treated with H_2SO_4 to gelatinize surface layers	Butter and margarine wrap
4	Greaseproof paper	High-density paper, very smooth surface	Wrapping paper requiring high resistance to grease
5	Glassine	High-density, greaseproof paper. brittle	Over wraps on candy
6	Tissue	Light weight paper produced from most pulps	Light weight and used to protect soft products from dust and bruising
7	Paperboard or cardboard	Compacted paper pulp	Cartons, boxes, trays, separators
8	Corrugated paper board	Paperboard sheets interspersed with paper corrugations	Secondary boxes of many kinds

1. Kraft paper is made from at least 80% sulphate wood pulp. It is a very strong paper, which is used to make grocery bags, multiwall bags, shipping sacks, and specialty bags that require both economy and strength for bulk packaging of powders, flour, sugar, fruits, and vegetables. Bleached papers are more expensive and weaker than unbleached ones, and they have excellent printability.
2. Vegetable parchment is produced from sulphate pulp, which is passed through a bath of sulphuric acid. It has a more intact surface than kraft paper and therefore has greater grease resistance and wet strength properties than kraft paper. Because of its high grease resistance and wet strength, it is used for packaging butter and shortening.
3. Sulfite paper is lighter and weaker than sulphate papers. Greaseproof paper is made from sulfite pulp in which the fibers are more thoroughly beaten to produce a closer structure. It is resistant to oils and fats when dry, but these properties are lost when the paper becomes wet. Packaging applications for greaseproof papers include margarine wraps; french-fry bags, inner liners for multiwall sacks, and a liner in composite cans for packaging frozen juices. Glassine is a greaseproof sulfite paper that is given a high-gloss finish by the finishing rollers. It is used as wrapping material for candy products and certain bakery products. Tissue paper is a soft, nonresilient paper used to protect fruits against dust and bruising.
4. A major disadvantage of paper as a packaging material is its poor barrier properties against moisture, gases, grease, and odors. Furthermore, it cannot be heat-sealed. To improve its barrier and heat-sealing properties, paper is

often combined with wax, plastic film, metal foil, or a combination of foil and plastic film.

5. Paperboard is made in a similar way to paper but is thicker in order to protect foods from mechanical damage. The main characteristics of board are thickness, stiffness, the ability to crease without cracking, the degree of whiteness, surface properties, and suitability for printing. White board is suitable for contact with food and is often coated with polyethylene, polyvinyl chloride, or wax for heat-sealability. It is commonly used to prevent freezer burn in stored frozen products. Pulp containers are made from paper pulp compressed in molds to remove moisture. Pulp containers are used for egg cartons, low-cost food trays, and cushioning of food products.

4.4. CORRUGATED PAPER, FIBRE BOARD, CBX ETC

4.4.1 Corrugated fiberboard

Corrugated fiberboard, also known as corrugated cardboard, is a paper-based construction material consisting of a fluted corrugated sheet and one or two flat linerboards. Corrugated board is the most common form of secondary food packaging and is used by virtually every industry in the manufacture of corrugated boxes and shipping containers.

1. Corrugated board has an outer and inner lining of kraft paper with a central corrugating (or fluting) material. This is made by softening kraft paperboard with steam and passing it over corrugating rollers. The liners are then applied to each side using a suitable adhesive. The board is formed into *cutouts*, which are then assembled into cases at the filling line.
2. The corrugated medium and linerboard are made of paperboard, a paper-like material usually over ten mils (0.010 inch, or 0.25 mm) thick. Paperboard and corrugated fiberboard are sometimes called *cardboard* by non-specialists; although cardboard might be any heavy paper-pulp based board.
3. Common corrugation / flute sizes are "A", "B", "C", "E" and "F" or microflute. The letter designation relates to the order that the flutes were invented, not the relative sizes. These vary in height and the number of flutes per unit length of board. Flute size refers to the number of flutes per linear foot, although the actual flute dimensions for different corrugator manufacturers may vary slightly. Measuring the number of flutes per linear foot is a more reliable method of identifying flute size than measuring board thickness, which can vary due to manufacturing conditions.
4. They can be used alone or in combination with one another to give single-face, single-wall, double-wall, and triple-wall corrugated board constructions. Corrugated board has good impact abrasion and compression strength and is mainly used as secondary packaging containers. The most standard type of secondary packaging material is single wall C flute. High storage humidity may cause delamination of the corrugated material. This is prevented by lining with polyethylene or greaseproof paper or coating with microcrystalline wax and polyethylene.

4.4.1.1. Standard US Corrugated Flutes

Table: 4.3: Standards of corrugated flutes

Flute Designation	Flutes per lineal foot	Flute thickness (in)	Flutes per lineal metre	Flute thickness (mm)
A flute	33 +/- 3	3/16	108 +/- 10	4.8
B flute	47 +/- 3	1/8	154 +/- 10	3.2
C flute	39 +/- 3	5/32	128 +/- 10	4.0
E flute	90 +/- 4	1/16	295 +/- 13	1.6
F flute	128 +/- 4	1/32	420 +/- 13	0.8

4.4.2 Chip Board / Bogus:

1. Old news papers, other scrap papers, various sizing material etc are beaten and converted in to paper/ board known as chipboard. Most often it comes with two to three layers of coating on the top and one layer on the reverse side. Because of its recycled content it will be grey from the inside. It is mainly used in packaging of shoes, toys etc.
2. Bogus is a paper product which is made from recycled fiber, paper or an inferior pulp to imitate higher quality grades. They are usually grey or light brownish in colour due to the raw material used. It is used as packaging material, void fill, wipes, bedding & cushioning etc.

4.5 WOOD

4.5.1 Advantages and Disadvantages of Wood as a packaging material:

1. With a good strength-to-weight ratio, wood is an economical structural material.
2. It does not require very sophisticated equipment to make a box or crate and for very rigid structures in small quantities it is the material of choice.
3. For small packages or for large quantities, however, wood does not lend it self to high speed operations or automatic assembly. It therefore has a high labour factor in relation to material costs.
4. It is also bulky and often presents a problem of storage space and shipping cubage.
5. If rigidity, stacking, strength, protection from the hazards of shipping and light weight are essential, it is difficult to find a better material than wood.
6. But if protection from moisture, rapid assembly, low cost, ready availability or attractive appearance is more important, then wooden containers may not be the best choice.

Lesson-5

Characteristics of Glass

5.1 INTRODUCTION

Glass generally refers to hard, brittle, transparent material, such as those used for windows, many bottles, or eyewear. Glass is one of the most important packaging materials because of its high barrier and see-through properties. In the technical sense, glass is an inorganic substance formed from a mixture of sand (73%), sodium oxide (13%), and calcium oxide (12%), with a proportion of broken glass or *culler* (15 to 30% of total weight). Many glasses contain silica as their main component and glass former.

5.1.1 What is Glass?

Glass is a mixture in which all the constituent atoms have been persuaded by heating to line up in to a random but rigid net wall in which each silica atom is linked to '4' oxygen atoms and then to other silica atoms, both atoms of sodium and calcium distributed in holes in the network.

5.1.2 Approximate composition of Glass:

- Natural White Glass:
 - Silica (SiO_2) – 73%
 - Lime (CaO) – 11%
 - Soda (Na_2O) – 13-14%
 - Alumina (Al_2O_3) – 1.7%
 - Magnesia (MgO) – 0.3%
 - Potash (K_2O) – 0.3-0.4%
 - Iron oxide (Fe_2O_3) 0.05%
 - Sulphur Trioxide (SO_3) – 0.19%

The content of soda decides the cost of the glass.

- To colour the glass appropriate materials are added for example:
 - Green colour – Chromium and Iron,
 - Amber – Iron, Sulphur and carbon
 - Opal – Fluorine

The principal raw materials required for manufacture of glass are sand lime stone and soda ash. Screen printing, ceramic spray and plastic coating are used for decoration or printing on the glass.

5.2. CHARACTERISTICS OF GLASS CONTAINERS

Glass containers have several characteristics that make them ideal for food and beverage packaging:

1. They are impervious to moisture, gases, odors, and microorganisms.
2. They are inert and do not react with or migrate into food products.
3. They have filling speeds comparable to those of cans.
4. They are suitable for heat processing when hermetically sealed.
5. They are transparent to microwaves.
6. They are reusable and recyclable.
7. They are resealable.
8. They are transparent and display the contents.
9. They can be molded into a variety of shapes and colors.
10. They are perceived by the customer to add value to the product.
11. They are rigid and allow stacking without container damage.
12. They can be printed on directly or by using paper labels.

The main disadvantages of glass as a packaging container are:

1. Higher weight and hence higher transportation costs than other types of packaging containers.
2. Lower resistance than other materials to fractures, scratches, and thermal shock.
3. More variable dimensions than other containers.
4. Potentially serious hazards arise from glass splinters or fragments in foods.
5. Permeability to UV light.

This latter problem can be overcome by incorporating various oxides, sulphides, or selenides to color glass and block out the incident UV radiation.

5.3. TYPES OF GLASS CONTAINERS

Commonly used glass containers are bottles, jars, tumblers and jugs, carboys, vials, and ampoules.

1. **Bottles** account for the bulk of glass containers. They are made in various shapes and sizes (from 100 ml to 4 lit) and are characterized by a round neck that is much narrower than the body. This facilitates pouring of contents and allows attachment of suitable closures such as screw-type or snap-on caps or

cork plugs. Fruit juices and drinks like flavoured/sterilized flavoured milk, milk beverages etc. are often packaged in bottles. The glass bottles used in Dairy industry are heat resistant bottles. But, they can withstand 50°C temperature difference during heating and only 30°C temperature difference during cooling, which is important during in-bottle sterilization of milk.

2. **Jars** are wide mouthed bottles with no neck, and this affords easy access to the product. They are used for liquid, viscous, solid, and semisolid products such as fruit pieces, sauces, and tomato pastes. They are closed in a similar manner to bottles, but with larger closures.
3. **Tumblers** are similar to jars but without a neck and a “finish” for the end closure. They are shaped like a drinking glass and are used for such products as jams and jellies.
4. **Jugs** are large sized bottles with carrying handles. They are used to package wine and institutional, industrial, and household products.
5. **Carboys** are large globular wicker-covered glass bottles for holding acids or other corrosive liquids.
6. **Vials and ampoules** are small, thin-walled glass containers. They are mainly used in the pharmaceutical industry for drugs and in the food industry for small quantities of very expensive ingredients, such as flavors.
7. Food products packed in glass: Baby foods, malted milk foods, sterilized flavoured milk, beer, soft drinks, meat/fish products, fruits and vegetable products.

5.4 GLASS CONTAINER PRODUCTION

Broadly, modern glass container factories are three-part operations: the **batch house**, the **hot end**, and the **cold end**. The batch house handles the raw materials; the hot end handles the manufacture, the furnaces, annealing ovens, and forming machines; and the cold end handles the product-inspection and packaging equipment.

5.4.1 Glass container forming process:

1. There are, currently, two primary methods of making a glass container —
 - The *blow and blow* method: The glass first is blown from below, into the blank moulds, to create a *parison*, or pre-container. The *parison* is then flipped over into a final mould, where a *final blow* blows the glass out, in to the mould, to make the final container shape.
 - The *press and blow* method: The *parison* is formed with a metal plunger, which pushes the glass out, into the blank mould. The process then continues as before, with the *parison* being transferred to the mould, and the glass being blown out into the mould.
2. When heated to a high temperature (1500 °C), the raw materials liquefy.
3. Specific amounts of molten glass or *gobs* are shaped in a parison mold by the blow-and-blow process or the press-and-blow process.

4. The glass is then annealed at ~ 540 °C to remove stresses and cooled under carefully controlled conditions to prevent distortion or fracturing.
5. In all cases a stream of molten glass, at its plastic temperature (1050°C-1500°C), is cut with a shearing blade to form a cylinder of glass, called a *gob*.
6. Both processes start with the *gob* falling, by gravity, and guided, through troughs and chutes, into the blank moulds.

5.5 CONSIDERATIONS FOR SELECTION OF GLASS CONTAINERS

1. When selecting a glass container for a food it is, important to be careful in choosing dimensions and finish so that the correct volume will be available, the product can be easily filled and dispensed, and a proper closure can be selected. 'Finish' refers to the type and dimension of neck and mouth of the containers, i.e. thread, lug, friction, snap-cap, roll-on etc. There are many standard finishes.
2. Other important factors in selecting a glass container for food are its colour which can influence the type of light reaching the food and its ability to resist thermal shock. Some glasses cannot withstand sudden changes in temperature i.e. filling a hot product into a container and then plunging it into cold water. Special glasses are available for this purpose.
3. Though total quantity of glass used is steadily increasing, its market share in packaging has been diminishing due to the entry of newer and cheaper materials like plastics.
4. Of late, the rediscovered virtue of recyclability of low weight and scratch resistant glass is likely to bring back its lost glory in food packaging.
5. Recent developments in West have given rise to light weight scratch resistant glass bottles and researches are on for making unbreakable bottles.
6. Novel features like vacuum ring; press-on and twist-off lug caps are being increasingly used.
7. In India, though glass is used in a wide variety of single use packaging applications, the technology needs updating and the light weight bottle is yet a dream.
8. The economic advantage of the returnable glass bottle as in case of soft drinks is still unbeatable.



Lesson-6

Characteristics of Metals and Metallic Containers

6.1 INTRODUCTION

Metal packaging materials are appropriate for packaging of light, moisture and oxygen sensitive products and carbonated beverages such as soft drinks, flavoured milk etc.

1. Mainly aluminum is used as packaging material in the form of cans.
2. Also tin plates are now a day used as metal packaging material.
3. Tin plate is solid, heavy steel covered with tin to protect it against rust. It is used to package canned foods. It can be recycled and again can be used as an outer packing material.
4. The earliest metals used by man were those found in native state, which were soft and easily workable. These include copper, silver and gold.
5. The commercial packaging of food stuffs in metal containers began in the early 19th century.
6. Metal cans, made from steel or aluminum, are widely used by the food industry to pack a wide range of foods.

There are two basic types of metal cans:

1. Those that are sealed using a 'double seam' and are used to make canned foods: Double-seamed cans are made from tinned steel or aluminum and are lined with specific lacquers for different types of food.
2. Those that have push-on lids or screw-caps that are used to pack dried foods (e.g. milk or coffee powder, dried yeast) or cooking oils respectively.

6.1.1 Tin Plate:

- "The term tin plate refers to low-carbon mild steel sheet varying in thickness from 0.15 mm to 0.5 mm with a coating of tin between 2.8 g/m² and 7 g/m² (0.4mm to 2.5mm thick) on each surface of material"
- The chemical composition of the base steel determines the corrosion resistance and mechanical properties of tin plate. For the packaging of acidic aggressive foods high purity type-2 steel is used
- Chemical composition of type-I steel

Constituent	% Maximum
Carbon	0.13
Manganese	0.60
Phosphorus	0.15
Sulphur	0.05
Silica	0.01
Copper	0.06

- For the fabrication of containers where high strength and rigidity is essential e.g. carbonated beverage ends, tin plate based on type 'N' steel or nitrogenized steel is used. The chemical composition of nitrogenized steel is similar to type-2 steel except with the addition of 0.02% Nitrogen to increase the rigidity.
- To make the tin plate corrosion resistant, the base steel plate is coated with tin. Tin is applied either by
 - Hot dipping process
 - Electrolytic deposition
- Tin plate in addition to the corrosion resistance gained by tin layers, is further protected by two surface treatments i.e

(A) *Passivation*: The passivation treatment is a cathodic electrochemical process using sodium dichromate solution. The passivation stabilizes the surface by controlling the growth of natural oxide film.

(B) *Oiling*: Surface oiling is to lubricate the plate to reduce the surface scratching and adhesion. The most common lubrication system used is dioctyl sebacate (DOS) is applied by electrostatic precipitation or by direct immersion

- Thinner gauge double reduced tin plate (DR) can also be used.
- Tin plates with bright finish or stone finish are also available.

6.1.2 Tin Free Steel:

- The high cost of Tin created necessity for the alternative to tin. Japanese developed a printable/lacquerable duplex chromium/chromium oxide treated low carbon steel material known as tin free steel or TFS.
- TFS has a surface more acceptable for lacquer coatings, printings than tin plate. However, TFS is less resistant to corrosion than tin plate. Further, TFS

containers cannot be soldered with Lead or tin. They are welded or organic adhesives are used.

6.1.3 Advantages of using Metal Cans:

1. They have a high strength-to-weight ratio.
2. They can be heat processed.
3. They have excellent barrier and protective properties.
4. They produce shelf-stable products that are safe and nutritious to eat and can be stored at ambient temperature.
5. They are tamperproof.
6. When sealed with a double-seam they provide total protection of the contents,
7. They can be made in a wide range of shapes and sizes.
8. Ease of fabrication.

6.1.4 Limitations of Metal Cans:

1. High cost of metal and relatively high manufacturing costs make cans expensive.
2. They are heavier than other materials, except glass, resulting in increased transportation costs for the finished product.

6.2 STEEL CANS

6.2.1 Three-piece cans:

- One of the most commonly used primary packaging containers for a wide variety of processed fruits and vegetables are the three-piece can or *sanitary* can.
- It is made from steel that is electrolytically coated on both sides with either a thin layer of tin (tin-plated steel) or a layer of chromium–chromium dioxide (tin-free steel).
- Two main types of base steel are commonly used in can manufacturing:
 - Type L: It is very corrosion-resistant and is used in canning of very corrosive products, e.g., apple juice, berries, prunes, and pickles.
 - Type MR: It is more suitable for canning moderately to mildly corrosive products, e.g., grapefruit, peaches, peas, and corn.
- Plain, uncoated tin plate or tin-free plate can be used to make cans when the interactions between the food and the container are not significant or when the quality of the food is better in an uncoated can.
- However, to further improve the tin plate or tin-free plate for use with certain classes of food products, it is coated with a lacquer or enamel.
- There are certain desirable qualities that enamels (lacquers) should possess before being applied to food cans. They should:

1. Be nontoxic
2. Not affect the flavor or color of the food
3. Provide a good barrier between the food and the container
4. Be easy to apply to the tin plate
5. Not peel off during sterilization or storage of canned product
6. Have mechanical resistance to can manufacturing
7. Be economical

Common types of enamels used by the food industry are:

Table 6.1: General Types of Coatings Used in Canned Fruits and Vegetables

No.	Coating	Typical Uses	Type
1	R-Fruit enamel	Dark colored berries and other fruits requiring protection from metallic salts	Oleo-resinous
2	C-Corn enamel	Corn, peas, and other sulphur-bearing products	Oleo-resinous suspended zinc oxide pigment
3	Citrus enamel	Citrus fruits and concentrates	Polybutadienes
4	Beverage can enamel	Vegetable juices; red fruit juices; highly corrosive fruits; noncarbonated beverages	Two-coat systems with various base coats and vinyl or acrylic top coats

- **Oleoresinous** linings are the most common enamels used in the food industry. These are formulated to give a good barrier between the can and acid products. They include
 - *R* fruit enamel: It is used to protect the natural pigment of highly colored food products such as berries, cherries, and beets
 - *C* corn enamel: It is used to prevent black discoloration in foods such as corn and peas. The *C* oleoresin enamel contains about 15% zinc oxide, which reacts with sulphides evolved during heat processing to form white or essentially colorless products.
- **Epoxy** linings are characterized by their heat stability. They do not impart flavor to the food and can be modified with phenolics for use with fruit products.
- **Vinyl** linings are used as double coatings in combination with oleo-resinous and phenolic enamels for highly corrosive products, e.g., fruit juices. They do

not impart flavor to the food but have poor resistance to high temperatures. They are well suited for acidic products that do not need to be heat-sterilized and can be processed at temperatures below 100 °C.

- Outer coatings can also be applied to the outer can surfaces to prevent corrosion. Outside coatings of acrylics, phenolics, oleoresins, and vinyls are usually **pigmented**. They must be able to survive the heat-processing treatment and be receptive to decorative coatings and inks.

Three-piece cans are fabricated as shown in Figure 6.1. Sheets of tin plate or tin-free plate, with or without enamel coating, are cut into pieces to form the body of the can. Each *body blank* is hooked at the corners, flattened, and then seamed by soldering, cementing, or welding (Figure 6.1). The body blank is flanged, and the can bottom (manufacturer's) is double seamed onto the body. The can top is seamed on at the production line after the can is filled with product.

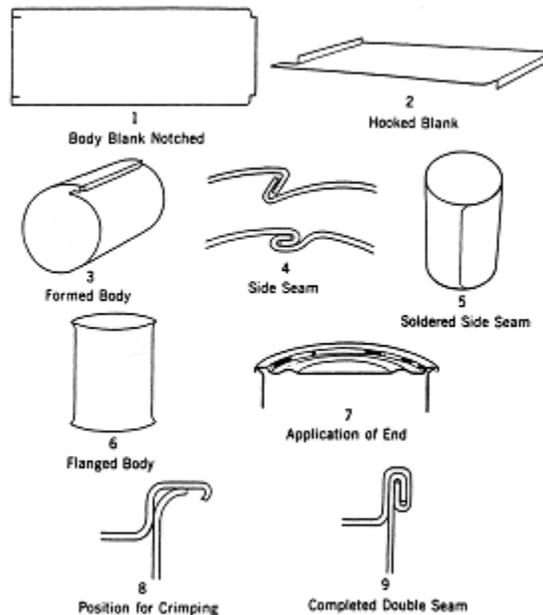


Fig: 6.1: Construction of three-piece (*sanitary*) tin can.

Three-piece cans come in a variety of shapes and sizes. Examples of common can sizes used by the food industry are summarized in Table 6.2.

Two-piece drawn and ironed and two-piece drawn and redrawn cans are also made. The advantage of two-piece steel cans is that it is possible to eliminate the side seam

and bottom sealing steps, resulting in improved structure and elimination of leakage problems; however, their production rate is slower than for three-piece cans.

6.3 ALUMINUM CANS

- Aluminum is attractive, light, and strong, but requires lot of energy and raw materials to produce the packaging cans. The majority of cans of soft drinks, lids, foils etc are made from aluminum. Two-piece cans made of aluminum are commonly used for packaging fruit drinks and beverages.
- Aluminum cans were first used for food products in Europe.
- Aluminum can be used
 - For making rigid containers/cans
 - For making Aluminum foil
 - For making collapsible metal tubes
- Aluminum is obtained from Aluminum ore – Bauxite

6.3.1 Properties of Aluminum:

1. It is lightest of the commonly used metals. Density is 2700 kg/m^3
2. Melting point is 660°C .
3. High electrical and thermal conductivity.
4. Soft, ductile and low tensile strength – i.e 93 MPa

6.3.2 Advantages of aluminum:

1. In comparison to tin plate & TFS, Aluminum is lighter and more ductile
2. Lower transportation costs, thus economical.
3. It has a good weight-strength ratio
4. It has a high quality surface for decorating or printing.
5. Easier to recover or recycle
6. More resistant to corrosion as compared to tin plate.
7. Easier to open (pull tab)
8. It is pleasant to handle.
9. Aluminum is non-toxic, odorless and does not have metallic taste.
10. Even thin aluminum foils are impervious to moisture & gases.

6.3.3 Disadvantages of Aluminum:

1. It cannot be soldered
2. Its chemical resistance is limited
3. Aluminum is softer than tin plate
4. Aluminum bleaches the pigments in food.

Uses: For increasing strength, aluminum alloys contain Magnesium and Manganese.

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Pure or commercially pure aluminum (Type 1100 and 1050) is used for the manufacture of foil and extruded containers.

Hardest grade (5182) alloy containing 4-5 % Magnesium and 0.35% Manganese is used for manufacture of carbonated beverage can ends.

Two-piece aluminum cans are made by the draw-and-wall-iron (DWI) or the draw-and-redrawn (DRD) process. The DWI process results in cans with thinner walls than the DRD process and is used to produce cans for carbonated drinks where the gas pressure supports the container. Thicker-walled DRD cans are able to withstand the head-space vacuum required in heat sterilization.

Lacquers are applied internally to prevent interactions between the metal and the product. The type of lacquer used depends on the type of product packed. Epoxy-phenolic or vinyl-based lacquers are commonly used.

6.3.4 Aluminum Foil:

“Aluminum foil is usually defined as pure aluminum (not less than 99.4% purity) which has been rolled to a thickness not more than 0.152 mm”

Commercial foils generally range in thickness of 30-70 gauge. In thinner gauges pinholes are problems in aluminum foils.

Properties:

Aluminum foil is impermeable to light, gas, moisture, odors, solvents and has the stiffness. However, Aluminum foil is subject to abrasion, scratching and rupture.

Uses:

1. 0.009 mm thickness foils are used for wrapping confectionary, processed cheese etc.
2. 0.05 mm foils are used for milk bottle caps.
3. 0.05 to 0.1 mm thickness is used for making rigid and semi rigid foil containers.
4. Thin foils are used for laminates (eg. Tetrapak film etc.).

Lesson-7

Characteristics of Plastics

7.1 INTRODUCTION

Plastic is the general term for a wide range of synthetic or semi-synthetic polymerization products derived from ethylene or coal tar products. **Plastic/s as per Webster dictionary** include any of a large group of materials of a high molecular weight that usually contain as the essential ingredient a synthetic or semi synthetic organic substance made by polymerization or condensation, or derived from a natural material or any chemical treatment, that are molded, cast, extruded, drawn or laminated under various conditions into objects of all sizes and shapes including films and filaments.

They are composed of organic condensation or addition polymers and may contain other substances to improve performance or economics. There are many natural polymers generally considered to be "plastics". Plastics can be formed into objects or films or fibers. Their name is derived from the fact that many are malleable, having the property of plasticity.

Plastics are polymers where long chains of atoms are bonded to one another. A **polymer** is a substance composed of molecules with large molecular mass composed of repeating structural units, or monomers, connected by covalent chemical bonds. The word is derived from the Greek, πολυ, polu, "many"; and μέρος, meros, "part". Well known examples of polymers include plastics, DNA and proteins.

While the term "polymer" in popular usage suggests "plastic", polymers comprise a large class of natural and synthetic materials with a variety of properties and purposes. Biopolymers such as proteins and nucleic acids play crucial roles in biological processes. A variety of other natural polymers exist, such as cellulose, which is the main constituent of wood and paper. Typical synthetic polymers are Bakelite, neoprene, nylon, PVC (polyvinyl chloride), polystyrene, polyacrylonitrile and PVB (polyvinyl butyral).

7.2 DEVELOPMENTS IN POLYMERS

- People experimented with plastics based on natural polymers for centuries.

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- The first plastic based on a synthetic polymer was made from phenol and formaldehyde, with the first viable and cheap synthesis methods, the product being known as Bakelite.
- Subsequently poly vinyl chloride, polystyrene, polyethylene (polyethene), polypropylene (polypropene), polyamides (nylons), polyesters, acrylics, silicones, polyurethanes were amongst the many varieties of plastics developed and used commercially.
- The development of plastics has come from the use of natural materials (e.g., chewing gum, shellac) to the use of chemically modified natural materials (e.g., natural rubber, nitrocellulose, collagen) and finally to completely synthetic molecules (e.g., epoxy, polyvinyl chloride, polyethylene).
- Recently, corn has been used to make biodegradable containers. Corn can be used to create non-petroleum plastic, which is often compostable.

7.2.1 Types of Plastics:

1. Thermosets: Thermosets soften and flow when heated but at the same time an irreversible chemical reaction takes place so that once hardening has occurred the material again can not again be softened by heating. If strong heat is applied to thermoset, it will char and decompose but will not soften and melt. Eg. Urea formaldehyde, Phenol formaldehyde.

2. Thermoplastics: Thermoplastics soften on heating and harden again on cooling, a process which can be repeated any number of times. Eg. Polyethylene, Nylon

Common thermoplastics range from 20,000 to 500,000 in molecular weight, while thermosets are assumed to have infinite molecular weight. These chains are made up of many repeating molecular units, known as "repeat units", derived from "monomers"; each polymer chain will have several 1000's of repeat units. The vast majority of plastics are composed of polymers of carbon and hydrogen alone or with oxygen, nitrogen, chlorine or sulfur in the backbone. (Some of commercial products are silicon based.) The backbone is that part of the chain on the main "path" linking a large number of repeat units together and to vary the properties of plastics, both the repeat unit with different molecular groups "hanging" or "pendant" from the backbone. This customization by repeat unit's molecular structure has allowed plastics to become such an indispensable part of twenty first-century life by fine tuning the properties of the polymer.

7.2.1.1 Urea Formaldehyde:

It is a thermoset. Urea formaldehyde resins are resistant to solvents but are decomposed by strong acids and attacked by strong alkalis. Their main use in food packaging is for screw cap closures.

7.2.1.2 Polyacetals:

The name polyacetals covers polymers and co-polymers of formaldehyde with compounds such as ethylene oxide. They have excellent load bearing properties and have been used in engineering applications. Chemically they are resistant to weak acids and alkalis but are attacked by strong ones. They have excellent solvent resistance.

Polyacetal container is used for hair lacquer aerosol.

7.3 ADVANTAGES OF PLASTICS OVER OTHER PACKAGING MATERIALS

1. **Versatility:** Glass/paper/board/wood has basic properties. Their modification is possible in narrow limits only. Whereas plastics have wide variety of properties. Their modification is possible by chemical processing. E.g. Rackzine (cloth + PVC+PVDC) Nomex (a fireproof dress withstands 900°C), “Kevlar” (bulletproof jacket -5 x stronger than Iron), PTFE (Kitchen wares), conductor /insulator (PET electric tube light choke)-silicone grease, etc.
2. **Energy requirements** for conversion of plastics 4-5 x less energy is required than that of Glass and 30-40 times less as compared to paper.
3. **Plastic containers** are light weight, flexible/rigid, has strength, so less breaking in handling. Attractive shapes, sizes can be formed. Good display and decoration at competitive price and having see-through properties.
4. **Multilayers used:** Multilayers collapsible tube MLCT : LDPE / LDPE / Glassine / EVA foil / EVA / LDPE. Cost of multilayers is at par with aluminum. Collapsible tube has additional benefits like wrinkle resistance, decorative printing, light weight.
5. **Cost:** Cost of plastics is comparatively lower than that of glass and metal containers.
6. **Consumer’s convenience** at lower cost. E.g. Laminates: PET/LDPE or PVC for shampoo pouches, Foil-LDPE for Tablets / Capsules packaging, PET or LDPE / metallized PET/HD or LDPE for Baby foods packaging PET/paper foil/LDPE for coffee packaging and carry home bags made of PP, PE, HDPE.
7. **Ease of opening** compared to metal containers. Grips can be provided, without adding much to cost.
8. **Retortable pouches** also possible (Boil-in-bags) from Nylon-PP; PET-PP thus helps in high temperature processing of food at low cost.
9. **Intramix packs** containing two components which are held separately with rupturable seal which can be broken by squeezing or mixing in pouch and then used. E.g. Self heating pouches containing two chemicals if mixed produce heat by exothermic reaction.
10. **Ease in Transportation and Distribution:**
 - a. It is easy to handle and convenient for the manufacturer, retailer, and consumer.

Packaging Of Dairy Products

- b. Plastics have less weight and add little weight to the product so more amount can be loaded and thus less cost. Plastic crates are light in weight than wooden crates so easy to stack.
 - c. Shrink wrapping can act as intermediate of bulk packaging and cause less loss during handling / transportation / distribution.
 - d. Plastic packaging fit closely to the shape of the food, thereby wasting little space during storage and distribution.
11. Plastics have good barrier properties against moisture and gases.
 12. Plastics are non-corrosive.
 13. Heat-sealable to prevent leakage of contents.
 14. Suitable for high-speed filling.
 15. Good wet and dry strength.
 16. Suitable for printing and even sandwiched printing layer can be provided.
 17. Plastics can be recycled.

Plastics may be made as flexible films or as semi-rigid and rigid containers to meet the varied packaging and processing requirements of food. Plastic films are made with a wide range of mechanical, optical, heat-seal, and barrier properties. Furthermore, they can be coated with another polymer or metallized to give a laminated structure with superior properties. Examples of some of the common flexible films and their properties are discussed here.

Table 7.1: Examples of Basic Plastics Used as Packaging Material

No.	Materials	Structural Unit	Important Properties
1	Cellulose	Glucose	Good strength, poor H ₂ O and gas barrier, good printability, no heat sealability
2	Polyethylene (PE)	Ethylene	Good strength, flexible, extensible, high H ₂ O barrier, poor gas barrier, low melting point, good heat-sealability
3	Polyester	Ethylene glycol + terephthalic acid	Stiff, high strength, inert, excellent mechanical properties, poor heat sealability, moderate H ₂ O and gas barrier
4	Polyamide	Diamine + various acids	Stiff, strong, inert, clear excellent machinability, heat-sealable, poor H ₂ O barrier, high gas barrier when dry
5	Polypropylene (PP)	Propylene	Tough, inert, clear, low melting point,

			high H ₂ O barrier, poor gas barrier
6	Polystyrene	Styrene	Stiff, strong, brittle, low H ₂ O and gas barrier, good base for printing, shiny surface
7	Poly vinyl-chloride (PVC)	Vinyl chloride	Soft, inert, clear, extensible good H ₂ O barrier, and moderate gas barrier
8	Polyvinylidene-chloride (PVDC)	Vinyl alcohol + Vinylidene chloride	Inert, clear, not very strong, high melting point, heat-sealable at high temperature, excellent H ₂ O and gas barrier
9	Ethylene vinyl acetate (EVA)	Vinyl acetate + ethylene	Tough, clear, inert, highly extensible, low melting point, heat sealable, intermediate H ₂ O barrier, poor gas barrier
10	Ethylene vinyl alcohol	Vinyl alcohol + ethylene	Strong, stiff, inert, heat-sealable at low temperature, low H ₂ O barrier, high gas barrier
11	Ionomer	Methacrylic acid + Ethylene	Tough, inert, clear, heat-sealable at low temperature, intermediate H ₂ O barrier and low gas barrier/ vast and varied properties possible

7.4 DISADVANTAGES OF PLASTICS

7.4.1 Negative health effects:

Following plastics have been associated with negative health effects:

PVC (polyvinyl chloride) contains numerous toxic chemicals called adipates and Phthalates ("plasticizers"), which are used to soften brittle PVC into a more flexible form. PVC is commonly used to package foods and liquids, ubiquitous in children's toys and teethers, plumbing and building materials. Traces of these chemicals can leach out of PVC when it comes in contact with food. The World Health Organization's International Agency for Research on Cancer (IARC) has recognized the chemical used to make PVC, vinyl chloride, as a known human carcinogen. The European Union has banned the use of DEHP (di-2-ethylhexyl phthalate), the most widely used plasticizer in PVC, and in children's toys.

PS (polystyrene) is one of the toxin the EPA (Environmental Protection Agency) monitors in America's drinking water. Its production also pollutes the atmosphere, destroying the ozone layer. Some compounds leaching from Styrofoam food containers interfere with hormone functions. It's a possible human carcinogen.

Other (usually polycarbonate - PC) group that consists mainly of polycarbonates, whose primary building block is bisphenol A (BPA), a hormone disrupter that releases into food and liquid and acts like estrogen. Research in Environmental Health Perspectives found that BPA (leached from the lining of tin cans, dental sealants and polycarbonate bottles) can increase body weight of lab animals' offspring, as well as impact hormone levels. A more recent animal study suggests that even low-level exposure to BPA results in insulin resistance, which can lead to inflammation and heart disease.

7.4.2 Negative effects on environment

1. Plastics are durable and degrade very slowly.
2. In some cases, burning plastic can release toxic fumes (Eg. PVC/PVDC).
3. The manufacturing of plastics often creates large quantities of chemical pollutants.
4. Unfortunately, recycling plastics has proven difficult. The biggest problem with plastic recycling is that it is difficult to automate the sorting of plastic waste, and so it is labor intensive.

Recycling certain types of plastics can be unprofitable, as well, e.g. polystyrene is rarely recycled because it is usually not cost effective.



Lesson-8

Sources of different plastic materials and process of manufacture

8.1 INTRODUCTION

This lesson covers the topics related to history, classification and different methods of manufacture of different plastic materials.

8.2 DEVELOPMENTS IN PLASTICS

- By 1936, American, British, and German companies were producing polymethyl methacrylate (PMMA), better known as acrylic glass. Although acrylics are now well known for their use in paints and synthetic fibers, such as fake furs, in their bulk form they are actually very hard and more transparent than glass, and are sold as glass replacements to build aircraft canopies during the war, and it is also now used as a marble replacement for countertops
- Another important plastic, polyethylene (PE), commonly known as polythene, was discovered in 1933 by Reginald Gibson and Eric Fawcett
- PEs are cheap, flexible, durable, and chemically resistant. LDPE is used to make films and packaging materials, while HDPE is used for containers, plumbing, and automotive fittings. While PE has low resistance to chemical attack, it was found later that a PE container could be made much more robust by exposing it to fluorine gas, which modified the surface layer of the container into the much tougher polyfluoroethylene
- Polypropylene (PP) is similar to polyethylene, and shares polyethylene's low cost, but it is much more robust. It is used in everything from plastic bottles to carpets to plastic furniture, and is very heavily used in automobiles
- Polyurethane was invented in blown form for mattresses, furniture padding, and thermal insulation
- Epoxies are a class of thermoset plastics that form cross-links and cure when a catalyzing agent, or hardener, is added. They are widely used for coatings, adhesives, and composite materials
- Two chemists named Rex Whinfield and James Dickson, developed polyethylene terephthalate (PET or PETE) in 1941, and it is used for synthetic fibers with names such as polyester, dacron, and terylene
- PET is less gas-permeable than other low-cost plastics and so is a popular material for making bottles for carbonated drinks, since carbonation tends to attack other plastics, and for acidic drinks such as fruit or vegetable juices. PET is also strong and abrasion resistant, and is used for making mechanical parts, food trays, and other items. PET films are used as a base for recording tape
- One of the most impressive plastics is polytetrafluoroethylene (PTFE), better known as **Teflon**, which could be deposited on metal surfaces as a scratch-proof and corrosion-resistant, low-friction protective coating

Packaging Of Dairy Products

- New manufacturing methods were developed, using various forming, molding, casting, and extrusion processes, to make plastic products in large quantities. Consumers enthusiastically accepted the endless range of colorful, cheap, and durable plastic containers/materials being produced.
- One of the most visible parts of this plastics invasion was a complete line of sealable polyethylene food containers which are highly effective and greatly reduce the spoilage of foods in storage. Thin-film plastic wrap that could be purchased in rolls also helped in keeping food fresh
- Formica, a plastic laminate is used to surface furniture and cabinetry. Formica was durable and attractive. It was particularly useful in kitchens, as it did not absorb, and could be easily cleaned of stains from food preparation, such as blood or grease.
- Polyurethane foam was used to fill mattresses, and Styrofoam was used to line ice coolers and make float toys
- Plastics are continuously subject to improvement. General Electric introduced Lexan, a high-impact polycarbonate plastic. Du Pont developed Kevlar®, an extremely strong synthetic fiber that is best known for its use in ballistic rated clothing and combat helmets

In the recent years, there has been a tremendous increase in the use of plastics replacing traditional packaging materials such as glass, metal, and paper. The raw materials for plastics are petroleum, natural gas, and coal. They are formed by a polymerization method that creates linkages between many small repeating chemical units (monomers) to form large molecules or polymers. Monomers are subjected to specific temperature and pressure conditions due to which chemical bonding takes place between them resulting in a chain structure. It is known as polymer and process is known as Polymerization (*Poly = many, meros = part*). The types of plastics are made by either of the following methods which decide their properties also:

- Chains of polymers are also cross - linked with one another.
- Structure : Loosely bound or tightly bound
 - - Depends on extent of branching in polymer chain.
- More branching : Less tighter bonding
- Less compact structure
- Low density: e.g. LDPE 0.910-0.920 gm/cc.
- Less Branching: More tight bonding
- More compact structure
- Higher density: e.g. HDPE 0.910-0.970 gm/cc.
- Branching depends on temperature and pressure employed during polymerization.

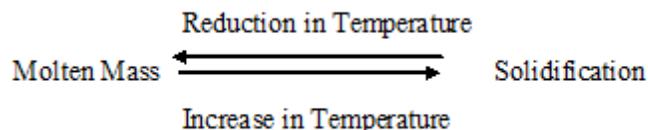
8.3. CLASSIFICATION OF PLASTICS

- Plastics can be classified in many ways, but most commonly by their polymer backbone (polyvinyl chloride, polyethylene, polymethyl methacrylate, and other acrylics, silicones, polyurethanes, etc.)
- Other classifications include thermoplastic, thermoset, elastomer, engineering plastic, addition or condensation or polyaddition (depending on polymerization method used), and glass transition temperature or T_g
- Some plastics are partially crystalline and partially amorphous in molecular structure, giving them both a melting point (the temperature at which the attractive intermolecular forces are overcome) and one or more glass transitions (temperatures above which the extent of localized molecular is substantially increased)
- Many plastics are completely amorphous, such as polystyrene and its copolymers, poly (methyl methacrylate), and all thermosets
- So-called semi-crystalline plastics include polyethylene, polypropylene, poly (vinyl chloride), polyamides (nylons), polyesters and some polyurethanes

8.3.1 Major Groups of Plastics:

8.3.1.1 Thermoplastics:

- A **thermoplastic** is a plastic that melts to a liquid when heated and freezes to a brittle, very glassy state when cooled sufficiently. They pass through several heating and cooling cycles during synthesis and thereafter to form container and films. Thus the reaction is reversible:



- Most thermoplastics are high molecular weight polymers whose chains associate through weak Van der Waals forces (polyethylene); stronger dipole-dipole interactions and hydrogen bonding (nylon); or even stacking of aromatic rings (polystyrene)
- Thermoplastic polymers differ from thermosetting polymers as they can, unlike thermosetting polymers, be remelted and remoulded. Many thermoplastic materials are addition polymers; e.g., vinyl chain-growth polymers such as polyethylene and polypropylene
- The difference between thermoplastics and thermosetting plastics is that thermoplastics become soft, remoldable and weldable when heat is added. Thermosetting plastics however cannot be welded or remolded when heated, simply burning instead. On the other hand, once a thermosetting is cured it tends to be stronger than a thermoplastic. Thermoplastic are mostly used for packaging

Some examples of Thermoplastics are:

- Acrylonitrile butadiene styrene (ABS)
- Acrylic
- Cellulose acetate
- Ethylene-Vinyl Acetate (EVA)
- Ethylene vinyl alcohol (EVAL)
- Fluoroplastics (PTFEs, including FEP, PFA, CTFE, ECTFE, ETFE)
- Ionomers
- Kydex, a trademarked acrylic/PVC alloy
- Polyacrylates (Acrylic)
- Polyamide (PA or Nylon)
- Polyethylene terephthalate (PET)
- Polycarbonate (PC)
- Polyester
- Polyethylene (PE)
- Polylactic acid (PLA)
- Polypropylene (PP)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)
- Polyvinylidene chloride (PVDC)

8.3.1.2 Thermoset Plastics:

Thermosetting plastics (thermosets) are polymer materials that irreversibly cure, to a stronger form. The cure may be done through heat (generally above 200°C), through a chemical reaction (e.g. two-part epoxy), or irradiation such as electron beam processing. It is possible to burn but re-melting is not possible in such plastic.

- Thermoset materials are usually liquid or malleable prior to curing, and designed to be molded into their final form, or used as adhesives
- The curing process transforms the resin into a plastic or rubber by a cross-linking process
- Energy and/or catalysts are added that cause the molecular chains to react at chemically active sites (e.g. unsaturated or epoxy sites), linking into a rigid, 3-D structure
- The cross-linking process forms a molecule with a larger molecular weight, resulting in a material with a higher melting point
- During the reaction, when the molecular weight has increased to a point so that the melting point is higher than the surrounding ambient temperature, the material forms into a solid material
- Uncontrolled reheating of the material results in reaching the decomposition temperature before the melting point is obtained. Therefore, a thermoset material cannot be melted and re-shaped after it is cured. This implies that thermosets cannot be recycled, except as filler material

- Thermoset materials are generally stronger than thermoplastic materials due to this 3-D network of bonds, and are also better suited to high-temperature applications up to the decomposition temperature of the material
- Generally it is not used for common packaging application. But used where high dimensional accuracy is required viz. automobile parts, machine design, caps, lids of bottle, transparent bus etc

Some examples of thermosets are:

- Vulcanized rubber
- Bakelite, a phenol-formaldehyde resin (used in electrical insulators and plastic wear)
- Urea-formaldehyde foam (used in plywood, particleboard and medium-density fibreboard)
- Melamine resin (used on worktop surfaces)
- Epoxy resin (used as an adhesive and in fibre reinforced plastics such as glass reinforced plastic and graphite-reinforced plastic)
- Polyimides (used in printed circuit boards and in body parts of modern airplanes)

8.4 Methods of manufacture of plastic packages

8.4.1 Molding Process:

Molding is the process of manufacturing by shaping pliable raw material using a rigid frame or model called a mold

A **mold** or **mould** is a hollowed-out block that is filled with a liquid like plastic, glass, metal, or ceramic raw materials. The liquid hardens or sets inside the mold, adopting its shape. A mold is the opposite of a cast. A release agent is typically used to make removal of the hardened/set substance from the mold easier

Types of molding include:

- Powder metallurgy and ceramics
- Compaction plus sintering
- Plastics
- Injection molding
- Compression molding
- Transfer molding
- Extrusion molding
- Blow molding

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- Rotational molding
- Thermoforming
- Vacuum forming, a simplified version of thermoforming
- Reaction Injection Molding
- Laminating
- Expandable bead molding
- Foam molding
- Rotomolding
- Vacuum plug assist molding
- Pressure plug assist molding
- Matched mold

8.4.1.1 Flexible mold

A mold is a hollow shape which exactly encloses the shape of a desired object. The object is usually created by pouring a liquid into the mold and allowing it to solidify: typical liquids include molten metal or plastic, plaster of Paris, epoxy resin

Molds generally divide into two classes: solid or flexible

There are five different types of flexible mold compounds in significant use today:

- Hot-Melt
- Latex
- Silicone rubbers
- Polysulfide rubbers
- Polyurethane flexible mold compounds

From the standpoint of general utility and economy, the polyurethanes surpass all other type

8.4.1.2 Injection molding:

Injection molding is a manufacturing technique for making parts from both thermoplastic and thermosetting plastic materials in production. Molten plastic is injected at high pressure into a mold / mould, which is the inverse of the product's shape. Injection molding is widely used for manufacturing a variety of parts, from the smallest component to entire body panels of cars. Injection molding is the most

common method of production, with some commonly made items including bottle caps and outdoor furniture



Figure 8.1: Standard two plates tooling - core and cavity are inserts in a mold base

Materials: The most commonly used thermoplastic materials are polystyrene (low cost, lacking the strength and longevity of other materials), ABS or acrylonitrile butadiene styrene (a ter-polymer or mixture of compounds used for everything from Lego parts to electronics housings), polyamide (chemically resistant, heat resistant, tough and flexible - used for combs), polypropylene (tough and flexible - used for containers), polyethylene, and polyvinyl chloride or PVC (more common in extrusions as used for pipes, window frames, or as the insulation on wiring where it is rendered flexible by the inclusion of a high proportion of plasticiser)

Injection Process:



Figure 8.2: Small injection molder showing hopper, nozzle and die area

8.4.1.2.1 Injection Molding process:

1. The *resin*, or raw material for injection molding, is usually in pellet or granule form, and is melted by heat and shearing forces shortly before being injected into the mold
2. Resin pellets are poured into the feed hopper, a large open bottomed container, which feeds the granules down to the screw

3. The screw is rotated by a motor, feeding pellets up the screw's grooves. The depth of the screw flights decreases towards the end of the screw nearest the mold, compressing the heated plastic
4. As the screw rotates, the pellets are moved forward in the screw and they undergo extreme pressure and friction which generates most of the heat needed to melt the pellets
5. Heaters on either side of the screw assist in the heating and temperature control during the melting process.
6. The channels through which the plastic flows toward the chamber will also solidify, forming an attached frame
7. This frame is composed of the *sprue*, which is the main channel from the reservoir of molten resin, parallel with the direction of draw, and *runners*, which are perpendicular to the direction of draw, and are used to convey molten resin to the *gate(s)*, or point(s) of injection

8.4.2 Plastics extrusion:

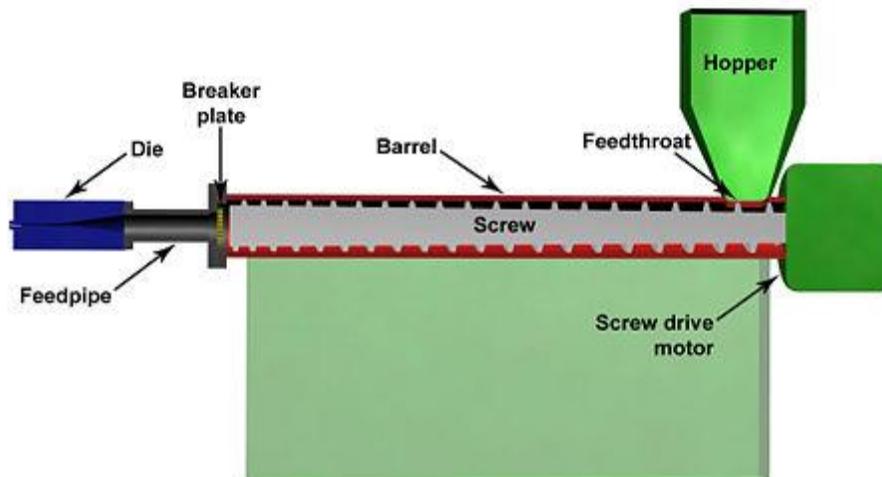


Figure 8.3: Cross section view of Plastic extruder

Plastics extrusion is a high volume manufacturing process in which raw plastic material is melted and formed into a continuous profile. Extrusion produces items such as pipe/tubing, weather stripping, window frames, plastic sheeting, adhesive tape and wire insulation.

8.4.2.1 Process of plastic extrusion:

- In the extrusion of plastics, raw thermoplastic material in the form of small beads (often called resin in the industry) is gravity fed from a top mounted hopper into the barrel of the extruder. Additives such as colorants and UV inhibitors (in either liquid or pellet form) which are often used can be mixed into the resin prior to arriving at the hopper.

- The material enters through the feed throat (an opening near the rear of the barrel) and comes into contact with the screw. The rotating screw forces the plastic beads forward into the barrel which is heated to the desired melt temperature of the molten plastic (~ 200 °C). In most processes, a heating profile is set for the barrel in which three or more independently controlled heaters gradually increase the temperature of the barrel from the rear (where the plastic enters) to the front. This allows the plastic beads to melt gradually as they are pushed through the barrel and lowers the risk of overheating which may cause degradation in the polymer. Extra heat is contributed by the intense pressure and friction taking place inside the barrel. In fact, if an extrusion line is running a certain material fast enough, the heaters can be shut off and the melt temperature maintained by pressure and friction alone inside the barrel. In most extruders, cooling fans are present to keep the temperature below a set value if too much heat is generated.
- At the front of the barrel, the molten plastic leaves the screw and travels through a screen pack to remove any contaminants in the melt. The screens are reinforced by a breaker plate (a thick metal puck with many holes drilled through it) since the pressure at this point can exceed 5000 psi (34 MPa). The screen pack/breaker plate assembly also serves to create back pressure in the barrel. Back pressure is required for uniform melting and proper mixing of the polymer. This breaker plate also does the function of converting "rotational memory" of the molten plastic into "longitudinal memory"
- After passing through the breaker plate, the molten plastic enters the die. The die is the component that gives the final product its profile and must be designed so that the molten plastic evenly flows from a cylindrical profile, to the product's profile shape. Uneven flow at this stage would produce a product with unwanted stresses at certain points in the profile. These stresses can cause warping upon cooling.
- The product must now be cooled and this is usually achieved by pulling the extrudate through a water bath. Plastics are very good thermal insulators and are therefore difficult to cool quickly. Compared with steel, plastic conducts its heat away 2000 times more slowly. In a tube or pipe extrusion line, a sealed water bath is acted upon by a carefully controlled vacuum to keep the newly formed and still molten tube or pipe from collapsing. For products such as plastic sheeting, the cooling is achieved by pulling through a set of cooling rolls.
- Sometimes on the same line a secondary process may occur before the product has finished its run. In the manufacture of adhesive tape, a second extruder melts adhesive and applies this to the plastic sheet while it's still hot. Once the product has cooled, it can be spooled, or cut into lengths for later use.

8.4.2.1.1 Sheet/Film extrusion:

- For products such as plastic sheet or film, the cooling is achieved by pulling through a set of cooling rolls (calender rolls), mostly 3-4 in number. In sheet extrusion, these rolls not only deliver the necessary cooling but also determine sheet thickness and surface.
- Often coextrusion is used to apply one or more layers to obtain specific properties such as UV-absorption, soft touch, matt surface, energy reflection, etc

Packaging Of Dairy Products

- A common post-extrusion process for plastic sheet stock is thermoforming, where the sheet is heated till soft (plastic), and formed on a mold into a new shape. When vacuum is used, this is often described as vacuum forming. Thermoforming can go from line banded pieces (e.g. displays) to complex shapes (computer housings), which often look like being injection moulded, because of the various possibilities in thermoforming, such as inserts, undercuts, divided moulds

8.4.2.1.2 Blown Film extrusion:

The manufacture of plastic film for products such as shopping bags is achieved using a blown film line

- This process is the same as a regular extrusion process up until the die
- The die is an upright cylinder with a circular opening similar to a pipe die
- The diameter can be a few centimeters to more than three metres across
- The molten plastic is pulled upwards from the die by a pair of nip rolls high above the die (4 metres to 20 metres or more depending on the amount of cooling required)
- Changing the speed of these nip rollers will change the gauge (thickness) of the film
- Around the die sits an air-ring. The air-ring cools the film as it travels upwards. In the centre of the die is an air outlet from which compressed air can be forced into the centre of the extruded circular profile, creating a bubble
- This expands the extruded circular cross section by some ratio (a multiple of the die diameter). This ratio, called the “blow-up ratio” can be just a few percent to more than 200 percent of the original diameter
- The nip rolls flatten the bubble into a double layer of film whose width (called the “layflat”) is equal to $\frac{1}{2}$ the circumference of the bubble
- This film can then be spooled or printed on, cut into shapes, and heat sealed into bags or other items

8.4.2.1.3 Overjacketing extrusion:

In a wire coating process, bare wire (or bundles of jacketed wires, filaments, etc) is pulled through the center of a die similar to a tubing die. Many different materials are used for this purpose depending on the application. Essentially, an insulated wire is a thin walled tube which has been formed around a bare wire.

8.4.2.1.4 Tubing extrusion:

Plastic tubing, such as drinking straws and medical tubing, is manufactured by extruding molten polymer through a die of the desired profile shape (square, round, triangular). Hollow sections are usually extruded by placing a pin or mandrel inside of

the die and in most cases positive pressure is applied to the internal cavities through the pin.

8.4.2.1.5 Coextrusion:

Coextrusion refers to the extrusion of multiple layers of material simultaneously. This type of extrusion utilizes two or more extruders to melt and deliver a steady volumetric throughput of different molten plastics to a single extrusion head which combines the materials in the desired shape. This technology is used on any of the processes described above (Blown Film, Overjacketing, Tubing). The layer thicknesses are controlled by the relative speeds and sizes of the individual extruders delivering the materials.

8.4.2.1.6 Extrusion coating:

Extrusion coating is using a blown or cast film process to coat an additional layer onto an existing rollstock of paper, foil or film. This process can be used to improve the characteristics of paper by coating it with polyethylene to make it more resistant to water. The extruded layer can also be used as an adhesive to bring two other materials together. A famous product that uses this technology is tetrapak (used for packing UHT milk).



Lesson-9

Forms of different plastic materials - 1

9.1 INTRODUCTION

In this lesson the topics related to different plastic materials like cellulose, polyethylene, polypropylene, polyester, polyamide etc are discussed.

9.2 CELLULOSE

Cellophane is produced from wood pulp, treated chemically, and cast into a film on heated rollers. Glycerol is added as a softener, and the film is dried on heated rollers. Higher quantities of softener produce more flexible films.

Art silk, technically known as Cellulose Acetate is well known under the trade name "rayon". It is cheap and feels smooth on the skin, though it is weak when wet and creases easily. It could also be produced in a transparent sheet form known as "cellophane".

9.2.1 Characteristics of Cellulose:

1. Plain, uncoated cellulose is a glossy, transparent film that is odorless, tasteless, and biodegradable.
2. It is tough and puncture-resistant although it tears easily.
3. However, it is not heat-sealable.
4. It has poor water and gas vapor barrier characteristics.
5. Plain cellophane is used for foods that do not require a complete moisture or gas barrier.
6. Most cellophane is sold coated either with nitrocellulose on one or both sides or with polyvinylidene chloride (Saran).

These coatings improve the gas barrier and heat-seal characteristics of cellophane.

9.2.2 Modified Celluloses:- Thermoplastics

- Cellulose acetate
- Cellulose acetate-butyrate
- Cellulose acetate-propionate

Application – Thermoformed blisters, windows for cartons and rigid transport cartons.

9.2.2.1 Cellulose Acetate:-

This is a cellulose plastic made from bark (CAC) and acetate anhydride in the presence of acetic and sulphuric acids. It has good clarity, gloss and abrasion resistance. It is very similar in properties to PS. The high gas and water vapour permeability can be utilized for wrapping fresh produce like tomatoes and grapes.

Cellulose acetate is resistant to aromatic hydrocarbons but is soluble in Ketones and esters and is decomposed by strong acids and alkalis, cellulose acetate is sensitive to moisture and is not dimensionally stable.

9.2.2.2 Cellophane:-

It is derived from natural cellulose which is a main substance of all plants. In natural cellulose glucose units may vary from 3000-4000. In 1928 a process was discovered by which cellulose could be obtained in a soluble form by treating with NaOH, followed by Carbon Di-sulphide (CS₂). In fiber form it is known as Rayon and in film form it is known as cellophane.

9.2.2.3 Regenerated Cellulose:-

This is essentially same as natural cellulose, but has a lower molecular weight and can not be heat sealed. The films are made from wood chips in which cellulose is taken in to solution and re-precipitated as a continuous transparent film. It is excellent barrier to gas but is sensitive and permeable to water vapour.

9.2.3 Water Soluble Films:

9.2.3.1 Carboxy Methyl Cellulose(CMC):

This film is available as Sodium EMC. It is hydrophilic and is insoluble in cold water.

Methyl Cellulose: It is obtained by treating cellulose with NaOH and then by alkylation. It is highly resistant to oils and greases. It can be formed in to small pouches.

9.2.3.2 Polyvinyl Alcohol:

The film is obtained by hydrolysis of polymerized vinyl acetate. It is insoluble in hydrocarbons. These are used for wrapping candies, single application for coffee, tea, derived milk, cold drinks, detergents and insecticides. It is soluble in water. It is utilized for manufacture of film, sachets used to give controlled dosage in water.

9.3 POLYETHYLENE:

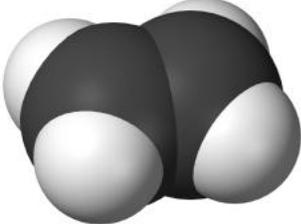
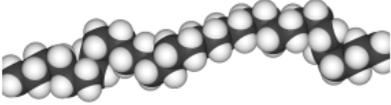
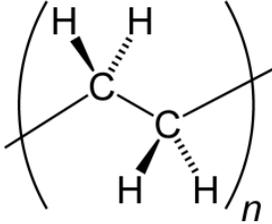
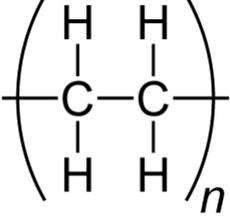
			
<p>Two CH₂ groups connected by a double bond</p>	<p>Space-filling model of a polyethylene chain</p>	<p>The repeating unit of polyethylene, showing its stereochemistry</p>	<p>A simpler way of representing the <u>repeating unit</u>. Note, however, that the <u>C-H bond angles</u> are not 90° as this diagram would indicate, but are ~ 110°, since each <u>carbon</u> atom is <u>tetrahedral</u> (sp³)</p>

FIGURE 9.1 basic structure and characteristics of polyethylene

Polyethylene or **polythene** (IUPAC name **polyethene**) is a thermoplastic commodity heavily used in consumer products and food packaging applications. It is produced by polymerization of ethylene.

Polyethylene is a polymer consisting of long chains of the monomer ethylene (IUPAC name ethene). In the polymer industry the name is sometimes shortened to **PE** or is commonly called **polythene** in UK. The ethene molecule (known almost universally as ethylene), C_2H_4 is $CH_2=CH_2$. Polyethylene is created through polymerization of ethene. It can be produced through radical polymerization, anionic addition polymerization, ion coordination polymerization or cationic addition polymerization. Each of these methods results in a different type of polyethylene

9.3.1 Characteristics of Polyethylene:

1) Polyethylene was first synthesized by the German chemist Hans von Pechmann in 1898. It contained long $-CH_2-$ chains and termed it *polymethylene*. The first industrially practical polyethylene synthesis was discovered in 1933 in England. The types of catalyst that promote ethylene polymerization at more mild temperatures and pressures are:

- Chromium trioxide based
- Titanium halides and organoaluminum compounds
- Metallocenes was discovered in 1976 in Germany

2) The catalyst families have since proven to be very flexible at copolymerizing ethylene with other olefins and have become the basis for the wide range of polyethylene resins available today, including very low density polyethylene , and linear low density polyethylene . Such resins, in the form of fibers have begun to be used in many high-strength applications

9.3.2 Physical properties of Polyethylene:

- For common commercial grades of medium-density and high-density polyethylene, the melting point is typically in the range 120 to 130 °C whereas for average commercial low-density polyethylene it is typically 105 to 115 °C.

- Most Low Density Polyethylene (LDPE) , Medium Density Polyethylene (MDPE), and High Density Polyethylene (HDPE) grades have excellent chemical resistance and do not dissolve at room temperature because of the crystallinity.
- Polyethylene is classified into several different categories based mostly on its density and branching. The mechanical properties of PE depend significantly on variables such as the extent and type of branching, the crystal structure, and the molecular weight
- Polyethylene (other than cross-linked polyethylene) usually can be dissolved at elevated temperatures in aromatic hydrocarbons, such as toluene or xylene, or chlorinated solvents, such as trichloroethane or trichlorobenzene

9.3.3 Classification of Polyethylene:

9.3.3.1 High-density polyethylene (HDPE):

- HDPE is defined by a density of greater or equal to 0.941 g/cm^3
- It also has a higher softening temperature (121°C) and can therefore be heat-sterilized.
- It has a low degree of branching and thus stronger intermolecular forces and tensile strength.
- It is stronger, thicker, less flexible, less transparent, and more brittle and has lower permeability to gases and moisture than LDPE.
- It is used in products and packaging such as milk jugs, detergent bottles, margarine tubs, garbage containers and water pipes. It is commonly used in the production of bags, as liners, and as an over wrap.

9.3.3.2 Medium-density polyethylene (MDPE):

- MDPE is defined by a density range of $0.926\text{--}0.940 \text{ g/cm}^3$
- It can be produced by chromium/silica catalysts, Ziegler-Natta catalysts or **metallocene** catalysts
- It has good shock and drop resistance properties
- It is also less notch sensitive than HDPE, stress cracking resistance is better than HDPE
- MDPE is typically used in gas pipes and fittings, sacks, shrink film, packaging film, carrier bags, screw closures etc.

9.3.3.3 Linear low-density polyethylene (LLDPE):

LLDPE is defined by a density range of $0.915\text{--}0.925 \text{ g/cm}^3$

- It is a substantially linear polymer, with significant numbers of short branches, commonly made by copolymerization of ethylene with short-chain alpha-olefins (e.g. 1-butene, 1-hexene, and 1-octene) and combines the clarity of LDPE and the strength of HDPE.
- It has higher tensile strength than LDPE, exhibits higher impact and puncture resistance than LDPE, Lower thickness (gauge) films can be blown compared to

LDPE, with better environmental stress cracking resistance compared to LDPE but is not as easy to process.

- It is used in packaging, particularly film for bags and sheets. Lower thickness (gauge) may be used compared to LDPE. Cable covering, toys, lids, buckets and containers, pipes etc.
- While other applications are available, LLDPE is used predominantly in film applications due to its toughness, flexibility, and relative transparency.

9.3.3.4 Low-density polyethylene (LDPE):

- LDPE is defined by a density range of 0.910–0.940 g/cm³.
- It has a high degree of short and long chain branching, which means that the chains do not pack into the crystal structure as well. It has therefore less strong intermolecular forces.
- This results in a lower tensile strength and increased ductility.
- It is created by free radical polymerization.
- The high degree of branches with long chains gives molten LDPE unique and desirable flow properties.
- It is used for both rigid containers and plastic film applications such as plastic bags and film wrap.
- It is heat-sealable at low temperatures (~80 °C).
- It is chemically inert, odor-free, and shrinks when heated.
- It is a good moisture barrier but a poor gas barrier. This selective permeability makes it a good choice of packaging material for such products as fresh meat, fruits, and vegetables.
- It is less expensive than most films and is therefore widely used for many packaging applications, including applications in shrink- or stretch-wrapping of products.

9.3.3.5 High Molecular High Density Polyethylene (HMHDPE)

HMHDPE films have superior mechanical and barrier properties. They can be folded easily, have good stiffness and high initial tear resistance. They can be used in thinner gauges. This resembles paper in feel. It is white translucent. It has better barrier properties to moisture, air, oil and grease. It is used for wrapping meat, fish, dairy products, bakery products and vegetables.

Table. 9.1 Properties of LDPE & HDPE

SN	Property	LDPE	HDPE
1	Yield Stress	1250 – 2000 psi	3000 – 4100 psi
2	Yield Elongation	16 – 20%	11 – 16%
3	Ultimate Elongation	200 – 600%	50 – 400%
4	Impact Strength (200 gauge film)	4.5	1.5
5	Hardness	41 – 43	60 – 70
6	Softening Point	85 - 87°C	137°C
7	Tearing Strength (gm / mil)	150	75
8	WVTR (gm / m ² / day)	18	5 – 6
9	Oxygen Transmission Rate (cc/cm ² /day)	15	3
10	CO ₂ Transmission Rate (cc/cm ² /day)	55	13
11	Nitrogen Transmission Rate (cc/cm ² /day)	5	1
12	Turpentine Grease Proof Test	2 hours	168 hours

Ethylene copolymers:

In addition to copolymerization with alpha-olefins, ethylene can also be copolymerized with a wide range of other monomers and ionic composition that creates ionized free radicals. Common examples include vinyl acetate (resulting product is ethylene-vinyl acetate copolymer, widely used in athletic shoe sole foams), and a variety of acrylates used in packaging and sporting goods.

9.4 POLYESTER

Polyester is a polycondensation product of ethylene glycol and terephthalic acid. The major polyester in the market place is polyethylene terephthalate (PET), marketed under the trade name *Mylar*.

- **Polyester** (Terylene) is a category of polymers which contain the ester functional group in their main chain. Although there are many forms of polyesters, the term "polyester" is most commonly used to refer to polyethylene terephthalate (PET). Other forms of polyester include naturally occurring cutin of plant cuticles as well as synthetic polyesters such as polycarbonate and polybutyrate.

- Polyester may be produced in numerous forms. For example, polyester as a thermoplastic may be heated and processed into different forms, e.g., fibers, sheets, and three-dimensional shapes.
- While combustible at high temperatures, polyester tends to shrink away from flames and self-extinguishes.

9.4.1 Characteristics of Polyester:

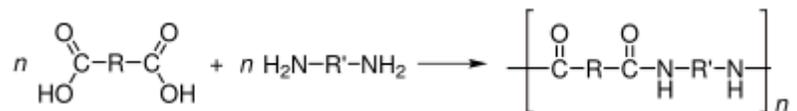
1. The main characteristics of PET are its strength and toughness (can resist pressures of 50-60 psi used for soft drinks), its clarity, its good barrier properties to moisture and gases, and its high melting point.
2. These characteristics make it an ideal packaging material for carbonated soft drink bottles and as a component of boil-in-bag food packages and retortable pouches (max. used temp. 150°C)
3. A more crystalline PET (CPET) is used to make “dual-ovenable” food trays that enable precooked food and entrees to be heated in a radiant oven or microwave without deformation of the packaging tray.
4. It has good chemical resistance, soluble in benzyl alcohol, hot phenols and alkalis.

9.4.2 Uses of Polyester:

1. Polyester is the most widely used manufactured fiber.
2. Polyesters are also used to make bottles, films, tarpaulin, liquid crystal displays, holograms, filters, dielectric film for capacitors, film insulation for wire and insulating tapes. In general they have extremely good mechanical properties and are extremely heat resistant.
3. Thermosetting polyester resins are generally copolymers of unsaturated polyesters with styrene. Another important family is the group of vinyl esters.
4. Unsaturated polyesters are commonly used as casting materials, fiberglass laminating resins, and non-metallic auto-body fillers.
5. It is good material for metallization, Metalized PET is used in dairy industry for packaging of powders and processed cheese.
6. It is also used for vacuum packaging of coffee and processed meat.

9.5 POLYAMIDE (PA)

A **polyamide** is a polymer containing monomers of amides joined by peptide bonds. They can occur both naturally, examples being proteins, such as wool and silk, and can be made artificially, examples being nylons, aramids, and sodium poly(aspartate). Thus, Polyamide is made by the condensation polymerization of an organic acid and an amine. Nylon was the first purely synthetic fiber, introduced by Du Pont Corporation in 1939.



Subsequently polyamides 6, 10, 11, and 12 have been developed based on monomers which are ring compounds, e.g. caprolactam. Nylon 66 is a material manufactured by condensation polymerization. Nylon 6, 66 and 11 are most widely used as packaging films.

(A) Nylon 6:- It is prepared from phenol. It is more flexible than Nylon 66 and has better grease resistance than Nylon 11. It can withstand dry heat up to 250°C and hence, it is used for roast-in-bags. It has high mechanical strength, high elongation, excellent abrasion and bursting resistance. Unsupported film is used for containing frozen foods, aromatic flavourings, fats & oils.

(B) Nylon 66:- This has higher softening point i.e 265°C.

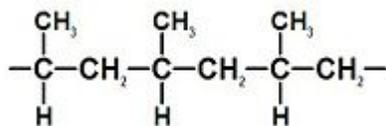
(C) Nylon 11:- It is manufactured from castor oil, undeconoic acid and ammonia. It softens at 125°C and is resistant to fats, oils and even concentrated alkalis and organic acids, but does not resist phenol and strong mineral acids.

9.5.1 Characteristics of Polyamide:

1. Nylon is a clear, tough film with good mechanical properties over a wide temperature range (from -60 °C to 200 °C).
2. It provides good gas and aroma barriers, but has poor moisture barrier properties.
3. However, the films are expensive to produce, and they require high temperatures to form a heat seal.
4. Nylons still remain important plastics, and not just for use in fabrics.
5. Nylon is commonly used as the outer layer of laminated structures to add strength to the laminated structure.
6. The barrier and mechanical properties of nylon can be enhanced through biaxial orientation to give biaxially oriented nylon (BON).
7. In its bulk form it is very wear resistant, particularly if oil-impregnated, and is used to build gears, bearings, bushings, and because of good heat-resistance, increasingly for under-the-hood applications in cars, and other mechanical parts.
8. Nylons have high WVTR rates, but are very good gas barriers and hence used in laminates for vacuum packing.
9. The transparency of nylon film is excellent.

10.They have good grease resistance and mechanical strength.

9.6 POLYPROPYLENE



Polypropylene was first polymerized in 1954 by Giulio Natta. **Polypropylene** or **polypropene (PP)** (IUPAC- Poly (1-methylethylene)) is a thermoplastic polymer, made by the chemical industry by an addition polymer from the monomer propylene. Its other names are: Polypropylene; Polypropene; Polipropene 25 USAN; Propene polymers; Propylene polymers; 1-Propene homopolymer. Its molecular formula is $(\text{C}_3\text{H}_6)_x$.

9.6.1 Characteristics of Polypropylene:

1. **Polypropylene (PP)** is one of the lightest of all plastics.
2. It has a melting point of $\sim 165^\circ\text{C}$ and density: Amorphous (0.85 g/cm^3); Crystalline: (0.95 g/cm^3).
3. There are three general types of PP: homopolymer, random copolymer and impact or block copolymer.
4. Two main types are made: Non-oriented or cast polypropylene (PP) and oriented polypropylene (OPP).
5. Melt processing of polypropylene can be achieved via two general methods: 1) extrusion and 2) molding.
6. **Biaxially oriented polypropylene (OPP)** is superior to PP in terms of clarity, impact strength and barrier properties to water vapor and gases.
7. Common extrusion methods include production of melt blown and spun bond fibers to form long rolls for future conversion into a wide range of useful products.
8. The most common molding technique for PP is injection molding. The types of molded parts made are almost limitless, but commonly include cups, cutlery, vials, caps, containers, housewares and automotive parts such as batteries. Blow molding and injection-stretch blow molding are techniques involving both extrusion and molding.
9. Compared to LDPE and HDPE, PP is stiffer, tougher, and more transparent.
10. It is rugged and unusually resistant to many chemical solvents, bases and acids.
11. It also has superior gas and moisture barrier properties and higher heat resistance than LDPE and HDPE, which make it suitable for boil-in-bag and retortable products.
12. It stretches, although less than polyethylene and it has low friction, which minimizes static buildup and makes it suitable for high-speed filling equipment.

13. However, it is more brittle than polyethylene at low temperatures.
14. Its resistance to oils & grease is better than polyethylene.
15. One outstanding property of PP is its resistance to fatigue when flexed.

Table. 9.2 Properties of Polypropylene

Sr. No.	Property	Cast PP	Oriented PP
1	Tensile Strength	5000 units	8000 units
2	WVTR (gm/m ² /day)	11.8	5.4
3	Oxygen Permeability (cc/cm ² /day)	100	60
4	Behaviour at 0°C	Brittle (It can not be used for freeze dehydration)	Unaltered

9.6.2 Applications of Polypropylene:

1. A common application for polypropylene is as Biaxially Oriented polypropylene (BOPP). These BOPP sheets are used to make a wide variety of materials including clear bags. When polypropylene is biaxially oriented, it becomes crystal clear and serves as an excellent packaging material for artistic and retail products.
2. It is used in a wide variety of applications, including packaging, textiles, stationery, plastic parts and reusable containers of various types.
3. It is most commonly used for plastic moldings where it is injected into a mold while molten, forming complex shapes at relatively low cost and high volume, e.g. bottle tops, bottles and fittings.
4. The large number of end use applications for PP is often possible because of the ability to tailor grades with specific molecular properties and additives during its manufacture. For example, antistatic additives can be added to help PP surfaces resist dust and dirt. Many physical finishing techniques can also be used on PP, such as machining. Surface treatments can be applied to PP parts in order to promote adhesion of printing ink and paints.
5. Polypropylene has a typical peak melting point of ~160°C. Many plastic items for medical or laboratory use can be made from polypropylene because it can withstand the heat in an **autoclave**. Food containers made from it will not melt in the dishwasher, and do not melt during industrial hot filling processes. For this reason, most plastic tubs for dairy products are made of polypropylene and sealed with aluminum foil. After the product is cooled, the tubs are often given lids made of a less heat-resistant material, such as LDPE or polystyrene. Such containers provide the rubbery (softer, more flexible) feeling of LDPE with respect to PP of the same thickness.

6. Rugged, translucent, reusable plastic containers made in a wide variety of shapes and sizes for consumers are commonly made of polypropylene, although the lids are often made of somewhat more flexible LDPE so they can snap on to the container to close it.
7. Polypropylene can also be made into disposable bottles to contain liquid, powdered or similar consumer products, although HDPE and polyethylene terephthalate are commonly used to make bottles.
8. PP can also be used to package soft bakery products and fresh produce because it is flexible enough to fit around irregular shapes.
9. PP has been produced in sheet form and this has been widely used for the production of stationary folders, packaging and storage boxes. The wide colour range, durability and resistance to dirt make it ideal as a protective cover for papers and other materials. It is used in stickers because of these characteristics.



Lesson-10

Forms of different plastic material-2

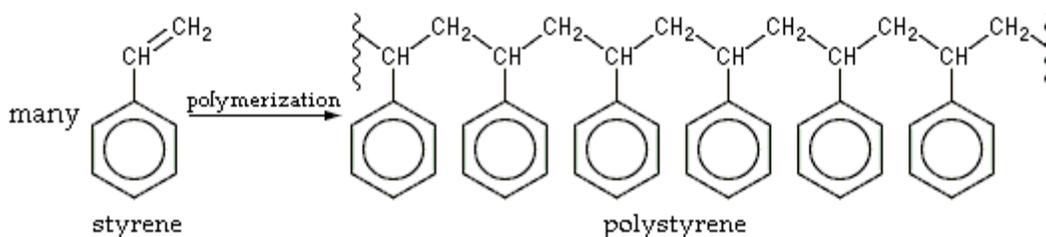
10.1. INTRODUCTION

In this lesson the topics related to different plastic materials like polystyrene, PVC, PVDC, EVA, EVOH etc are discussed in detail.

10.2. POLYSTYRENE (PS)

Polystyrene (IUPAC Polyphenylethene) is an aromatic polymer made from the aromatic monomer styrene, a liquid hydrocarbon via the double bond in the ethylene group attached to the benzene ring of the monomer unit that is commercially manufactured from petroleum. **Polystyrene foam (Thermocole) or expanded polystyrene (EPS)** is made by adding hexane during polymerization.

10.2.1. Characteristics



- Polystyrene is a thermoplastic substance, normally existing in solid state at room temperature, but melting if heated (for molding or extrusion), and becoming solid again when cooling off. It can be cast into molds with fine detail
- Polystyrene is a rigid, brittle, hard, inexpensive, clear, transparent and sparkling low strength with limited flexibility plastic film with a low melting point and poor impact resistance and can be made to take on various colours.
- PS has a fairly high tensile strength. It softens at about 90-95°C. It is relatively cheap. It has high WVTR & GTR and hence called as breathing film. It deteriorates on exposure to sunlight.
- Polystyrene production methods include sheet stamping (PS) and injection molding

- Polystyrene may be oriented to improve its gas barrier properties & improve strength.
- It can be used as Expanded Polystyrene (EPS) or Extruded polystyrene (XPS)
- Expanded polystyrene is produced from a mixture of about 90-95% polystyrene and 5-10% gaseous blowing agent, most commonly pentane or carbon dioxide. The solid plastic is expanded into foam through the use of heat, usually steam
- Extruded polystyrene (XPS) is commonly known by the trade name Styrofoam. The voids filled with trapped air give it low thermal conductivity
- The density of expanded polystyrene varies greatly from around 25 kg/m³ to 200 kg/m³ depending on how much gas was admixed to create the foam.

10.2.2. Copolymers:

- **High-impact polystyrene** or **HIPS**: Pure polystyrene is brittle, but hard enough that a fairly high-performance product can be made by giving it some of the properties of a stretchier material, such as polybutadiene rubber. The two such materials can never normally be mixed because of the amplified effect of intermolecular forces on polymer insolubility, but if polybutadiene is added during polymerization it can become chemically bonded to the polystyrene, forming a graft copolymer which helps to incorporate normal polybutadiene into the final mix, resulting in **high-impact polystyrene** or **HIPS**, often called "high-impact plastic". HIPS are usually injection molded in production. Autoclaving polystyrene can compress and harden the material
- Acrylonitrile butadiene styrene or ABS plastic is similar to HIPS: a copolymer of acrylonitrile and styrene, toughened with polybutadiene. Most electronics cases are made of this form of polystyrene, as are many sewer pipes. ABS pipes may become brittle over time. ABS is used for manufacture of Margarine tubs.
- Styrene can be copolymerized with other monomers; for example, divinylbenzene for cross-linking the polystyrene chains
- It has got shining surface, good printing property and easy thermo-formability.

10.2.3. Uses of Polystyrene

1. PS films are used as windows in paperboard boxes due to their excellent clarity.
2. Polystyrene's most common use is as expanded polystyrene (EPS).
 - a. EPS is a rigid, low-density material that is widely used to make meat trays, egg cartons, cups, and containers.
 - b. However, EPS is a poor gas barrier to oxygen and moisture vapor.
 - c. EPS trays are commonly used with PE or PP over wraps that provide the necessary barrier properties to moisture.
3. High Impact styrene is not brittle. It finds much current use as the substance of toy figurines and novelties.

4. The voids in Extruded polystyrene (XPS) are filled with trapped air which give it low thermal conductivity. This makes it ideal as a construction material and it is therefore sometimes used in structural insulated panel building systems. It is also used as insulation in building structures, as molded packing material for cushioning fragile equipment inside boxes, as packing "peanuts", as non-weight-bearing architectural structures (such as pillars), and also in crafts and model building, particularly architectural models. Foamed between two sheets of paper, it makes a more-uniform substitute for corrugated cardboard, trade named Foamcore.
5. Polystyrene is economical and is used for producing plastic model assembly kits, license plate frames, plastic cutlery, CD "jewel" cases, and many other objects where a fairly rigid, economical plastic is desired.
6. Polystyrene can be dish washed at 70 °C without deformation since it has a glass transition temperature of 95 °C.
7. Petri dishes and other containers such as test tubes, made of polystyrene are used in biomedical research and science. For these uses, articles are almost always made by injection molding, and often sterilized post molding, either by irradiation or treatment with ethylene oxide.
8. Polystyrene is also used in preparing breath-in boxes type packaging for fruits, which keeps fruits fresh for longer time.
9. HIPS is used for thermoformed trays, tubs, cups for packing yogurt, dahi, ice-cream and meats.

10.2.4. Dangers and fire hazard

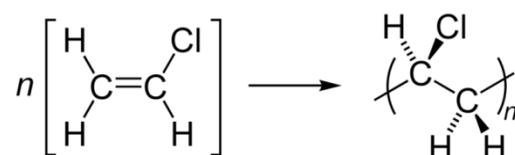
- The health effects caused by consuming polystyrene when it migrates from food containers into food are under serious investigation
- Benzene, a material used in the production of polystyrene, is a known human carcinogen. Moreover, butadiene and styrene (in ABS), when combined, become benzene-like in both form and function
- The acute exposure to styrene in humans results in mucous membrane and eye irritation, and gastrointestinal effects, effects on the central nervous system such as headache, fatigue, weakness, and depression, its dysfunction, hearing loss, and peripheral neuropathy, an increased risk of leukemia and lymphoma. However, the evidence is inconclusive

- Polystyrene, though is an efficient insulator at low temperatures, it is prohibited from being used in any exposed installations as long the material is not flame retarded e.g. with hexabromocyclododecane
- Polystyrene is used in some polymer-bonded explosives such as RDX and is also a component of Napalm and a component of most designs of hydrogen bombs.

10.2.5. Environmental concerns and bans

- Expanded polystyrene is not easily recyclable because of its light weight and low scrap value
- Expanded polystyrene foam takes a very long time to decompose in the environment

10.3. POLYVINYL CHLORIDE (PVC)



Polyvinyl chloride, (as per IUPAC called as Polychloroethene) commonly abbreviated **PVC**, is a widely used thermoplastic polymer. In terms of revenue generated, it is one of the most valuable products of the chemical industry. Polyvinyl chloride (PVC) is made by the low-pressure polymerization of vinyl chloride. PVC has side chains incorporating chlorine atoms, which form strong bonds

10.3.1. Characteristics of PVC

About 57% of its mass is chlorine, creating a given mass of PVC requiring less petroleum than many other polymers

- In 1926, Waldo Semon and the B.F. Goodrich Company developed a method to plasticize PVC by blending it with various additives which resulted into a more flexible and more easily-processed material that soon achieved widespread commercial use
- Plasticized PVC films are tough, clear, and glossy with excellent moisture resistance and low gas permeability, and they can be processed to give films with good shrink properties
- PVC is cheap, durable, and easy to assemble
- PVC in its normal form is stiff, strong, heat and weather resistant
- It is an extremely brittle film, which requires large amounts of plasticizers to soften the film (0 to 150%).
- PVC has a density of 1.35 – 1.4 gm/cm³.
- Chemically it is resistant to weak or strong acids & alkalis.

Packaging Of Dairy Products

- PVC has excellent oil and grease resistance.
- Heat sealing is good but gives off corrosive HCl vapours.
- PVC is unsuitable for sterilization. It decomposes at about 60°C

10.3.2. Health and safety

- Plasticizers used to make soft PVC for toys can leach out into the mouths of the children chewing on the toys. In 2006, the EU placed a ban on six types of phthalate softeners, including DEHP (diethylhexyl phthalate), used in toys. An alternative plasticizer, DINP (diisononyl phthalate) is also found to be risky
- PVC plastic has been used safely for more than 70 years in a variety of medical and commercial applications and humans. No reports of adverse human health effects have been reported from intravenous (IV) bags and medical tubing made with PVC
- **Vinyl chloride monomer:** The carcinogenicity of vinyl chloride monomer to humans who were exposed to very high VCM levels, routinely, for many years have been linked. Vinyl chloride is a known human carcinogen that causes a rare cancer of the liver
- **Dioxins:** The dioxin is produced as a byproduct of vinyl chloride manufacture and from incineration of waste PVC in domestic garbage
- Dioxins are a global health threat because they persist in the environment and can travel long distances
- At very low levels, dioxins have been linked to immune system suppression, reproductive disorders, a variety of cancers, and endometriosis

10.3.3. Recycling

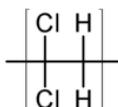
- Post-consumer PVC is not typically recycled due to the prohibitive cost of regrinding and recompounding the resin compared to the cost of virgin (unrecycled) resin
- The thermal depolymerization process can safely and efficiently convert PVC into fuel and minerals, according to the company that developed it. It is not yet in widespread use
- A new process of PVC Recycling is being developed in Europe and Japan called Texiloop®. This process consists of recovering PVC plastic from composite materials through dissolution and precipitation.

10.3.4. Uses of PVC

1. Despite the fact that PVC production negatively affects the natural environment and human health, it is still widely used
2. In recent years, PVC has been replacing traditional building materials such as wood, concrete and clay in many areas
3. The material is often used in Plastic Pressure Pipe Systems for pipelines in the water and sewer industries because of its inexpensive nature and flexibility
4. PVC is widely used to make clear plastic bottles and as an overwrap with EPS trays for meat and fresh produce

5. PVC can also be softened with chemical processing, and in this form it is now used for shrink-wrap, food packaging, and raingear
6. UPVC (Unplasticized PVC) can sometimes be used as bullet proof glass for a cars window as it is very hard and thick.
7. Food grade PVC can be used for packaging, butter, fish, poultry and bakery items.
8. PVC bottles are used for edible oils, wines, and non-carbonated beverages.
9. PVC jars are used for chocolate drink powders, instant coffee and pickles.

10.4. POLYVINYLIDENE CHLORIDE



Polyvinylidene chloride (PVDC) is made by copolymerizing the monomers vinylidene chloride and vinyl chloride.

- Ralph Wiley, a Dow Chemical lab worker, accidentally discovered polyvinylidene chloride in 1933. Dow researchers made this material into a greasy, dark green film, first called "Eonite" and then "Saran" (mainly made from PVC and PVDC)
- The most well known use of polyvinylidene chloride came in 1953, when Saran Wrap, a plastic food wrap was introduced
- Saran fiber is manufactured by melt spinning vinylidene chloride copolymer. Saran is pigment dyed before fiber spinning if color is desired

10.4.1. Characteristics of PVDC

- PVDC is a clear, heavy, very strong film with excellent cling properties and is commonly used for packaging cheese (as a layer in a multilayer film)
- It is a remarkable barrier against water, oxygen and aromas, has superior chemical resistance to alkalis and acids, is insoluble in oil and organic solvents, has very low moisture regain and is impervious to mold, bacteria, and insects. Saran fiber has a high elastic recovery and resists wrinkling and creasing
- It is heat-shrinkable and heat-sealable
- It is expensive to produce and hence it is commonly used in very thin gauges and laminated to other films for mechanical support and strength
- Because it is pigment dyed before fiber spinning, it has excellent color fastness and high light permeability
- Saran is also flame-retardant and self extinguishing, it may soften or char in flame, and decomposes in moderate heat

10.4.2. Uses of PVDC:

1. **Packaging:** Polyvinylidene chloride is applied as a water-barrier coating to other plastic films such as biaxially-oriented polypropylene (BOPP) and polyester

Packaging Of Dairy Products

(PET). This coating increases the barrier properties of the film, reducing the permeability of the film to oxygen and flavours and thus extending the shelf life of the food inside the package. So used when high barrier characteristics are required, e.g., gas packaging

2. **Household:** Cleaning cloths, filters, screens, tape, shower curtains, garden furniture
3. **Industry:** Screens, artificial turf, waste-water treatment materials, underground materials and industrial applications

10.4.3. Limitations of PVDC:

- While extremely useful as a food packaging material, the major disadvantage of Saran is that it will undergo thermally induced dehydrochlorination at temperatures very near to processing temperatures
- This degradation easily propagates, leaving polyene sequences long enough to absorb visible light, and change the color of the material from colorless to an undesirable transparent brown (unacceptable as food packaging)
- Therefore, there is a significant amount of product loss in the manufacturing process, which increases production and consumer costs

10.5. ETHYLENE VINYL ACETATE

Ethylene vinyl acetate (EVA) is comprised of low-density polyethylene copolymerized with vinyl acetate.

10.5.1 Characteristics of EVA

- EVA is a clear, tough film (especially at low storage temperatures), and it has moderate moisture and poor gas barrier properties.
- It is heat-sealable at low temperatures and is commonly used as a heat-sealant layer in many laminated structures.
- EVA is used as an overwrap for fresh meat and poultry and as a tie layer when two films of dissimilar properties are laminated together.

10.6 ETHYLENE VINYL ALCOHOL

Ethylene vinyl alcohol (EVOH) is a hydrolyzed copolymer of vinyl alcohol and ethylene.

10.6.1 Characteristics of EVOH

1. EVOH films are strong, have good clarity, are heat-sealable, and have excellent odor, gas, and moisture barrier characteristics.

2. The major disadvantage of EVOH films is that they are hydrophilic and hygroscopic.
3. When they absorb moisture at high relative humidity, the absorbed moisture acts as a plasticizer and the gas barrier properties of the film decrease. This can be overcome by
 - a. Increasing the ethylene content of the film,
 - b. Laminating it between two films that protect it against moisture, or
 - c. Adding a desiccant to the tie layer.
4. EVOH is commonly used in laminated structures where high gas and moisture barrier characteristics are desired, e.g., modified atmosphere packaging applications.



Lesson-11

Forms of different plastic materials - 3

11.1 INTRODUCTION

In this lesson the topics related to different plastic materials like PET, Polyurethane, Acrylonitrile Butadiene Styrene, Polycarbonate and Ionomers are discussed in detail.

11.2 POLYETHYLENE TEREPHTHALATE (PET)

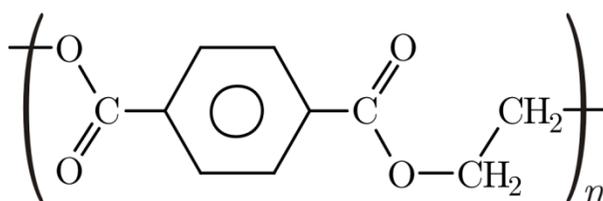


Fig. 11.1: Polyethylene terephthalate

- **Polyethylene terephthalate (PET, PETE** or the obsolete PETP or PET-P) is a thermoplastic polymer resin of the polyester family
- It is used in synthetic fibers; beverage, food and other liquid containers; thermoforming applications; and engineering resins often in combination with glass fiber. It is one of the most important raw materials used in man-made fibers. Depending on its processing and thermal history, it may exist both as an amorphous (transparent) and as a semi-crystalline (opaque and white) material
- Its monomer can be synthesized by the esterification reaction between terephthalic acid and ethylene glycol with water as a byproduct, or the transesterification reaction between ethylene glycol and dimethyl terephthalate with methanol as a byproduct. Polymerization is through a polycondensation reaction of the monomers
- The majority of the world's PET production is for synthetic fibers (>60%) with bottle production accounting for around 30% of global demand. In textile applications, PET is generally referred to as simply "polyester" while "PET" is used most often to refer to packaging applications

11.2.1 Processing:

There are two basic molding methods, one-step and two-step:

In two-step molding, two separate machines are used. The first machine injection molds the preform. The preform looks like a test tube. The bottle-cap threads are already molded into place, and the body of the tube is significantly thicker, as it will be inflated into its final shape in the second step using stretch-blow molding.

In the second process, the preforms are heated rapidly and then inflated against a two-part mold to form them into the final shape of the bottle. Preforms (uninflated bottles) are now also used as containers for candy.

In one-step machines, the entire process from raw material to finished container is conducted within one machine, making it especially suitable for molding non-standard shapes (custom molding), including jars, flat oval, flask shapes etc. Its greatest merit is the reduction in space, product handling and energy, and far higher visual quality than can be achieved by the two-step system.

11.2.2 Copolymers:

- In some cases, the modified properties of copolymer are more desirable for a particular application
- Such copolymers are advantageous for certain moulding applications, such as thermoforming, which is used to make tray or blister packaging from PETG film, or PETG sheet. For PET bottles, the use of small amounts of cyclohexane dimethanol (CHDM) or other comonomers can be useful: if only small amounts of comonomers are used, crystallization is slowed but not prevented entirely. As a result, bottles are obtainable via stretch blow molding ("SBM"), which are both clear and crystalline enough to be an adequate barrier to aromas and even gases, such as carbon dioxide in carbonated beverages

11.2.3 Degradation of PET:

- PET is subject to various types of degradations during processing.
- The main degradations that can occur are hydrolytic, thermal and probably most important thermal oxidation.
- When PET degrades, several things happen: discolouration, chain scissions resulting in reduced molecular weight, formation of acetaldehyde and cross-links ("gel" or "fish-eye" formation).

11.2.4 Characteristics of PET:

- PET can be semi-rigid to rigid, depending on its thickness.
- It makes a good gas and fair moisture barrier, as well as a good barrier to alcohol and solvents.
- It is strong and impact-resistant.
- It is naturally colorless with high transparency.
- When produced as a thin film (trade name Mylar), PET is often metalized with aluminum to reduce its permeability, and to make it reflective and opaque.
- PET bottles are excellent barrier materials and are widely used for soft drinks.
- PET or Dacron is also used as a thermal insulation layer.
- For certain specialty bottles, PET sandwiches an additional polyvinyl alcohol to further reduce its oxygen permeability.
- When filled with glass particles or fibers, it becomes significantly stiffer and more durable.
- While all thermoplastics are technically recyclable, PET bottle recycling is more practical than many other plastic applications. The primary reason is that plastic carbonated soft drink bottles and water bottles are almost exclusively PET which makes them more easily identifiable in a recycle stream
- PET is also an excellent candidate for thermal recycling (incineration) as it is composed of carbon, hydrogen and oxygen with only trace amounts of catalyst elements (no sulphur) and has the energy content of soft coal.
- PET can withstand temperature upto 150°C and hence it is heat sterilizable and used for boil-in-bags.

11.3 POLYURETHANE

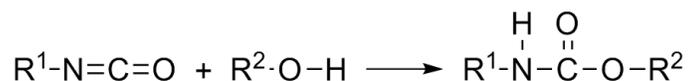


FIGURE 11.2: Generalized polyurethane reaction

Polyurethane, commonly abbreviated **PU**, is any polymer consisting of a chain of organic units joined by urethane links. Polyurethane polymers are formed by reacting a monomer containing at least two isocyanate functional groups with another monomer containing at least two alcohol groups in the presence of a catalyst

The physical and chemical character, structure, and molecular size of these compounds influence the polymerization reaction as well as ease of processing and final physical properties of the finished polyurethane

In addition, additive such as catalysts, surfactants, blowing agents, cross linkers, flame retardants, light stabilizers, and fillers are used to control and modify the reaction.

Polyurethane formulations cover an extremely wide range of stiffness, hardness, and densities. These materials include:

- Low density flexible foam used in upholstery and bedding
- Low density rigid foam used for thermal insulation and e.g. automobile dashboards
- Soft solid elastomers used for gel pads and print rollers, and
- Hard solid plastics used as electronic instrument bezels and structural parts

Commercial production of flexible polyurethane foam began in 1954, based on toluene diisocyanate (TDI) and polyester polyols. These foams were initially called *imitation swiss cheese* by the inventors

11.3.1 Health and safety aspects:

- Fully reacted polyurethane polymer is chemically inert.
- It is not regulated for carcinogenicity.
- Polyurethane polymer is a combustible solid and will ignite if exposed to an open flame for a sufficient period of time.
- Decomposition products include carbon monoxide, oxides of nitrogen, and hydrogen cyanide.
- Polyurethane polymer dust can cause mechanical irritation to the eyes and lungs.
- Liquid resin blends and isocyanates may contain hazardous or regulated components. Isocyanates are known skin and respiratory sensitizers.

11.3.2 Uses of PU:

Table 11.1 Characteristics and Uses of polyurethane materials

Density	Stiffness	Flexible	Semi-Rigid	Rigid
6 kg/m ³	Low Density Foams	High resiliency foam for bedding & upholstery	Packaging Foam	Insulation Foam
400 kg/m ³	High Density Foams	Footwear mid soles & Footwear cut soles	Integral skin foam for vehicle interior	Simulated wood
800 kg/m ³	Microcellular Foams & Elastomers	Fabric coatings and synthetic fibers, Vehicle external parts		Structural Foam
1200 kg/m ³	Solid Elastomers	Coatings, adhesives, sealants and elastomers		
		Print Rollers	Cast Elastomers	RIM Solid plastics

11.4 ACRYLONITRILE BUTADIENE STYRENE (ABS):

11.4.1 Characteristics of ABS:

1. **Acrylonitrile butadiene styrene, or ABS** (C₈H₈·C₄H₆·C₃H₃N)_n is a common thermoplastic
2. ABS is derived from acrylonitrile, butadiene, and styrene
3. Acrylonitrile is a synthetic monomer produced from propylene and ammonia; butadiene is a petroleum hydrocarbon obtained from butane and styrene monomers, derived from coal, are commercially obtained from benzene and ethylene from coal
4. ABS polymers are resistant to aqueous acids, alkalis, concentrated hydrochloric and phosphoric acids, alcohols and animal, vegetable and mineral oils, but they are swollen by glacial acetic acid, carbon tetrachloride and aromatic hydrocarbons and are attacked by concentrated sulfuric and nitric acids. They are soluble in esters, ketones and ethylene dichloride
5. The aging characteristics of the polymers are largely influenced by the polybutadiene content, and it is normal to include antioxidants in the composition
6. Though the cost of producing ABS is roughly twice the cost of producing polystyrene, ABS is considered superior for its hardness, gloss, toughness, and electrical insulation properties
7. ABS will be degraded (dissolve) when exposed to acetone
8. ABS is flammable when it is exposed to high temperatures, such as a wood fire. It will "boil", then burst spectacularly into intense, hot flames

11.4.2 Uses of ABS:

ABS can be used between -25 and 60 °C. It is used to make light, rigid, molded products such as piping, musical instruments, golf club heads (used for its good shock absorbance), automotive body parts, wheel covers, enclosures, protective head gear and toys.

It is used for manufacture of inside liner of refrigerators.

11.5 POLYCARBONATE

Polycarbonates are a particular group of thermoplastic polymers. They are easily worked, moulded, and thermoformed; as such, these plastics are very widely used in the modern chemical industry. Their interesting features (temperature resistance, impact resistance and optical properties) position them between commodity plastics and engineering plastics

11.5.1 Moulding / Extrusion techniques

- Injection moulding into ready articles: lighting lenses, sunglass/eyeglass lenses, safety glasses, automotive headlamp lenses, compact discs, DVDs, lab equipment, research animal enclosures, drinking bottles, iPod/Mp3 player cases
- Extrusion into tubes, rods and other profiles
- Extrusion into sheets (0.5-15 mm) and films (<1 mm), which can be used directly or manufactured into other shapes using thermoforming or secondary fabrication techniques, such as bending, drilling, routing, laser cutting etc

11.5.2 Characteristics of Polycarbonate:

1. **Polycarbonates** got their name because they are polymers having functional groups linked together by carbonate groups ($-O-(C=O)-O-$) in a long molecular chain
2. One type of polycarbonate plastic is made from bisphenol A. This polycarbonate is a very durable material, and can be laminated to make "bullet-resistant glass"
3. Although polycarbonate has high impact-resistance, it has low scratch-resistance and so a hard coating is applied to polycarbonate eyewear lenses
4. The characteristics of polycarbonate are quite like those of polymethyl methacrylate (*PMMA*; *acrylic*), but polycarbonate is stronger and more expensive. This polymer is highly transparent to visible light and has better light transmission characteristics than many kinds of glass

11.5.3 Uses of Polycarbonate:

1. Polycarbonate is becoming more common in housewares as well as laboratories and in industry, especially in applications where any of its main features—high impact resistance, temperature resistance, optical properties—are required
2. Polycarbonate may be appealing to manufacturers and purchasers of food storage containers due to its clarity and toughness, being described as lightweight and highly break resistant particularly when compared to silica glass
3. Polycarbonate may be seen in the form of single use and refillable plastic water bottles
4. Polycarbonate is now used in returnable milk bottles also.

11.5.4. Health effects

1. Bisphenol A appeared to be released from polycarbonate animal cages into water at room temperature and that it may have been responsible for enlargement of the reproductive organs of female mice
2. There is "some concern that exposure to the chemical bisphenol A in utero causes neural and behavioral effects."

Using sodium hypochlorite bleach and other alkali cleaners to clean polycarbonate is not recommended, as they catalyze the release of the bisphenol-A, a known endocrine disrupter

11.6 IONOMER

Polymer compound derived from monomeric units where in metal ions is one of the prosthetic group in ethylene. Thus, Ionomers are copolymers of methacrylic acid and ethylene and have some of the hydrogen atoms of the carboxyl groups replaced by either zinc or sodium atoms. Commercially it is known as **surlyn**.

11.6.1 Characteristics of Ionomers:

1. Ionomers have exceptional toughness and clarity and heat-seal characteristics.
2. They are commonly used to give a strong seal in laminated films used for packaging products with a high fat content, e.g., meat products.
3. They are also used in skin packaging applications where clarity and toughness are required in the package. Ionomers also form strong bonds with aluminum foil and are acid resistant.

Lesson-12

Newer forms with combination of two or more ingredients

12.1 INTRODUCTION

This lesson deals with topics related to newer forms of plastic materials involving multi-ingredients like coated films, copolymers, laminates, common and special purpose plastics, and current trend in use of plastic as packaging material.

12.2 COATED FILMS

Individual films are often coated with other polymers and/or aluminum foil to improve the barrier properties or to impart heat-sealability as follows:

12.2.1 Characteristics:

1. **Nitrocellulose** is coated on one side with cellulose film to provide a moisture barrier property while retaining oxygen permeability.
2. A nitrocellulose coating on both sides of the film improves the barrier to oxygen, moisture, and odors and enables the film to be heat-sealed when broad seals are used.
3. **Polyvinylidene chloride** coating is applied to cellulose, using either an aqueous dispersion (MXXT/A Cellulose) or an organic solvent (MXXT/S Cellulose). In each case, the film becomes heat-sealable, and the barrier properties are improved.
4. A coating of **Vinyl chloride** or **Vinyl acetate** gives a stiffer film that has intermediate permeability. Sleeves of this material are tough, stretchable and permeable to air and moisture.
5. A thin coating of **Aluminum (termed Metallization)** produces a very good barrier to oils, gases, moisture, odors, and light. Metallized film is less expensive and more flexible than foil laminates that have similar barrier properties, and it is therefore suitable for high-speed filling on form-fill-seal equipment. Cellulose, polypropylene or polyester is metallized by depositing vaporized aluminum onto the surface of the film under vacuum. Metallized layer is basically made up of an initial layer of spherical metallic particles which become embedded in the plastic material. Subsequent layers are then built-up of metal particles. Metallized polyester has higher barrier properties than metallized polypropylene, but polypropylene is finding more widespread use as it is currently less expensive.

Packaging Of Dairy Products

6. Metallized polyester laminates saves 15-20% in material costs besides saving an extra laminating process as compared with other laminated packaging material.
7. Metallized polyester film is used for packaging WMP, Pan masala, nut powder, fruit drinks, coffee etc.

12.2.2 Coated Cellophane Films:

About 80% of the total film manufactured is coated because plain cellophane is hygroscopic, not moisture proof and not heat sealable.

Nomenclature:

P = Plain uncoated film

T = Transparent

C = Coloured

M = Moisture proof

A = Anchored (Coated more firmly secured to the base film) hence more resistance to water under wet and humid conditions.

D = Darning (one side coated)

L = Low moisture vapour proof ness

X = Saran coated

Q = Opaque

S = heat sealable

Tw = twist wrap (toffees)

H = Resistant to blocking at high humidity.

(a) PT Film: Plain transparent film: It is flexible, strong, transparent and grease proof and can be handled on automatic machinery and can be printed

easily. (It is a barrier against non-boring insects). But PT film is hygroscopic and permeable to water vapour but, impermeable to dry gasses except water soluble gases like CO₂. It is used as a hygienic wrapping for goods where some interchange of moisture with the surroundings may be permissible or even desired. Used for wrapping bread, soaps, paper plates & cups.

- (b) **MST:** Moisture proof & heat sealable. It is used where moisture proofness and heat sealability are required. It is used as direct wrap for bread, cakes, over wrap for cigarettes, cartons of tea bags and cartons of biscuits.
- (c) **MSAT:** Anchored grade of MST film used extensively for food packaging particularly hygroscopic frozen food.
- (d) **MSC:** Moisture proof, heat sealable and coloured. It is decorative in nature. Amber, yellow or orange film is used to absorb UV rays which cause rancidity in foods products that have a high fat content.
- (e) **LSAT:** Low moisture, heat sealable. This film is used for packing food products that are sensitive to deterioration by excess moisture inside the package. It is used to pack certain bacons, crushed backed goods.
- (f) **MSADT:** This film has a sealable moisture proof coating on one side only. The importance of this film is due to its high OTR. Since it can readily transmit oxygen under moist and humid condition it is suited as direct wrap for fresh meat, with the uncoated side inside the package. The constant supply of fresh oxygen maintains the blood pigment of meat and at the same time moisture proof coating prevents desiccation of meat.
- (g) **MASXT:** It resists puncturing by hard sharp foods stuffs and offers very good performance at low temperatures and hence also known as winter film. It is used for nuts, hard candies, biscuits and small hardware.
- (h) **MXXT:** Moisture proof, coated with saran both the sides. It is highly moisture proof even after creasing and printing and has a good resistance to fats, greases and oils. (The film is more dimensionally stable; i.e resists

Packaging Of Dairy Products

wrinkling and shrinkage caused by changing humidity conditions.) It is used for packing desiccated coconut, potato chips, dried foods, biscuits and some type of cheese.

(i) MSAQ: opaque grade used for light sensitive foods like cheese, butter etc.

(j) MTTW: A non heat sealable Nitrocellulose coated type of cellophane used for twist packaging of sweets.

12.3 CO-POLYMER

At the time of polymerization we can polymerize more than one monomer to form polymers. The resultant polymer is called co-polymer. It has modified/superior properties those are not available in homopolymers.

Advantages of co-polymers:

1. No problems of exudation, migration and leaking associated with plasticizers.
2. Controlling co-polymerization and selecting right type basic monomer combination can produce tailor made Plastic materials.

12.3.1 Other Additives

Many plastics contain very small amounts of additives such as plasticizers, antioxidants, lubricants, antistatic agents, heat stabilizers, and UV stabilizers. These are added to facilitate processing of plastics or to impart some desirable properties to the plastics. For example, plasticizers are added to soften plastics, thus making them more flexible and less brittle for use in cold climates or with frozen stored products.

12.4 LAMINATED FILMS:

“Laminates are the combination of two or more layers of packaging films.” They are used when required properties are not achieved in single packaging material.

Laminates are used for:

1. Good water vapour barrier properties
2. Good gas barrier properties
3. Good grease resistance
4. Heat sealing facility
5. To provide strength to the base film
6. To improve toughness
7. To improve tear resistance
8. To improve abrasion resistance
9. To improve machinability
10. To improve printability

Lamination of two or more films improves the appearance, barrier properties, or mechanical strength of a package. Materials that can be laminated to each other include

- Plastic to plastic,
- Paper to plastic,
- Paper to aluminum foil, and
- Paper to aluminum foil and then to plastic.

Several methods can be used to laminate materials.

(A) Adhesive Lamination: The webs are bonded by means of a suitable adhesive which may be (i) Aqueous, (ii) Lacquer or (iii) Hot melt. The adhesive is applied to the web which is subsequently brought in to contact with another by passing through two rollers.

- *Aqueous adhesives:* Dextrin, Starch, Casein, Sodium silicate
- *Lacquers:* Polymethanes, urea formaldehyde, nylons, vinyls.
- *Hot melts:* Wax and wax blends.

(B) Extrusion Lamination: A thermoplastic web is directly extruded on to a suitable substrate web. Extrusion coating could also be achieved. It is a cheap process. A thermal extrusion or co-extrusion can be used.

(C) Direct Heat Lamination: A thermoplastic web maybe bonded to a second one by heat and pressure without the use of an adhesive.

12.4.1 Characteristics of Laminated films:

1. Laminated materials are used when high gas and moisture characteristics are required for a long shelf life.
2. Laminated structures usually consist of an outer protective tougher layer, e.g., nylon or polypropylene, a middle high gas barrier layer, e.g., EVOH or PVDC, and an inner heat sealant layer.
3. LDPE is commonly used as a heat-sealant layer because of its low melting temperature; however, it sometimes does not give a good seal with starchy or greasy food products.
4. The choice of sealant layer for these food products is either EVA or Surlyn.

12.4.2 Laminated packaging material:

A laminated packaging material suitable for use in flexible containers for potato chips, corn chips, and the like, have an excellent moisture resistance and sealing properties.

It can comprise:

1. As an outer surface: a transparent sheet of nylon, polyester, cellophane, or polypropylene,
2. A coextruded laminate: A pigmented polyethylene and ethylene acrylic acid copolymer,
3. A metallic foil: Preferably aluminum, and
4. An inner surface: A heat-sealable polyolefin.

12.5 ALUMINUM FOILS:



12.5.1 Advantages and disadvantages of aluminum foils:

Advantages: It is a good barrier, grease proof, non sorptive, shrink proof, neither brittle nor soften at low temperature, odourless, tasteless, hygienic, non-toxic, sterile, corrosion resistant, head reflects, opaque to light, dead folding and light appearance.

Disadvantages: Low tear strength, corroded by strong acids and alkalies, heat sealing is not possible.

Foil thicknesses used:

Use	Thickness
Confectionary wrapping	0.009 - 0.012 mm
Cheese wrapping	0.012 - 0.015 mm
Strip packaging, milk bottle caps	0.018 - 0.038 mm
Semi - rigid containers	0.03 - 0.15 mm
Fat Products	0.009 mm
Household Foil	0.0018 mm
Plated food stuff & pie dish containers	0.03 - 0.12 mm

12.6 CURRENT TRENDS IN USE OF PACKAGING MATERIALS:

Presentation (graphics and material), cost, consumer friendliness (easy to open and use) and effect on environment are the four most important issues in packaging industry today. They are fulfilled by the following newer materials:

1. To cut down the **cost**, the preformed containers are used for the dairy products such as cream and yogurt, curd, shrikhand etc.
2. Lid machines are being replaced by form-fill-seal machines to produce and fill the polystyrene (or polypropylene) containers.
3. Considerable improvement has been achieved in the **lid materials**:
 - i) The paper/polyester heat seal lidding and more recently metalized polyester peelable film laminate gives an even peel without tearing when lid is removed from a container.
 - ii) Proprietary structures such as MARDOCOTE (Saran: polyvinylidene chloride) are encroaching on PVDC because of better sealing properties and improved shelf life at lower cost in cheese packaging.
4. There is also a switch from the thermo formed (Multivac) packaging using nylon / polyester laminate to flow pack type of systems incorporating polypropylene or polyester barriers often incorporating gas flushing in cheese packaging.

Packaging Of Dairy Products

5. High barrier structures/laminate based on polyester / EVOH / polythene and polypropylene / EVOH polythene are being developed for products like yoghurts and milk based desserts.
6. EVOH (Ethylene Vinyl Alcohol) has excellent **gas barrier** properties in dry conditions, and such materials would be particularly suitable for aseptic packaging.
7. EVOH is also more **environment-friendly** than saran, the alternate high barrier material.
8. PVDC however continues to dominate in foods that come in **retorted** pouches. A typical laminate structure for such use might consist of polyester / polypropylene / PVDC / polypropylene.
9. The developments in **laminate** (paper/polyethylene/aluminium/polyethylene) used for milk have been restricted to improvement in print quality, better glass lacquers, more rapid sealing characteristics, using different and thinner polymer films reduce costs mainly by down gauging.
10. Until now, **permeability** in plastic food packaging was provided only by polyvinylidene chlorides (PVDC) and ethylene vinyl alcohol (EVOH) co-polymers. Recently, a third, complementary polymer, metaxylenediamine and adipic acid poly condensate (NMXD₆) is under development and is likely to provide more flexibility.
11. Similarly, HNR (High Nitrile Resins) also known as nitrile group produced by co-polymerization of acrylonitrile and methyl acrylate in 75:25 ratio, and amorphous nylon Selar PA are other **barrier materials** that can be used monolithically because their barrier properties are not adversely affected by moisture. In fact, the oxygen barrier of Selar PA increases with an increase in moisture (humidity). Both resins also offer clarity and rigidity providing for good **aesthetic** and **structural** properties.

12. Depending on ethylene content and humidity, EVOH can potentially give the best **cost / performance**, followed closely by PVDC and NMXD₆.
13. EVOH and NMXD₆ are very **sensitive to moisture** and therefore, must be used in a multi layer system of blends, as a sandwiched layer.
14. PVDC is not moisture sensitive but is difficult to process and scrap reuse is still an issue. PVDC is, therefore, predominantly used as a **thin layer** in laminations and coating.

12.7 COMMON PLASTICS AND THEIR USES

Table 12.1: Common plastics and their uses

No.	Plastic	Use
1	Polypropylene (PP)	Food containers such as tubs, cups, trays
2	Polystyrene (PS)	Packaging foam, food containers for ice-cream, disposable cups, plates, Cutlery, CD and cassette boxes
3	High impact polystyrene (HIPS)	Fridge liners, food packaging (ice-cream, yoghurt, curd, buttermilk, lassi), vending cups
4	Acrylonitrile butadiene styrene (ABS)	Electronic equipment cases (e.g., computer monitors, printers, keyboards)
5	Polyethylene terephthalate (PET)	Carbonated drinks bottles, jars, plastic film, microwavable packaging, drinking water bottles
6	Polyester (PES)	Fibers, textiles, applied as one of the layers in cheddar cheese and bigger blocks of cheese for providing strength
7	Polyamides (PA) (Nylons)	Nylon-6 is used in roast-in bag and frozen foods. Nylon laminates are used in vacuum packaging
8	Polyvinyl chloride (PVC)	Plumbing pipes and guttering, shower curtains, window frames, flooring
9	Polyurethanes (PU)	Cushioning foams, thermal insulation foams, surface coatings, printing rollers. Shoe soles
10	Polycarbonate (PC)	polycarbonate bottles are used for milk and fruit juices

Packaging Of Dairy Products

11	Polyvinylidene chloride (PVDC) (Saran)	Laminates of Food packaging viz. retortable pouches
12	Polyethylene (PE)	Wide range of inexpensive uses including supermarket bags, plastic bottles, milk pouch film and as heat sealing layer in laminates/coated films
13	Polytetrafluoroethylene (PTFE) (trade name Teflon)	Heat-resistant, low-friction coatings, used in things like non-stick surfaces for frying pans, plumber's tape and water slides, Heat sealing per covering.

Table 12.2: Desirable attributes of commonly used flexible materials

No.	Flexible substrate	Primary function	Other characteristics
1	Paper	Stiffness, Printability	Low cost, rigidity, strength, machine performance. Deficient in: clarity, sealability and barrier properties (Parchment, Glassine)
2	Foil	Barrier properties, Strength, Aesthetic appeal	Lacks clarity, poor printability, Difficulty to seal
3	Cellophane	Clarity, printability, stiffness, machinability	Susceptible to moisture, poor tear strength, not heat sealable.
4	LDPE	Low cost, heat sealability, Excellent compatibility with a wide range of substrates	Some barrier properties, Versatility
5	HDPE	Stiffness, low WVTR (>LDPE)	Heat sealability < LDPE.
6	EVA	Strength and heat sealability	
7	PP	Clarity cello strength, stiff, moisture barrier	Non oriented easily, heat sealed, PPTQ (PP tubular quenched): Clarity and

		economy BOPP (Bi-axially oriented PP): -Do-Barrier properties.
8	Polyester	Impact strength, Barrier properties, High and low temp. performance
9	PVC	Economy, versatility, grease resistance, heat sealability.
10	Nylon	Strength, toughness, grease/oil resistance, formability
11	Rubber HC	Grease resistance, Heat sealability
	Coating material	Primary function
1	Paraffin waxes	Low temp, sealability, economy
2	PVDC (Saran)	Grease Resistance, Barrier properties
3	Ionomer	Heat sealability and grease resistance
4	Lacquer	Gloss.

Table 12.3: Compatibility of various Packaging Materials to work as a layer in Laminates

	LDPE	HDPE	PP	EVA	Nylon	PVDC	Ionomer
LDPE	Good	Good	Fair	Good	Poor	Poor	Good
HDPE	Good	Good	Fair	Good	Poor	Poor	Good
PP	Fair	Fair	Good	Good	Poor	Poor	Fair
EVA	Good	Good	Good	Good	Poor	Good	--
Nylon	Poor	Poor	Poor	Poor	Good	Poor	Good
PVDC	Poor	Poor	Poor	Good	Poor	Good	Poor
Ionomer	Good	Good	Fair	--	Good	Poor	Good

Lesson-13

Foils and Laminates – Characteristics and Importance in Food Industry

13.1 INTRODUCTION

This lesson covers topics related to foils and laminates, composite cans and barrier properties of different packaging materials in detail.

13.2 ALUMINUM FOIL

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

13.2.1 The advantages of foil as a packaging material are:

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

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

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

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

13.3 COMPOSITE CONTAINERS

- Recently due to development of laminates with metalized films which are having similar properties of a metal container with less cost, the use of metal containers is decreasing.
- Therefore, cans made from a combination of paperboard, foil, and plastic are now used in place of metal cans.
- Kraft paper is the main component in the can body. The inside of the can is plastic (low-density polyethylene, polypropylene, or ionomer) often backed by foil for added barrier properties. End closures can be made of metal, plastic, paper, or a combination of these materials.
- Composite cans are manufactured by a spin convolute wound method, with spiral cans dominating the market due to their superior barrier characteristics.
- Composite cans are widely used to package shortening, powdered and dehydrated baby foods, aseptically packaged single-strength fruit juices, and frozen dough.

13.4 BARRIER PROPERTIES OF PACKAGING MATERIALS

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

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

One of the most important characteristics is the barrier properties to both oxygen and moisture vapor, which varies greatly from material to material. Because tin plate and glass are excellent gas barriers, examples of the barrier properties of various flexible films only are shown in Table 13.1 and Table 13.2 respectively. Examples of laminated structures and their barrier properties are shown in Table 13.3.

- High-barrier materials usually provide high barriers to both moisture and oxygen, e.g., glass, tin plate, and aluminum foil.

Packaging Of Dairy Products

- However, the barrier properties to oxygen and moisture may be different and may also vary as a function of the relative humidity and temperature of the storage conditions. E.g. EVOH, a hygroscopic film that is an excellent oxygen barrier at low relative humidity. At higher relative humidity, it absorbs moisture that has a plasticizing effect and reduces the barrier characteristics to oxygen.
- Some films have mixed barrier properties, i.e., low oxygen barrier characteristics and high-moisture vapor barriers. E.g. LDPE, which explains why this film is selected for packaging fresh meat and produce and for frozen stored products to prevent freezer burn.

	Table 13.1		Table 13.2		Table 13.3
No.	Oxygen Transmission Rate (OTR) of Selected Packaging Materials		Moisture Vapor Transmission Rate (MVTR) of Selected Packaging Materials		Laminated Packaging Materials
	Materials	CC/m²/d^a	Materials	CC/mil/m²/d^b	
1	High Barrier Materials				High Barrier (Flexible)
	Glass	0	Glass	0	Nylon/Saran/EVA
	Aluminum	0.1	Aluminum	0	Nylon/Saran/Surlyn
	EVOH (0% RH)	0.2	HDPE	3.8	Nylon/EVOH/Surlyn
	PVDC	2.5	PVDC	4.0	PET/Saran/EVA
			PP	6-10	PET/Saran/Surlyn
			LDPE	18-23	Nylon/Saran/LDPE
			Oriented PET	19	PET/Foil/LDPE
2	Medium Barrier Materials				High Barrier (Semi rigid)
	Oriented nylon	28	EVOH	22-59	PVC/EVOH/EVA coextrusion
	Oriented PET	36	Surlyn	27	PVC/EVOH/Surlyn coextrusion
	Nonoriented nylon	78	Rigid PVC	39-48	Medium Barrier (Flexible)
	Nonoriented PET	109	Nonoriented PET	46	Nylon/EVA
	Rigid PVC	150-205			Nylon/Surlyn
	EVOH (100%	160-280			Polyester/EVA

	RH)				
					Polyester/Surlyn
3	Low Barrier Materials				Low Barrier (Flexible)
	Polystyrene	1500	Polystyrene	78-132	OPP/EVA
	HDPE	1705	Oriented nylon	1523	OPP/Surlyn
	PP	2320	Polycarbonate	217	PP/EVA
	Polycarbonate	3500	Nonoriented nylon	340	PP/Surlyn
	Surlyn	5500			
	LDPE	7500			

^a Measured @23°C and 0% RH.; ^b Measured @37.8 °C and 100% RH.

1 mil = 25 μ = 0.001 in

Table 13.4: Multilayer films used for dairy products packaging

No.	Product	Structure	Characteristics
1	Milk	LDPE/LDPE	Sealability, moisture barrier, 2 colour (light barrier)
		LD/LLDPE	
		Paper or paperboard/ EVA/LDPE/EVA/Al-foil/ LDPE	Aseptic packaging, moisture barrier, sealability, release
2	Cheese	PP/EVA/LDPE	Moisture barrier sealability, release
		PA/Tie/LDPE/Ionomer	Gas and moisture barrier, sealable.
3	Processed cheese	PP/Tie/LDPE	Moisture barrier, sealability
		PP/PP (copolymer)	-do-
		BOPP/Adhesive/Met. PET/Adhesion/LDPE	High gas, moisture barrier, sealable.
		PS/Tie/EVOH/Tie/LDPE	Good gas, H ₂ O, barrier. Thermoformable.
4	Baby Food	PP/Tie/LDPE or Ionomer	Moisture barrier sealability

Packaging Of Dairy Products

		PP/Tie/EVOH/Tie/PP PET/Met PET/PE	Gas and moisture barrier, sealability
5	Yoghurt	HIPS/HIPS, PP	Thermoformable
		HIPS/GPPS	2 colour, gloss, strength, Rigidity
6	Cream	PP/PP	Thermoformable, moisture barrier, strength, Rigidity
7	Butter	PA/TIE/LLDPE or LDPE/PA/TLE/Ionomer or EVA	Good gas, moisture barrier, sealability
		LDPE/TIE/EVOH/ TIE/LDPE(Surlyn) PS/TIE/EVOH/TIE/LDPE(Surlyn)	Thermoformable, good gas and moisture and odour barrier.



Lesson-14

Characteristics of Retort Pouches

14.1 INTRODUCTION

Retort is a cooking process that uses heat and pressure to cook food in its sealed package. Retort Pouches conditions are quite demanding with temperatures typically ranging from 120°C to 130°C.

14.2 RETORT POUCH PROCESSING OF FOODS

- Retort processing of foods in rigid, semi-rigid and flexible packaging systems is the most acceptable form of food preservation.
- It represents unique combination of package, process and product technology with potential economic benefits.
- Traditionally, tin containers have contributed to a large extent in building the confidence in processed foods.
- The increasing public awareness and aversion to accept other methods of food preservation like chemical preservation, irradiation, etc. have offered a vast scope for retort processing of foods.
- Different retort grade films are **laminated** together to provide the strength, toughness, puncture and burst resistance that enable flexible retort pouches to withstand the strenuous retort process.
- A number of different virgin, multilayer and co-extruded packaging materials such as polypropylene, nylon (pp/nylon/pp), polyester cast propylene (pet/c.pp) and polyester aluminum foil cast polypropylene (PET/A foil/C.PP) have been evaluated and are in use for their mechanical strength to withstand retort conditions at temperature up to 135 °C, optimum oxygen barrier properties, compatibility with the food products and required shelf-life of 12 months under ambient conditions.
- Retort pouches and packaging are available in two variants one is aluminum foil laminated and another transparent see through **retort pouches**.
- When the retortable pouch is heated in a microwave oven, the laminated cover film having the aluminum foil is removed from the laminated base film, whereby microwaves generated by a magnetron are not intercepted, and cooked food packaged in the retortable pouch can be heated adequately.

14.2.1 Characteristics of Retort Pouches:

- Because Retort pouches have thinner dimensions, it takes less time to cook food in a flexible retort pouch than in other forms of rigid packaging such as cans and jars. This reduced retort time results in foods that have superior taste in retort pouches.
- Retort Pouch packaging has superior barrier and printing qualities and can be supplied as stand-up, flat or in roll form.
- Retort pouches are suitable to pack a variety of food products.
- The laminated material has a high puncture resistance.
- It offers a variety of styles of retort packaging such as foil based or completely transparent.
- Flexible retort pouches offer a variety of additional benefits over rigid packaging to both retailers and consumers that include:
 1. Superior taste due to reduced retort time
 2. Extended shelf life in **retort pouches**
 3. Reduced storage space, both in warehouse and pantries
 4. Reduced transportation costs
 5. Easier and safer tear-open/disposal consumer experience
 6. Microwave convenience

14.2.2 Common Structures used for retort processing:

1. Retortable pouch and packaging material for the retortable pouch comprises

- A laminated base film formed by laminating together a polyester film and an inelastic polypropylene film,
- A laminated cover film formed by laminating together a polyester film and an aluminum foil, and
- An adhesive layer detachably bonding the polyester film of the laminated base film to the aluminum foil of the laminated cover film, thereby laminately bonding the laminated cover film to the laminated base film.

2. Common flexible retort pouch structures include the following:

- PET / NYLON / LLDPE,
- PET / NYLON / CPP,
- PET / FOIL / Nylon / CPP,
- PET / Nylon / FOIL / CPP,
- PET-SiOX or
- AIOX / Nylon / CPP

3. **PET / NY / AL / Retortable CPP:** High Retort (Under 125 °C), High Barrier (OTR, MVTR) Non-Microwaveable.

- High temperature sterilization, Excellent sealing capability, Excellent up to 8 colors gravure printing, Lower OTR, WTR and Longer shelf life, Optional laminated layers for better barriers against moisture, humidity, puncturing are the major characteristics.

4. **Alox-PET / NY / Retortable CPP:** High Retort (Under 125 °C), High Barrier (OTR, MVTR) Microwaveable.

- Microwavable pouch is advanced version of regular retort pouch.
- It is very convenient to use and microwavable pouch started to replace retort pouch lately.
- Microwavable pouch does not contain aluminum and barrier comes from special polyester film.
- It can be used in seafood, stew, meat, curry, rice, and other processed foods.
- Normally, microwavable pouch is standup pouch because end user wants to put pouch in to the microwave and eat right out of the pouch.

14.3 RETORTABLE POUCHES



- A typical laminate for retortable pouch is 0.0005 polyester / 0.00035 foil / 0.003 polypropylene, with the outer ply designated first as is customary for pouch material.
- Filled pouches are sterilized at 115-121° C, with overriding air pressure of ~ 2 kg/cm² to prevent bursting.
- Pouch material that will not delaminate at these temperatures must be selected, and the seals should withstand a tensile test of 0.08 kg/m of width, internal pressure of 1 kg/cm² for 30 s, pinhole strength of 0.6 kg and a drop test of 1.22 m.

Lesson-15

Forms of packages used for packaging of food and dairy products

15.1 INTRODUCTION

In this lesson the topics related to different forms of package like foils, containers, jars, blister packs, pouches etc are discussed in detail.

15.2 DEVELOPMENTS IN PACKAGE FORMS:

1. In Paleolithic times, food was consumed where found and when needed, man used natural containers such as hollow tree trunks, gourds, hollow rocks, shells, leaves and pieces of bark.
2. In later times man learned to fashion containers from natural materials. He deliberately hollowed out logs of stones, and animal parts used such as bladders, skins, horns, bones, sinews and hair.
3. Mesolithic man stored food surpluses in baskets made of rushes and grasses.
4. Neolithic man fashioned metal containers and discovered pottery.
5. From prehistoric times until about 1200 AD the status of packaging could be summed up as follows:

Material	Package Forms & Uses
Leather	Wrappings, bags, bottles
Cloth	Wrapping sacks
Wood	Barrels, boxes, kegs, chests
Grass or split wood	Baskets, matting
Stone	Small pots or jars
Earthenware	Pots, jars, urns, ewers, bowls, etc
Metal	Pots, bowls, cups, etc
Glass	Jars, bottles, cups, bowls etc

6. The barrel, wooden box, ceramic jar or pot, leather bag and cloth sack are as old as civilization.

15.2.1. Common Package Forms:

- (A) **Rigid Packages:** They are formed in to a definite shape from a sufficiently strong materials, so that they retain their shape when filled with product and are not deformed unless subjected to sufficient force to destroy or severely damage the total structure. Eg. Metal, glass bottles, plastic cans etc.
- (B) **Semi-rigid Packages:** They are formed in to a definite shape from less massive or weaker materials, so that although they are not intended to be distorted substantially when filled with product, but they can be distorted without severely damaging the total structure by the application of a moderate force. Eg. Collapsible tubes, Bag-in-box system.
- (C) **Flexible Packages:** They are formed to a definite shape when empty but are made from sufficiently flexible materials that they generally confirm their shape to the product they contain and may be distorted or crushed with ease unless supported by the rigidity of the product. Eg. Flexible pouches & bags.

Some of the important package forms are discussed here.

15.3 METAL BOXES/CANS/TINS:



With the invention of tinplate, the fabrication of soldered metal boxes was made possible. Boxes can be designed with embossed lettering or patterns, or printed paper labels can be applied. Also metal itself can be printed.

15.3.1 Metal cans:



1. Traditionally, cans have been made from soldered triplet steel. More recently aluminum can has been introduced. Today there are several more choices available: standard tinfoil, light weight double reduced tinfoil, tin free steel (coated), vacuum - deposited aluminum on steel and aluminum.
2. Can bodies can be soldered, welded or cemented. Steel bodies can be combined with aluminum ends. Many new easy open devices are available for cans ranging from pop-tabs for beverages to complete removal of lids or panels for frozen or meat products.
3. Can coatings are now regarded as vital components - especially for foods and beverages. Coatings must be non-toxic and free from odour or taste. They must not deteriorate or come loose from the can wall during food processing and storage. Interior coatings are made from acrylics, alkyds, butadienes, epoxy amines, epoxy - esters, epoxy - phenolics, oleoresins, phenolics and vinyls depending upon the type of food and process. Outside coatings include acrylics, alkyds, oleoresins, phenolics and vinyls and are usually pigmented. They are less exposed to food contact but must survive processing and be receptive to further decorative coatings and inks.
4. The tinfoil is made of thin sheets (0.025mm thick) of mild steel coated on both sides with a layer of pure tin. The steel sheet is made by
 1. (a) Hot Rolling - hot dipping in bath of molten tin.
 2. (b) Cold Rolling or Electro tinning i.e. by electro decomposition from solution of tin salts - this process enables application of much smaller thickness of tin coatings.
5. For packaging certain dairy products, it is desired to use an externally and internally lacquered can. Lacquer offers protection against corrosive attack by acids, discolouration etc. Protection offered by lacquer is not always complete, but pinhole leaks may give pitting corrosion. Production of hydrogen causes swelling of lacquer and ultimately perforation of the can. This increases the amount of lead and iron dissolved in canned foods. Lacquer reduces attack on tin and hence it will no longer act as sacrificial anode, hence amount of dissolved lead in food increases. In non - lacquered cans, iron is attacked only after extensive de-tinning. Once the can is opened, uptake of lead increases due to ingress of O₂. It is more marked in case of unlacquered cans.
6. The lacquered cans are made by passing the sheets of tinfoil through rollers running in a bath of lacquer (a protective coating consisting of synthetic or natural resin and for cellulose acetate dissolved in a volatile solvent), which

apply a thin coating to the sheet. The coated sheet is passed through a heated oven, which causes the lacquer to dry and harden. Such lacquered sheets can then be made into cans exactly as plain sheets.

Types of metal cans used for Dairy Products are:

A	Open Top	D	Valve - Open top
B	Vent hole	E	Sanitary
C	Drawn		

15.3.2 Tin packaging:

1. It is one of the earliest food packages and tin can heralded the year-round supply of conveniently packaged food even before the science of food preservation was understood.
2. As for the developments in the tin can, the stringent requirements of zero lead contamination of canned foods have led to complete replacement of soldered can by the welded one.
3. Continuous efforts are on to improve and develop better can lacquers like polyester lacquer, and to reduce tin coating weights.
4. Tin - free steel (TFS) can, an economic alternative to the open top sanitary (OTS) can is also being used extensively.
5. With respect to developments in India, soldered can is being replaced gradually. A significant development is the partial replacement of imported tin plate with the indigenous one.
6. For carbonated beverages, aluminum can have been dominating, because very thin walls can be used taking advantage of the internal pressure of the beverage to obtain structural rigidity and strength.
7. With aluminum becoming costlier now, the recapture of a sizable market of the carbonated beverages by the 2 - piece steel can seems imminent. This is further strengthened by the newer research development which has made it possible to produce steel cans of extremely thin walls.
8. In spite of India being a major aluminum producer, the aluminum can has not yet come to be used widely, the reason being prohibitive cost. Hence it is used for special applications such as gift boxes and export purposes.
9. Tinsplate containers with ring open lids with or without re-closure facilities are used for larger quantities say 500 gm and more.
10. Fancy containers having different shapes are used with friction lids and generally intended for after use applications. Alternatives to these types of traditional metal containers include composite cans, Tin Free Steel (TFS) cans and Plastic Containers.

15.3.3 Metal tubes:



1. Collapsible tubes were first made from soft metal for artist's paints and replaced animal bladders.
2. They found early use in dispensing glues, medicinal salves and tooth pastes, but little use was made of them for food products until the past decade.
3. Plastic collapsible tubes (MLCT) have come on the market containing sandwich pastes, cake icings, pudding toppings etc..
4. The first closure of collapsible tubes was by a metal screw with double head.
5. The moulded screw cap was a later innovation.

15.4 ALUMINUM CONTAINERS:

1. They provide extreme convenience in preparation and serving of foods.
2. They withstand extremes of temperatures.
3. Foods may be frozen in the package or cooked in it.
4. Aluminum protects the food against moisture, gases and light.
5. General categories are compartmented, folded end, ovals, pie plates, rectangulars, rounds, squares, and specialty items.
6. Newer techniques of forming are now producing smooth flanges and smooth side walls. With smooth flanges flat-web materials can be hermetically sealed on as closures.
7. Coloured containers can be decorated attractively to permit the container to be placed on the table as a server. Soft butter and margarine product are now found in such packages.

15.4.1 Uses of Al – containers:



1. Aluminum can was first used in Scandinavia and Switzerland for filling fresh milk, meat and vegetables.
2. It is used as cans and wrappers (foil) for dairy products, chocolates etc.
3. It is also used as component of laminates.
4. It is used as tubes and pre-formed containers for cooking.
5. It is used in Food Processing plants and machines.
6. It has excellent resistance to wide range of corrosive agents like
 - o Oxalates are more corrosive than hydroxyl acids such as tartaric, malic and citric.
 - o Chlorides are strong corrosive for pitting
 - o Sugar reduces corrosion.
7. It does not produce dark sulphur taint.
8. Cans are more readily opened than tinfoil cans but will not withstand hydrogen swells to the same degree.

15.5 GLASS CONTAINERS:



With a history dating back to ancient Egyptian civilization, glass is still one of the major packaging materials the world over. Glass containers are one of the stalwarts of food packaging. Narrow-necked glass containers are called bottles and wide necked are called jars.

15.5.1 Bottles:



1. Bottles are the most extensively used type of glass container.
2. They may be many different shapes but the neck is always round and much narrower than the body. The neck facilitates pouring and reduces the size of the closures required.
3. Principal uses are for liquids or small sized solids.
4. Until recently, almost all milk was packaged in glass bottles.
5. The increase in supermarket shopping and the decrease in home delivered milk has decreased the usage of glass milk bottles.
6. Glass milk bottles originally were round, tapering to a rather wide mouth with a thick flange. The move to a squared body saved considerable space in the home refrigerator.
7. Glass bottles average about 50 trips and are packed at rates up to 24000 per hour.
8. Brown glass is used sometimes to filter out harmful light (UV light).
9. Bottle closures are formed from aluminum foil, high density polyethylene, polypropylene and paper board.
10. Most closures are applied by automatic machinery at high speeds.

15.5.3 Jars:



1. Jars are really very wide mouthed bottles and usually have no appreciable neck.
2. The opening permits the insertion of fingers or a utensil to remove portions of their contents.
3. They may be used for liquids, solids and non pourable semi - liquids such as thick sauces and pastes.

15.5.4 Tumblers:

1. These are like jars but they are open-ended.
2. They have no neck and no 'finish'.
3. They are shaped like a drinking glass and are used for products like jams and jellies.

15.5.5 Jugs:

1. These are large-sized bottles with carrying handles.
2. Necks are usually short and narrow.
3. They are usually used for liquids in large sizes.

15.5.6 Carboys:

1. These are very heavy shipping containers shaped like a short necked bottle and having 10 liters or more capacity.
2. Typically they have been used with a wooden crate holder. Other outer protective frames are now finding use.

15.5.7 Vials and Ampoules:



1. These are small glass containers.
2. The ampoules are principally used for pharmaceuticals.
3. Vials are sometimes used for small quantities of foods such as spices or food colorants and cultures.

15.6 TRAYS, PANS AND OTHER CONTAINERS:



1. This category of packages includes dishes, cups, bowls, pans, or trays such as pie pans and the TV dinner tray.

Packaging Of Dairy Products

2. Molded paper and picnic plates both rectangular and round with and without compartmentation have been made for several decades.
3. Pulp board trays are also used to package meats and produce in supermarkets.
4. Aluminum foil containers are available in many shapes.
5. Convoluted and spiral wound canisters made from paper are used extensively, with asphalt providing moisture barrier.
6. Aluminum foil liner is used to provide superior moisture barrier.
7. Foil is also incorporated as an inner liner, thereby making it possible to package liquids.
8. With the introduction of plastic that could be thermoformed, a wide variety of molded plastic boxes, trays, pans and the like became possible.

15.7 WOODEN AND CARDBOARD BOXES:



1. One of the earliest packaging materials, and one that is still very useful, is wood in its various forms.
2. Although it is used less frequently as other more sophisticated materials are substituted, it has still an important place in industrial packaging for heavy and or fragile items that require rigidity and strength.
3. The different types of packaging made from wood include baskets and hampers, tight and slack barrels, nailed wood boxes and crates, wire bound boxes pallets and skids, and containerization units.
4. They are made from lumber, veneer, or plywood.
5. Veneer is defined as wood that is less than 3/8" thick, regardless of whether it is sawed, sliced, or rotary-cut.
6. The types of fasteners that are used include wire, nails, screws, staples and bands.

15.7.1 Advantages and Disadvantages:

1. With a good strength-to-weight ratio, wood is an economical structural material.
2. It does not require very sophisticated equipment to make a box or crate and for very rigid structures in small quantities it is the material of choice.
3. For small packages or for large quantities, however, wood does not lend itself to high speed operations or automatic assembly. It therefore has a high labour factor in relation to material costs.
4. It is also bulky and often presents a problem of storage space and shipping cubage.
5. If rigidity, stacking, strength, protection from the hazards of shipping and light weight are essential, it is difficult to find a better material than wood.

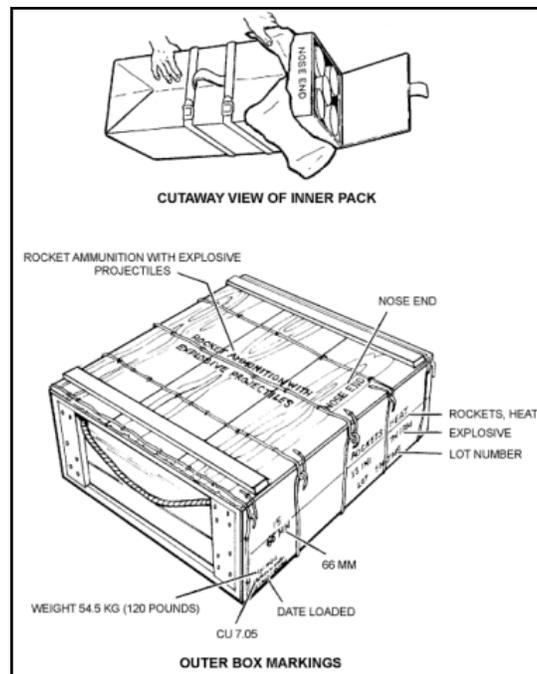
6. But if protection from moisture, rapid assembly, low cost, ready availability or attractive appearance is more important, then wooden containers may not be the best choice.

15.7.2 Nailed Boxes:



There are various methods of constructing a nailed wood box, depending upon the type of service required.

15.7.3 Wire bound boxes:

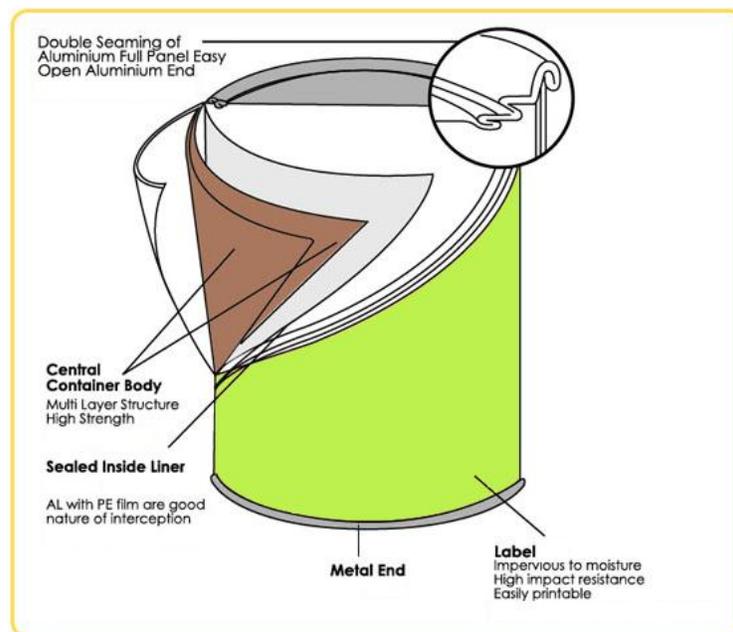


1. Very thin lumber is used to make wire bound boxes, and wires around the girth of the container are stapled to the wood at frequent intervals. Wood cleats are placed at the ends and sometimes in between.
2. The type and cure of wood used will affect the weight, strength and ease of fabrication of the container.
3. Soft woods are earlier to nail but not as strong as hardwood.
4. Green lumber is excessively heavy, weaker and will warp and shrink causing loosening of nails or other fasteners.

Packaging Of Dairy Products

5. **Boxes** are usually solidly walled, rectangular shaped, nailed wooden containers and will vary in construction and in extra cleats and braces as may be required by the load. The top, bottom, and sides of a box provide the main structural strength.
6. **Crates** are similar to boxes but may be of lighter weight and more open construction - that is spaces may be left between boards or the crack may be fully enclosed or sheathed.
7. A crate differs from a box in that the frame members carry the load. The sheath merely encloses, hence sheathing may be corrugated fiber board or thin plywood or light weight lumber.
8. Other joining methods may be used for boxes and crates. These include metal fasteners, glues, and wires or wire tapes. When using wires, thinner side, top and bottom sheathing can be utilized as the wires add strength. Cleated ends and stiffeners provide the structured strength required.
9. Advantage of wooden boxes and crates depend on the relative cost, strength, and weight ratios involved.
10. In most food uses today, wooden containers are being phased out and solid or corrugated fiberboard containers are replacing them. Some wood is still used for reinforcing cleats and bottoms.

15.8 COMPOSITE CONTAINERS:



A composite container is a container made from two or more constituent materials. It usually consists of a paperboard body with metal or plastic ends. The basic principle in a composite type of structure is to use the competition of materials which is best suited for the purpose, in the minimum amounts that are necessary to accomplish the packaging objectives.

1. Three basic types are available:
 1. **Spiral-wound** containers: They are made in cylindrical shapes where two or more plies of board are glued together around a mandrel.
 2. **Convolute-wound** composites: They are produced by straight winding and is used for squares, oblongs and ovals in addition to the cylindrical type.
 3. **Lap-wound:** Lap-seam bodies are made from laminated material cut into blanks and joined at the side with adhesive.
2. The convolute method Spiral winding does not make as strong a container as convolute winding and for larger packages for which resistance to hazards of shipping and storage is of paramount importance, the convolute construction will outperform spiral winding.
3. Body materials used are chipboard and Kraft paper.
4. Linings used are vegetable parchment, wax laminates, aluminum foils, glassine and polyethylene coated paper. Other linings can also be used depending on the product to be packaged.
5. Composite cans are closed by either a snap-on lid, plug-in lid or a lever lid.
6. In the non-detachable type of closure, perforated tops and string-opening devices are used as well as double seamed ends.
7. Specific advantages in using composite cans are ease of disposal and economics.
8. In recent years, composite cans have widely used for refrigerated dough and other food products.
9. Combinations of metal and paperboard or plastic and paperboard, incorporating films, foils, coatings or adhesives where needed are finding applications in many fields. Citrus juice cans, spice boxes, and cocoa canisters are examples among food packages.
10. Expensive materials can be kept to a minimum by using them in thin layers, supported by inexpensive paperboard for strength and rigidity.
11. In comparison with metal containers, a fabricant will provide far more thermal insulation, which may be good or bad, depending on the type of product it contains.
12. If quick freezing is part of the process, the fiberboard will interfere with the rapid cooling.
13. On the other hand, it will protect the contents from a temperature change that might be detrimental

15.9 FIBRE DRUMS:

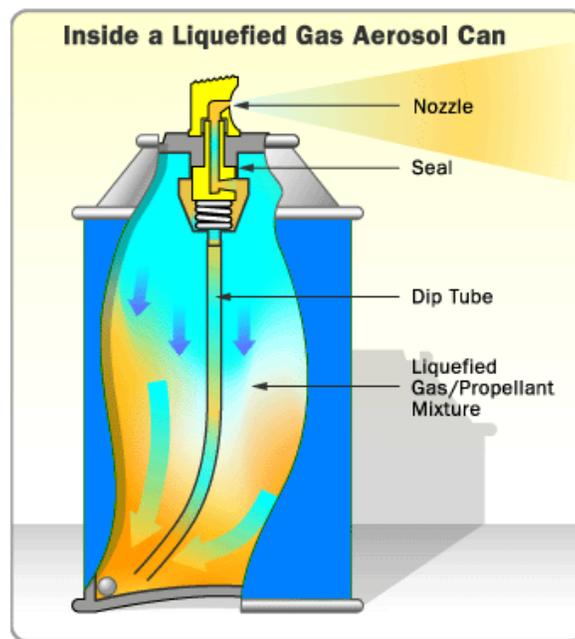


Packaging Of Dairy Products

1. A large version of the fibre can is the fibre drum that is used for shipping bulk chemicals and other industrial products.
2. Fibre drums are generally used for dry products, although with suitable plastic liners they can be used for pastes and certain types of liquids.
3. A wide range of sizes is available from stock, with end pieces of metal, wood or fiberboard, and body constructions that include a variety of laminations and coatings.
4. Fiber drums are light in weight and they have exceptional strength in proportion to their weight.
5. Although a fibre drum is essentially a single trip container, it is sometimes reconditioned and used for several trips.

15.10 AEROSOL CONTAINERS:

The aerosol can generally a 3 piece or 2 piece tin plate or aluminum container that has been specially designed to hold a product under high internal pressure and to dispense the product through an aerosol valve.



The precise meaning of the word "aerosol" is a "production of minute solid or liquid particles so fine that they remain suspended in the air for long periods of time." The more commonly accepted definition is a "container of liquid under pressure that is released through a pushbutton valve."

- Aerosol containers are used to dispense a product by means of a pressurized gas (CFC Free) or liquid that is held in the same container.

- The basic components of the package are the valve, the container and the protective cap.
- The container must be gas-tight and may be constructed from steel cans, aluminum cans, glass, plastic, or a combination. Choice of material must be related to safety (ability to hold pressure and lack of fragility), size, and product compatibility.
- There are several types of aerosols which can dispense products as fine mists, sprays, dusts or foams depending upon the type of valve used and the product/propellant arrangement.
- A Single phase aerosol contains a liquid product layer and a compressed gas propellant layer.
- A two phase aerosol contains a liquid product with dissolved propellant layer plus a compressed gas propellant layer.
- A three phase aerosol contains a layer of liquid propellant, a layer of product and a layer of propellant vapor. Removal of product causes the liquid propellant to boil and replenish the vapour phase.
- Piston aerosols contain a flexible plastic barrier between the product and the propellant gas.
- Co-dispensing aerosols disperse two products through the same nozzles.
- **Use:** Aerosol containers have been used for beverage concentrates, cocktails mixes, cake icings, pan cake mixes, syrups, salad dressings, seasonings, whipped cream, pan release spray and cheese spread.

15.10.1 Advantages and disadvantages of aerosol cans:

- The convenience of dispensing materials from aerosols at the touch of a button is an outstanding feature of this type of package.
- The other advantages are premixing, lack of evaporation and exclusion of air even when partly used.

Disadvantages:

- High costs (100-200% of the cost of product), risk of explosion, breakage or leakage are main disadvantages.

15.11 RIGID PLASTIC PACKAGES

A wide variety of rigid plastic can be used in the form of thermoformed, injection - molded or blow molded containers.



15.12 BLISTER PACKS



- It is a thermoformed package and it is obtained by using transparent sheet and cardboard.
- It is a pack which encloses an article between a formed plastic cover and a flat backing paperboard.
- These blister packs provide a great success in merchandising.
- Blister packaging is self selling and tends to reduce pilferage.
- The blisters may be obtained in many desirable options - single, double or multiple blisters and in desirable shapes and sizes.
- Based on product, a blister pack can be tear open type for repeated use.
- The backing card is an important component of the blister pack. While the transparent blister shows the product, card on its part tell the customer about brand, manufacturer's name, instructions for use, area of application, price etc.

- A colorful graphic design on the blister card attracts the consumer from a distance and puts his eyes on the product through transparent blister.

15.13 TRANSPORT / SHIPPING PACKAGES

15.13.1 Master Packages:

- Normally they are outer containers in which the commodity in bulk or packed units is placed to give protection against transit hazards.
- These master packs also could be unitized into a palletized load of 500 to 2000 kgs or loaded into containers of 5, 10 or 20 tons capacity, which ensures minimum handling of unit packages.
- The unitization either in pallets or containers results in considerable economy, since the cost of the master pack will be considerably less than for the package designed for transport on its own.
- The transport packages could be broadly classified into following categories:

I	Rigid	
	Wooden cases	Plywood containers
	Wooden crates	Plastic crates
	Wooden barrels	Plastic containers
	Metallic crates	Tin containers
	Composite containers	Metallic drums
II	Collapsible (Rigid when erected) containers	
	Wooden crates (wire bound)	Plywood
	Hardboard	Corrugated board
	Composites of above with plastic & metal	
III	Flexible Containers	
	Plastic Wooven bags	Plastic bags
	Multiwall Paper bags	Above with loose liner and /or laminated
IV	Indigenous	
	Bamboo baskets	Leaf
	Mud pots	Straw etc

- Depending upon the nature of protection required by the product, the necessary properties could be built into the package.

Packaging Of Dairy Products

- **Solid and corrugated fiberboard materials** are used to fabricate shipping cartons and cases used extensively in wholesale and Industrial shipping.
- They are not usually used as direct containers for foods but are extensively employed as after shippers for food packages i.e. cans and bottles.
- Both are made from heavy fibrous craft paperboards.
- Solid fiberboard is made by gluing several plies of paperboard together. By using asphalt or special resin adhesives, such as urea formaldehyde, enhanced moisture resistance may be built in. Selection of weight, fibrous construction and number of plies is related to the desired burst, tear, puncture and bend resistance.
- Corrugated fiber board is made from similar base materials but is generally thinner, as it is then constructed by combining facing (flat sheet) and liners (corrugated or fluted sheets) by means of adhesives.
- There are four major types of corrugated paperboard:
 - Unlined single faced,
 - Double faced,
 - Double walled, and
 - Triple walled.
- The first two types are used for wrappings of fragile objects or as interior padding of boxes.
- The latter two types are used where exceptional strength and rigidity are essential.
- Double - faced corrugated is the most commonly used type for boxes liners and partitions.
- Each flute has particular properties with respect to load support in each of the three possible directions.
- In double wall construction different flutes can be combined.
- Corrugated containers are now available with easy open tear strips, self locking assembly and smooth white liners permitting flexographic printing on the exterior. Special reinforcements can be employed. Where strength is less important molded pulp has been used for liner material.
- Other special corrugated boards or fiberboard constructions include foil laminated facings and plastic foam fillers between paper facings

	A. Flute	B. Flute	C. Flute	E. Flute
Flutes / foot	35-37	50-52	41-45	90-96
Flute height (in.)	0.185	0.105	0.145	0.085
Thickness (in.)	3/16-7/32	4/32	5/32	5/64

15.13.1.1 Advantages and Disadvantages:

- Corrugated board packages are versatile, light weight, strong, disposable and having low cost.

Disadvantages:

- Low wet strength - newer techniques of manufacture and new coatings are eliminating this disadvantage.

15.13.2 Cylindrical shipping containers:

- Cylindrical containers have high stacking strength and can be rolled in handling.
- They may be made from fiberboard, glass, metal, plastic or wood.
- A **barrel** is a cylindrical container of greater length than breadth, having two flat ends of equal diameter and bulging at the waist.



- A **drum** has straight sides and flat or bumped ends.
- A **pail** is a cylindrical or tapered (truncated cone) shaped container with or without a wire handle or bail.
- Small pails may be called **cans**.



- A **keg** is a small barrel.
- A **cask** is a large tight wooden barrel.
- Barrels may be made of wooden staves bound together with hoops and may be tight or slack.
- Metal barrels are made of steel or aluminum.
- Drums may be made of metal, plywood or fiberboard, fiberboard drums may have wood, metal or fiber ends.
- **Fiber drums** and cans are made from spiral or convolute wound paper or paperboard bodies and may be closed with metal, plastic or fiber ends. With

Packaging Of Dairy Products

interior facings of special papers, foils, or plastics such as glassine, parchment, aluminium foil, polyethylene, or pliofilm, they may be used successfully for bulk shipment of foods as the linings prevent contamination of the food or weakening of the container. Other barrier components can be built into the side wall at time of lamination. These may be asphalt, foil, or polyethylene to achieve a moisture barrier.

- **Steel drums** are used as single trip or returnable containers. Drum heads may be removable or fixed. Fixed heads may be fastened to the body by brazing, welding or double seaming. Some drums are formed in two halves and joined circumferentially at the waist.
- Drums may be fitted with removable covers which are of the friction lid type or which may be held in place by locking rings or lugs.
- Tight head drums or pails are furnished with small capped or screw plug openings for easy of pouring. Additional vents and drains may be specified.
- Aluminum drums are designed to have similar features to steel drums. Stainless steel drums are used where corrosion resistance or high levels of sanitation are required.
- Latest types of drum constructions are blow molded polyethylene drums as the primary container and a steel shell for added protection and rigidity.

15.14 SEMI - RIGID CONTAINERS



- The containers formed out of metal sheets / foils differ in the degree of rigidity depending upon thickness, temper, alloy and container design.
- Some are called rigid as they are not easily deformed.
- Other which are more delicate to deformation are known as semi - rigid containers. i.e. a package which is intended to maintain a definite form or shape and is not influenced by the shape or bulk of the contents but which can rather readily be bent or dented.

15.15 SET UP PAPERBOARD BOXES

- Four basic components are used to make set up paperboard boxes: paper board, adhesive, corner stays, and covering.
- Paperboard is selected to give the right weight and smoothness for the size box required.
- Sheets of the boxboard are cut and scored, the sides are folded up to make a tray, and the corner stays are adhered.
- This is repeated for the cover.
- Finally the covering material is glued on.
- Coverings may be coloured papers, foil laminates, or highly coated embossed and printed litho papers.
- Boxes can be made in almost any shape and with a wide variety of lid arrangements - separate or hinged.
- Semi - rigid plastics can be used as lids for better product display, or die cut windows can be similarly employed.

15.15.1 Advantages & Disadvantages of Paperboard Boxes:

- Convenience, individuality, strength, reusability and excellent product protection and display are the main advantages.
- Equipment required is minimum and low cost.
- Boxes are shipped set up - hence no set up time.
- Small quantities are no more expensive than large quantities making large inventories unnecessary.

Disadvantages of Paperboard Boxes:

- Generally higher cost in comparison to folding cartons produced in large quantities.

15.16 FOLDING PAPERBOARD CARTONS

- A folding carton is a container made from bending - type boxboard by die-cutting and scoring it properly to fold into the desired form.
- It is supplied by the maker as a flat blank, pre-glued, or partially glued and collapsed.
- It is erected, filled and closed by the packer.
- Because they are supplied in knocked-down form (flat), folding cartons are easier to pack than set up boxes and provide economies in transportation.
- Paperboards used in folding cartons must be capable of being bent and scored.
- There are many grades and thickness ranging from cheap lined or unlined chipboards to manila, kraft, laminated and clay coated solid bleached sulfate boards. The later is best for high quality printing.
- Boards may also be coated with plastics such as polyethylene, ethylene vinyl acetate, wax or blends of resins.
- Foil laminates are used both for aesthetics and for added product protection.

Packaging Of Dairy Products

- There are two common styles of folding cartons and a large number of special constructions.
- **Tube types** are one piece cartons that are bent into a tube (generally square) with a longitudinal glued body seam. End flaps are glued shut, tucked or self-locking.
- **Tray types** may be one or two piece with or without a lid. They are shipped flat and are set up and glued to form the tray and / or lid in the packager's plant. Some tray types are glued by the box manufacturer and folded flat along diagonal score lines. They can be snapped open to set up.
- Carriers for cans or bottles are special types of folding cartons.
- Cartons may be printed, embossed or die cut prior to blanking. Printing may be by letter press, offset lithography or rotogravure.
- Folding cartons are widely used for both solid and liquid foods.
- **Advantages** are low cost, ease of automatic high speed set up, filling and closing, good stack ability, easy opening and reclosure and excellent graphics.

15.17 MOLDED PULP CONTAINERS



- When a fibrous material is mixed with water and molded, a molded pulp container results.
- These containers are made of various virgin and chemical wood pulp or wastepaper pulp. The process used closely resembles conventional papermaking techniques.
- Molded containers can be formed by pressure injection or suction molding methods.
- They are usually water sensitive but low cost.
- **Uses** in the food industry are for egg containers and various produce containers.

Packaging Of Dairy Products

- The simplest wrappers are sheets of paper, metal foil or plastic film with or without decoration.
- Many films can be heat sealed but paper and foil require coatings in order to make them heat sealable.
- Early types of paper wrappers were glued shut.
- The earliest types of heat - seal coating were waxes.
- Many advances have been made in wax formulations and hot melt so that today some wrappers can be sealed with pressure alone (cold tack adhesives).
- The advent of plastic resin coatings such as the vinyls, nitrocelluloses, sarans and polyolefins made it possible not only to add heat seal properties but also to substantially improve strength and barrier properties of laminates of paper and plastics.
- Metal foil is in itself an excellent barrier. Coating and other substrates serve only to add strength, decoration and heat sealability.
- A wrapper that comes in direct contact with a food such as candy or a loaf of bread is called an **intimate wrap** whereas if it wraps an inner package such as a carton it is called an **overwrap**.
- Wraps may be purchased as roll stock or as precut sheets. The latter are usually used for hand or semi automatic production.
- Other variations of wrappers include **labels** which wrap only part of a rigid package and serve primarily to identify the contents. Some completely wrapped around labels on paper containers contribute barrier protection also.
- Another variation of a wrapper is a **bundling overwrap** which combines several smaller packages into one larger unit. Plastic film **shrink wraps** serve this function. The ultimate is extremely large pallet overwraps where a plastic film stabilizes an entire pallet load of smaller packages.
- There are at least 13 distinct types of twists and folds by which wrapper may be closed neatly before sealing. Over wrapping machinery has been developed for each type of wrap and fold and for specific products.

15.20 PREFORMED BAGS OR ENVELOPES



- A flexible container which is open at one end is broadly called a "bag". Although in any size it can also be called a "sack", this term is usually reserved for very large bags holding 25 kgs or more.
- An 'envelope' is usually but not necessarily smaller than a bag, envelopes are die-cut and are folded differently from bags.

15.20.1 Sacks:

- Multiwall sacks are either 'sewn' across the top and bottom or are of 'pasted' construction.
- The side seams in either case are glued.
- If only one of the ends is closed, the container is called an 'open mouth' sack.
- In other cases both ends are closed except for a small valve in one corner, which may have an extended 'sleeve' that is folded in after filling or may depend on the check valve action of an internal sleeve for a tight closure. The folded sleeve in a pasted bag will give the least amount of sifting.

15.20.2 Bags:

- Plastic bags and paper bags require completely different type of equipment, both for manufacturing and for sealing.
- Plastic bags may be made from plastic tubing or from a flat web that is folded and joined in 'back-seam' construction.
- Either of these can be 'flat' or they can be 'gusseted', the ends are generally heat-sealed to complete the closure.
- In some cases a web of film is folded and heat - sealed to give a 'side-seam' bag.
- The folded edge forms the bottom and can be accordion-folded if a bottom gusset is desired.
- The top edge usually has a lip for easy opening when filling which is one advantage of a side seam bag over the other types, which must be flush - cut.

15.20.2.1 Advantages & Disadvantages of Bags:

1. The paper bag is lowest in unit cost,
2. It keep shipping costs to a minimum since they have the lowest - tare weight ratio.
3. They are essentially dust - tight and protect the contents from outside contaminations.
4. They can be tailored to fit snugly around the products they contain.
5. They adjust to any shift in the shape of the contents
6. A fluffy product which tends to settle at bottom, will take up less space in storage.
7. Bags take minimum of space in storage and shipment, both before and after filling
8. Size can be made to suit almost any conceivable product.

Disadvantages:

1. Non - supporting and hence do not stand neatly on shelf
2. Wrinkles and folds may be unattractive for some product
3. Stacking may pose problem
4. Durability is usually borderline
5. A bulky low - cost product is often put into minimum of packaging for economic reasons.

15.21 RETORTABLE POUCHES



- A typical laminate for retortable pouch is 0.0005 polyester / 0.00035 foil / 0.003 polypropylene, with the outer ply designated first as is customary for pouch material.
- Filled pouches are sterilized at 115-121^o C, with overriding air pressure of ~ 2 kg/cm² to prevent bursting.
- Pouch material that will not delaminate at these temperatures must be selected, and the seals should withstand a tensile test of 0.08 kg/m of width, internal pressure of 1 kg/cm² for 30 s, pinhole strength of 0.6 kg and a drop test of 1.22 m.

15.22 MULTILAYER COLLAPSIBLE TUBES (MLCT)



- The collapsible tube has traditionally been made of soft metal, tin, lead, tin-lead and in recent years aluminum.
- One end of the tube is a threaded dispensing nozzle which can be closed by a screw cap closure.

- The entire tube is formed by impact extrusion from a slug of metal, and then it is trimmed, threaded and annealed.
- Exteriors are decorated by roller coating and offset printing.
- Interiors may be lined by dipping, flushing or spraying prior to exterior coatings.
- Linings may be waxes or vinyls, phenolic or epoxy resins.
- Product is filled through the open bottom which is then crimped or sealed shut.
- In use, the closure is removed, the interior seal (if present) is punctured and product is dispensed through the nozzle by squeezing the tube.
- Tubes are marketed on cards, in blister packs or in folded cartons.
- Blow-molded **plastic tubes** are now being used for some products. Their main disadvantage is lack of dead - fold. They tend to spring back when squeezed making total dispensing of the product difficult.
- Tubes are best for packaging thick liquids or thin pasty solids.
- It is used for packaging of process cheese spread/ fruit jams, fat spread and ketch-ups.



Lesson-16

Safety requirements of packaging materials and product information

16.1 INTRODUCTION

Most of the packaging related regulatory initiatives are concerned to the Product quality, Public Health and Hygiene, Safety, Export Promotion, Transportation and Consumer protection.

Packaging needs to communicate clearly all the mandatory information about the product to the consumer. Wrong information given on the package could mislead the consumer. Moreover, the packaging must communicate the way to handle the package or the product. This helps in protecting the consumers from accidents that could occur while opening the pack or during disposal, as in the case of glass bottles.

The international markets are governed by various packaging rules and regulations that make it mandatory for an exporting country to abide by them. Therefore, packaging for exports should comply with global norms to match with international standards. Government of India has instituted various laws and regulations. All these legislations are classified into two types i.e. Compulsory and Voluntary Standards.

To ensure product quality and provide safety to the consumer, it is important to regulate manufacturing, distribution, marketing and retailing of packaged products. This can be achieved by mandating rules and regulations. The Government of India has formulated a number of laws pertaining to packaging in the past years. Due to the sensitive nature of food, stringent rules and regulations have been mandated to address specific issues that could arise due to faulty packaging.

16.2 NEGATIVE EFFECTS OF PLASTICS AS PACKAGING MATERIAL

16.2.1 Negative health effects:

Following plastics have been associated with negative health effects:

PVC (polyvinyl chloride) contains numerous toxic chemicals called adipates and Phthalates ("plasticizers"), which are used to soften brittle PVC into a more flexible form.

The World Health Organization's International Agency for Research on Cancer (IARC) has recognized the chemical used to make PVC, vinyl chloride, as a known human carcinogen.

- Plasticizers used to make soft PVC for toys can leach out into the mouths of the children chewing on the toys. In 2006, the EU placed a ban on six types of phthalate softeners, including DEHP (diethylhexyl phthalate), used in toys. An alternative plasticizer, DINP (diisononyl phthalate) is also found to be risky
- PVC plastic has been used safely for more than 70 years in a variety of medical and commercial applications and humans. No reports of adverse human health effects have been reported from intravenous (IV) bags and medical tubing made with PVC
- **Vinyl chloride monomer:** The carcinogenicity of vinyl chloride monomer to humans who were exposed to very high VCM levels, routinely, for many years have been linked. Vinyl chloride is a known human carcinogen that causes a rare cancer of the liver
- **Dioxins:** The dioxin is produced as a byproduct of vinyl chloride manufacture and from incineration of waste PVC in domestic garbage
- Dioxins are a global health threat because they persist in the environment and can travel long distances

At very low levels, dioxins have been linked to immune system suppression, reproductive disorders, a variety of cancers, and endometriosis

PS (polystyrene) is one of the toxins the EPA (Environmental Protection Agency) monitors in America's drinking water. Its production also pollutes the atmosphere, destroying the ozone layer. Some compounds leaching from Styrofoam food containers interfere with hormone functions. It's a possible human carcinogen.

Other (usually polycarbonate - PC) group that consists mainly of polycarbonates, whose primary building block is bisphenol A (BPA), a hormone disrupter that releases

into food and liquid and acts like estrogen. Research in Environmental Health Perspectives finds that BPA (leached from the lining of tin cans, dental sealants and polycarbonate bottles) can increase body weight of lab animals' offspring, as well as impact hormone levels. A more recent animal study suggests that even low-level exposure to BPA results in insulin resistance, which can lead to inflammation and heart disease.

16.2.2 Negative effects on environment

1. Plastics are durable and degrade very slowly.
2. In some cases, burning plastic can release toxic fumes.
3. The manufacturing of plastics often creates large quantities of chemical pollutants.
4. Thermoplastics can be remelted and reused, and thermoset plastics can be ground up and used as filler, though the purity of the material tends to degrade with each reuse cycle.
5. To assist recycling of disposable items, the Plastic Bottle Institute of the Society of the Plastics Industry devised a now-familiar scheme to mark plastic bottles by plastic type. A recyclable plastic container using this scheme is marked with a triangle of three "chasing arrows", which encloses a number giving the plastic type i.e. Resin identification code.
6. Unfortunately, recycling plastics has proven difficult. The biggest problem with plastic recycling is that it is difficult to automate the sorting of plastic waste, and so it is labor intensive.

Recycling certain types of plastics can be unprofitable, as well, e.g. polystyrene is rarely recycled because it is usually not cost effective. These unrecyclable wastes can be disposed of in landfills, incinerated or used to produce electricity at waste-to-energy plants.

16.3 RESIDUAL TOXIC COMPONENTS PRESENT IN PLASTICS

This is a plastic era and lot many plastics are used for foods. Packaging materials are made up of polymers which are insoluble in beverages as well as pharmaceutical products and foods. Great number of substances are extracted by food such as plasticizers, pigments, catalyst, adhesives and monomers or low molecular weight, polymer/oligomers and these are hazardous and toxic for human health. Even leaching of plasticizers by liquid product from packaging material results into embrittlement of the packaging material itself. The preservatives in

food/pharmaceutical are absorbed into plastic and therefore the resulting unprotected product leads to spoilage.

In case of PE bottles, the milk fat gets into plastic by absorption and it results into rancidity of the product and therefore such bottles can't be reused. Also product and packaging material reacts with each other. Human health is affected by continuous consumption of such product which increases the level of undesirable components in blood. Therefore, for food grade plastics, two types of limits are fixed:

- 1. Global migration:** Includes all substances (from plastics) transferred to food i.e. sum of all mobile packaging components transferred to food. They may be toxic/non-toxic, even substances physiologically harmless and even unknown also.
- 2. Specific migration:** Includes one or two individual, identifiable components only. For these reasons Toxicological substances and Labeled components are used.

Overall migration units are fixed at 10 mg/cm² of the surface of the packaging material or articles in the following cases as per BIS:

- Containers or articles which are similar to containers or which in any case may be filled to a capacity of less than 250 ml provided it is possible to calculate the surface area of contact with the food stuff.
- Sheets, foils and other non-fillable articles for which ratio between the surface areas of the material or article and the quantity of food stuffs in contact may not be calculated.
- Rigorous scrutiny and list "Food Grade materials" is to be made. Global migration limits of 60 mg/kg of food stuff or 10 mg/cm² is been suggested by EEC. Typical food simulating solvents suggested are water, 3% acetic acid, 50/80% ethanol, Rectified spirit or heptane. Extraction conditions are high temperature, short duration or moderate temperature and long duration.
- India: BIS and CCFS (Central committee on Food Standards) Guide lines prepared.
- PVC: the VC monomer content limit: 1 ppm (max)
- PS: Styrene monomer limit: 0.2% by mass of polymer.
- Test method specified (IS: 9845 Revised 1986): With a view to help both manufacturer and health authorities, CFTRI and IIP (Indian Institute of

packaging, Bombay) have built up infrastructural facilities to assess the compatibility of plastics and also to estimate the migration.

16.3.1 Residual toxic compounds likely to be transferred to food through plastics:

1. **Monomers and oligomers:** Polymers have very high molecular weight and hence not assimilated by the body. Monomers being small may be assimilated by the body and therefore may pose health problems.
2. **Polymerization residues:** There may be presence of catalysts, solvents, emulsifiers and wetting agents having low molecular weight. During film container manufacturing a variety of processing aids are added which are
 - a. **Antioxidants:** To prevent fading of colour and prevent cracking, viz. BHA/BHT etc.
 - b. **Antiblock agents:** To avoid blocking of film i.e. when it is drawn rolled the film surfaces should not adhere to each other.
 - c. **Antistatic agents:** They are important in packaging industries, when two materials/surfaces are in contact, the electrons on the surface atoms intermingle and may move from one material to another.

The nature of plastic will determine the degree to which this takes place e.g. PS is most active followed by Acrylic and PE. Friction between the materials increases movement of electrons when they are separated. Absence of antistatic agents may lead to:

1. Fire/spark hazard
2. Dust attraction and
3. Difficulty in Derolling

Presence of moisture in air causes ionization resulting into neutralized electrons. The antistatic agents absorb moisture from air.

- d. **Plasticizers:** At lower processing temperature they avoid decomposition of polymer and modify processing characteristics like flexibility. They do these functions by acting as lubricant. They allow the molecules of plastic to slide over one another freely or by acting as a partial solvent for the resin. Plasticizers tend to ooze out during long contact or high temp and they may migrate from one plastic to another (e.g. from vinyl to PS if they are in contact). They may also leach out by solvents or by liquid product. Even some plastic becomes stiff and brittle when cold. Greatest use of plasticizers is in PVC – PVA. For e.g. Dioctyl phthalate (DOP), therefore PVC has poor resistance to oil. About 33% of DOP migrate into oil products.
- e. **Lubricants:** Internal lubricants such as Fatty acid glycerides reduce friction between plastic molecules, and External lubricants like Montanic acid reduce friction with processing equipments.
- f. **Slip agents** like Silicon components help in easy rolling/derolling of film

Many additives used, may migrate to food. Therefore limit has to be specified along with list of safe components.

However, in case of recycled materials, it is almost impossible to have migration within the prescribed unit, hence should never be used for food materials.

16.3.2 Methods of reducing migration from packaging material to food:

1. Use of new migration resistant plasticizers.
2. Improvement in formulation to reduce greatly their use.
3. Surface treatment of finished plastic products to reduce plasticizer migration (U.V. light, laser radiation treatments given).
4. Plasticizers related to cancer by International Agency for Research on Cancer are:

Packaging Of Dairy Products

DEHA- BIS-2-Ethyl Hexyl Adipate BBP: Butyl Phenyl Methyl or Butyl Benzyl Phthalate

DEHP: Bis-2- Ethyl Myxyl or Di-Ethyl Hexyl Phthalate

16.3.3 Factors involved in migration:

1. Composition and properties of packaging materials
2. Composition and properties of food stuffs
3. Surface (plastic) to volume (food) ratio
4. Temperature conditions
5. Duration of contact
6. Influence of light

16.4 (43-A). RESTRICTION ON ADVERTISEMENT-

There shall be no advertisement of any food which is misleading or contravening the provisions of Prevention of Food Adulteration Act, 1954 (37 of 1954) or the rules made thereunder.

Explanation: The term 'Advertisement' means any visible representation or announcement made by means of any light, sound, smoke gas, print, electronic media, internet or website"

Test procedures that are applicable for general classes of materials or packages are available and published in standardized form. The institutions involved are:

1.	ASTM	American Society of Testing and Materials Standards
2	TAPPI	Technical Association for the Pulp and Paper Industry (USA) Standards
3	BIS	Bureau of Indian Standards
4	ISO/R	International Standards Recommendations
5	BS	British Standards

6	FEFCO	Federation Europeenne des Fabricants de Carton Ondule Test Methods
7	PIFA	Packaging and Industrial Films Association Standards
8	ABA	American Box Board Association
9	BPBMA	British Paper and Board Manufacturers' Association
10	NFPA	National Flexible Packaging Association
11	PFMA	Packaging Film Manufacturers Association
12	FPA	Flexible Packaging Association
13		Federation of Corrugated Box Manufacturers Association of India

**(E) LIST OF APPROVED INDIAN STANDARDS UNDER BIS LABORATORY
RECOGNITION SCHEME**

A. PAPER & PAPER BOARD		
SR.NO.	STANDARD	DETAILS
1	1397	Kraft Paper Specification Reaffirmed 1995
2	1848	Writing and Printing Specification (Third Revision) Reaffirmed 1995
3	6956	Cover paper specification Year 2001
B. STEEL / METAL		
1	1783	Type - 1 Specification for drum Part - I Year 1993 Reaffirmed 1998
2	2552	Steel Drums (Galvanized & Un-Galvanized) Reaffirmed 1995
3	3575	Specification of Bitumen Drum - Year 1993 (Third Revision) Round & Rectangular Tinplate Cans for Liquid Pesticides - Year 1991
4	9992	((First Revision) Square Tins - 15 Kg./litre for Ghee, Vanaspati, Edible Oils and Bakery
5	10325	Shortening - 2000 (Second Revision)
C. PLASTIC & ALLIED MATERIALS		
1	13262	Specification for pressure sensitive adhesive cellulose tapes : Year

Packaging Of Dairy Products

		1992 Reaffirmed 2003
2	6312	Polyethylene Containers for the Transport of Material - specification Year 1994 Reaffirmed 1999
3	8069	High Density Polyethylene (HDPE) Woven Sacks for Packing Pesticides - Specification (Second Revision) Year 1989 Part (1 & 2) Reaffirmed 1997
4	2508	Low Density Polyethylene Specification Year 1984 Reprint Dec 1996
D. PLASTIC FEEDING BOTTLE		
1	14625	Plastic Feeding Bottle Year 1999 Reaffirmed 2004
E. PACKAGED MINERAL WATER		
1	15410	Containers for packaging of Natural Mineral Water and Packaged Drinking Water Specification Year 2003
2	15609	Specification for polyethylene Flexible pouches for the packaging of Natural Mineral Water and Packaged Drinking Water Reprint August 2005
F. JUTE FABRIC		
1	1943	Textile - A - Twill Jute Bags Year 1995 Reprint 1999
2	2566	Textile - B - Twill Jute Sacking Bags for packing Food Grains
3	7407 (Part - to III)	Specifications for Jute Tarpaulin Fabric Year 1980 1st Reprint September 1996



Lesson-17

Pasteurized Milk

17.1 INTRODUCTION

The appropriate packaging of milk is of utmost importance not only to preserve its nutritive value and saving of wastage, but also to improve the marketability to achieve better returns. The challenge to the packaging industry is to deliver the nutritious milk to the consumer in most economical, hygienic, safe and environmentally friendly package.

There are two main types of packaging systems for fluid milk one is traditional bottling system in which container is to be returned and other is one way delivery in which container is disposable and does not travel back to the dairy. In the non-returnable distribution system there are several alternative systems where different packaging materials, shapes, sizes, forms and machines are employed for packs.

For selection of a suitable package material, the knowledge of important characteristics of milk/ milk products is essential.

17.2 CHARACTERISTICS OF PASTEURIZED MILK

1. Milk has a tendency to absorb the flavours from its environment
2. Risk of Contamination is more in liquid milk
3. Adulteration can be done easily when not packed properly
4. It is difficult to handle milk in bulk quantities
5. Milk is prone for oxidation when exposed to sun light

17.3 CRITERIA FOR SELECTION OF MILK PACKAGING MATERIAL FOR PASTEURIZED MILK

Milk, an extremely perishable and sensitive product, need exact packaging material in order to preserve its initial quality for some span of time. The necessary characteristics of packages for pasteurized milk are:

Packaging Of Dairy Products

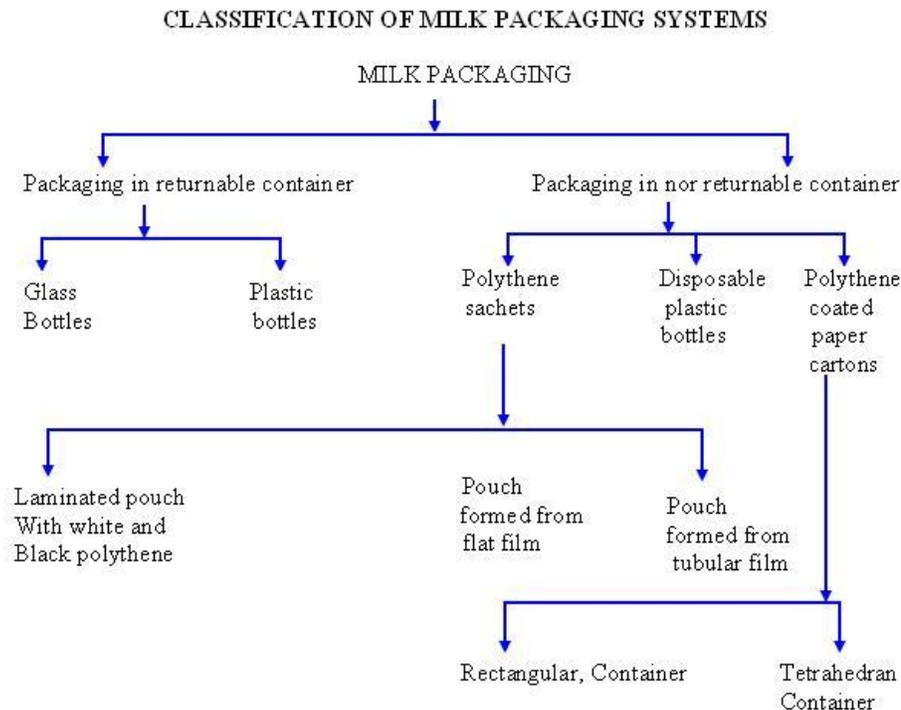
1. It should be free from off-flavours
2. It should not impart any taste or flavour to the product.
3. It should act as barrier to bacterial contamination,
4. It should be resistant to UV light (max transmission: 8% at 500 nm & 2% at 400nm)
5. It should have no physiological effects on the products
6. It should possess good mechanical properties (sealing, tensile, structural strength etc.)
7. It should be tamper proof.
8. It should possess good oxygen barrier properties
9. It should be economical
10. It should fit in to processing- in-Line.

17.4 MATERIALS USED

1. Glass
2. Plastics: (1) LDPE is widely used (2) LLDPE: 25% thinner film used and LDPE and LLDPE in 5:1 to 4:1 ratio.
3. Others: Coated paper board, wax coated paper board ESL (Extended Shelf life Pouch)

17.5 CLASSIFICATION OF MILK PACKAGING SYSTEMS

Classification of milk packaging materials can be done broadly in two categories which can be seen from the below flow diagram.



Milk is packed in various packaging materials according to the market requirement and table below describes the packaging material that is commonly in use.

Table 17.1 Types of packaging materials used for milk packaging

Type of packaging	
Sachet	LDPE 45-75 m (LDPE+LLDPE)
Glass Bottle	500 ml
Tetra pack	200 ml brick, 500 ml tetrahedron/brick, 1000 ml brick
Pillow pack	500 ml pillow pouch

Of the total milk packed, flexible pouches dominate followed by aseptic packaging whose usage level is increasing day by day. Flexible pouches have proved to be a safe, quick and cost effective packaging method and with a wide distribution network, providing ease of packaging and handling. A good consumer response to milk pouches paved the way for the technological changes. In the form-fill-seal (FFS) system, the plastic film is formed into a tube, sealed along its length, sealed at the bottom to form a pouch, filled with milk and then sealed at the top. Butane LLDPE or C-4 and Octane LLDPE or C-8 is widely used because of their excellent cold storage properties.

17.5.1 Glass Bottles:

Packaging of milk in glass bottles is the oldest system. Clear glass bottles of 500ml capacity conforming to IS: 1392 – 1967 are used. The glass bottles offer certain advantages like transparency, rigidity, hygienic and non-toxic nature and compatibility. This system involves collection and transportation of empty bottles to processing plant, washing and sterilization of dairy bottles. This packaging system requires large storage space requirement for both empty as well as filled bottles. These factors increase the fixed and the variable costs. Heavy weight, fragility and return ability of bottles has inconvenience both to the distributor as to the well as consumer which made this packaging system undesirable and is not in use at present.

17.5.2 Returnable Plastic Bottles:

Plastic bottles reduce the weight and the chances of breakage are rare but most other characteristics of packaging milk in glass bottles remain same.

17.5.3 Non-Returnable Plastic Bottles:

This system reduces transport charges through light weight and one way of delivery of bottles in a convenient way in comparison to any other system.

Ex: HDPE with PP lid, car buoy.

17.5.3.1 Plastic Films:

Plastic pouches are generally made of low-density polyethylene (LDPE) film. Co-extruded LDPE-LLDPE film is also used because of its advantage of eliminating pin-hole problems. The films are of 45-75 μ thick. The pouches are formed and filled on form-fill-seal (FFS) machines in capacities of 200, 500ml and 1000 ml. The film should conform to IS: 11805 – 1999. The plastic pouches are clean, hygienic and safe for this application and since these are not reused, the cleaning operation is eliminated and energy loss is avoided. Moreover, these pouches are easily recyclable for other purpose.

17.5.3.1.1: Developments in milk packaging in plastic pouches: The milk pouch concept actually originated in Europe with late fifties and had received growing popularity among consumers because of its convenience and reduced costs. Polyethylene, particularly LDPE has been used for packing milk. In Czechoslovakia milk was packed in 0.09 mm thick white pigmented film. In Denmark and Finland, milk has been packaged mostly in co- extruded PE laminate consisting of a black inner layer and white outer layer. Similar packaging was also used in India by certain Dairies. In North America clear plastic material is used. The thickness of LDPE film got gradually reduced to 55 μ - 65 μ . Now a days, in India milk pouches are formed from LLDPE film of 50-55 μ thickness.

17.5.3.2 Aseptic Packaging of Milk:

Aseptic or long-life milk was originally introduced in Sweden in the early 1960's originally called the "Tetra-pack" system. It utilizes a laminate pre sterilizer and a filling environment heater. Aluminium foil is an integral part of the flexible laminate in order to provide a barrier against light and gas. In UHT processing, Milk is preheated to 73– 85°C then rapidly raised to 135 °C for fraction of second and then suddenly cooled by flashing into a vacuum chamber. It must be packed under completely sterile conditions. No refrigeration is necessary for at least 3-6 months. If kept under refrigeration a self life of up to 1 year is possible.

In the distribution system, the pouches are placed in reusable multi-trip plastic crates. The crates are made of HDPE or PP and packs are nestable and stackable. The plastic crates shall conform to specifications laid down in IS: 11584 – 1986.



Lesson-18

UHT-Sterilized milk

18.1 INTRODUCTION

High heat treatment of milk is not enough to give long shelf life of UHT milks if packaging is not proper. So packaging plays an important role in UHT products.

UHT milks, like pasteurized and sterilized milks, can be packed in plastic bottles and pouches. The bottles may be blow-moulded at the point of packing, or pre-moulded on either unsterilized or sterilized form. Because of the shelf-life requirements of UHT milks, multiple laminates, for example a triple layer of high density polyethylene are used. An intermediate light barrier may be incorporated, according to the manufacturer's preference. Oxygen penetration during storage is not usually a problem. Whatever the source of bottles, aseptic techniques are used in filling and sealing to prevent contamination, and milk can be expected to have a shelf-life of 6 months at ambient temperatures.

For short shelf-life (10-15 days) products, pouches are usually made of white polyethylene and paper.

18.1.1 Cans

Aseptic canning is expensive, particularly for a low cost product like milk. Cans are not preferred for packaging of UHT processed products as the processors and marketers of the product generally want to emphasise the newness of the process whereas cans are identified with conventionally retorted products. The cans may be of tinfoil or drawn aluminium. The solder in tinfoil cans must be of higher melting point than normal to withstand the in-can sterilization temperatures. The cans pass along a conveyor belt within a continuous tunnel. Tunnel temperature (200-220 °C) for sterilization of cans is attained by steam (at atmospheric pressure), superheated with gas flames-sterilization time being 40s, normally. The cans having passed through the sterilizing tunnel continue through the filling chamber where they are filled with the product. The can lids are sterilized, again by superheated steam, in a separate unit.

The lids are applied and seamed in a chamber kept sterile by super heated steam and flue gas.

18.1.2 Paper Board Cartons:

This kind of packaging materials are commonly used in aseptic filling systems for milk, cream, fruit juices, soups etc. The filling systems could be either of the following two types: those in which the carton is formed within the filler from a continuous reel of material; and those in which the cartons are supplied as preformed blanks, folded flat, which are assembled into cartons in the filler. The packaging material is mainly composed of printed-

paper coated with aluminium foil and several plastic layers (Polyethylene-paper board-polyethylene-aluminium foil polyethylene). The inner material side of the finished package is coated with a special layer facilitating the sealing process. Each layer has a specific function:

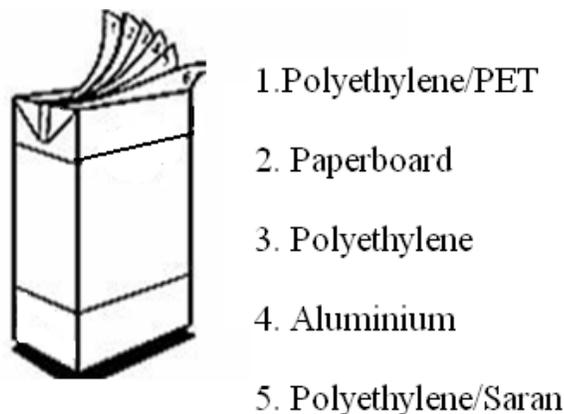


Fig.18.1 Multi layered Packaging

- The outer polyethylene layer protects the ink and enables the sealing process of the package flaps.
- The paperboard serves as a carrier of the décor and printing gives the package required mechanical strength.
- The laminated polyethylene binds the aluminium to the paper.
- The aluminium foil acts as a gas and light barrier.
- The inner polyethylene layer provides liquid barrier and sealing

18.2 FLAVOURED MILK:

Flavoured milk drinks are generally skimmed or partly-skimmed and contain less than 1.5% fat. The package should be leak and tamper proof, should have sufficient wet strength and should not pass on any odour or taint to the product packed inside. The plastic based material used for sachets is octane LLDPE (O-LLDPE). OLLDPE when blended with 50% LDPE provides excellent puncture resistance, excellent seal strength. Co-extended multiple layers low-density films with an outer opaque film and an inner black film for reducing the transmission of light are also used.

In India, flavoured milk drinks are available in sterilizable crown cork glass bottles, glass bottles with aluminium foil lid or snap-on plastic lid, plastic sachets and aseptic packs (Tetra bricks). Recently 200ml, translucent bottles of HDPE with an aluminium foil cap have also been introduced. Poly carbonate bottles with the leak proof screw cap are also used in place of glass bottles as these are unbreakable and are much lower in weight (1/6th the weight of glass bottle). PET containers are in use as they are light in weight, have good sales appeal and are strong.



Lesson-19

Aseptic packaging

9.1 INTRODUCTION

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

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

The basic operation in aseptic packaging consists of:

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

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

Packaging Of Dairy Products

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

19.2 PACKAGING MATERIALS USED IN ASEPTIC PACKAGING

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

19.2.1 Properties sought in laminate for aseptic packaging

No.	Properties	Example of suitable material
1	Tear resistance	PVC, PVDC/PVC, PE, PP
2	Stiffness	Paper, PS
3	Puncture resistance	Ionomer, PET
4	Printability	Paper, Al-foil, PS, PE, PET
5	Folding	Al-foil, paper
6	Heat sealing	LDPE/LDPE
7	Light barrier	Al-foil, paper, metallized film
8	H ₂ O vapour barrier	Al-foil, PE, PVDC
9	O ₂ barrier	Al-foil, PET, PVDC, PVA, EVA i.e. EVOH

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

Various packaging materials are used for milk, from paper-based laminates or carton board, to bottles made from polyethylene or polypropylene. The common packing is typically a combination of polyethylene, paper and aluminium foil. The polyethylene forms a mono-layer protective coat on the outer surface of the carton, and a co-extruded double layer on the inner food-contact surface which aids in sealing.

Between the polyethylene layers is a paper layer which provides strength, rigidity and printability and the aluminium foil layer serves as an oxygen barrier.

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

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

Figure 19.1 shows the principle of aseptically forming and filling UHT milk cartons. Pre-formed cartons may be used for UHT milk, in which case the packaging is usually pre-sterilized, for example with ethylene oxide gas, and once again with a combination of H_2O_2 and sterile air at around 180°C, just prior to filling and sealing.

Pipelines valves and fittings that are coming in contact with sterile milk are pre-sterilized before use.

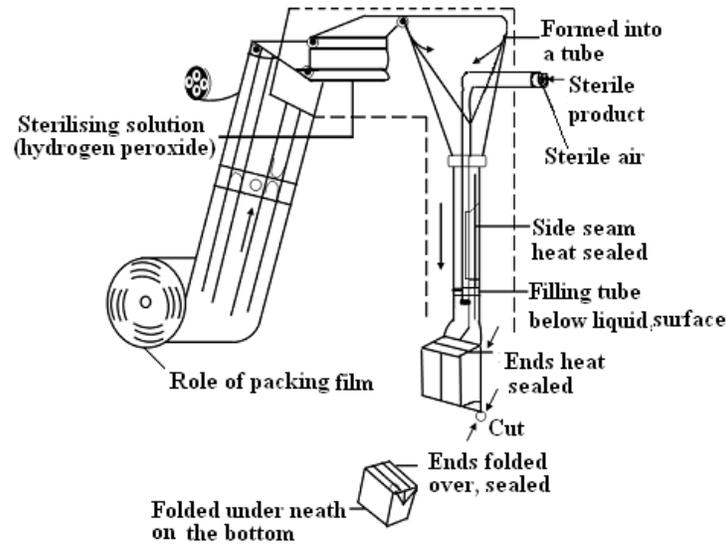


Fig. 19.1 Aseptic Packaging of UHT Milk

There are various packaging forms in which the UHT milk is packed.

19.2.2 Tetra pack cartons: Tetra Pak group of Sweden had launched various types of cartons and 'Tetra Hedron' cartons were the first type introduced in fifties, which required the development of heavy weight paper board/aluminium/polyethylene and have proved to be quite successful for UHT milk packaging. The Tetra Pak Company had gradually replaced these Tetra Hedron cartons with Tetra Brick cartons as the former posed problems of collating and stacking and short shelf life



Lesson-20

Fat Rich Dairy Products - Butter and Ghee

20.1 INTRODUCTION

Cream, Butter and ghee contains a high percentage of fat, so they are very susceptible to spoilage. So packaging material used should be selected in such a way that it possesses good grease resistance, and barrier properties against oxygen and moisture.

20.2 CREAM

Cream is the concentrated form of milk fat

20.2.1 Characteristics of Cream:

1. Cream contains a high % of milk fat and is very susceptible to spoilage.
2. Moisture loss can occur if not properly packed
3. Prone to oxidative and lipolytic rancidity
4. Can absorb flavours

20.2.2 Characteristics of Packaging Material required:

1. Prevent light passage
2. Prevent water loss
3. Prevent oxygen transmission
4. Shall offer resistance for microbial contamination

In early 20th century waxed paperboard cartons were used as containers for cream. Now a days creams is packed in similar packages used for milk i.e. Newer cream packaging concepts include thermoformed packs made from linear polyethylene, polystyrene or polypropylene. These may be closed with a peelable lid or snap-on cover. Tin plate containers have also been used for larger sizes. Whipped cream and synthetic formulations are sold in aerosol cans and polyethylene tubes.

Imitation cream made from soybeans and vegetable oils is often marketed in wax coated paper board cartons. Ultra pasteurization has been applied to heavy and light creams. The product then goes for packing. A strong seal is necessary for product

protection. PE extruded or wax coated paperboard tubs are used to pack single portion cream. Sterilized/ UHT cream is packed in similar lines to that of UHT milk.

20.3 BUTTER

It consists primarily of about 80% milk fat, 15% moisture and in table butter upto 3% common salt. Because of high moisture content butter is susceptible to mould growth and lypolytic rancidity

20.3.1 Characteristics of Butter

1. Due to high moisture content butter unlike solid fats is susceptible to mold growth.
2. Flavour and odour are easily absorbed by butter from its environment.
3. Deterioration of the butter may take place due to rancidity.
4. Butter has tendency to lose Moisture.

20.3.2 Requirement of Packaging

1. Non toxic, not harmful to consumer's health.
2. It should be grease/moisture proof.
3. Shall be barrier for Oxygen.
4. Low metallic content as metals favour oxidation of fat.
5. Shall not transmit light.

20.3.3 Packaging Material Used: In India, butter is packed in bulk as well as in retail packages. For bulk packaging there is no standard method, and generally polyethylene bags/parchment paper along with corrugated boxes are used.

Al-foil 0.09 mm thick, surface treated with lacquer for protecting against corrosion: Al-foil/parchment or glassine paper (40-42 gsm): PVC or cardboard with a parchment insert can be used.

Indian Standard 2034 - 1961 gives specifications for tin cans of 200 g and 400 g capacity that are to be used for package of butter. They specify tinplate thickness of 0.24 mm and -0.27 mm respectively and minimum tin coating of 17 g/m², besides many other requirements. Though tinplate containers are the best for product protection, owing to their high cost very little quantity of butter is packed in the tin containers. Flexible packaging materials like vegetable parchment paper or grease

proof paper, aluminium foil, and paper board cartons which together give similar protection to the product are more commonly used.

Indian Standard 7161 - 1973 gives specifications for vegetable parchment paper or Grease Proof paper/ Aluminium foil laminate for wrapping butter. As vegetable parchment paper has good wet strength, generally paper of 45 gsm and above and aluminium foil above 0.009 mm thickness are used. As butter is highly susceptible to foreign odour, care must be exercised while choosing adhesive and printing inks used in the manufacture of the laminates.

There is also another IS: 8113-1976 standard for primary cartons for packaging of 100 g, 200 g and 250 g. butter slabs. Cartons protect butter while handling after packaging in primary Wrapper, in the distribution system. Since butter is stored in the refrigerator, cartons may be waxed with about 10 gsm wax on each side though it is not mandatory. Paperboard can be extrusion coated with PP. Injection-moulded pots and tubs of PP can also be used for packaging of the butter.

High-impact polystyrene or HIPS is also used in multilayer sheet extrusion with a variety of other polymers, like PE, PP, PET, PVDC and EVOH.

Large packs of 10, 20 and 50 kg butter are packed formerly in wooden barrels/boxes or parchment paper lined corrugated boxes. For better handling, easier storage, more efficient use of storage space and economy Fibre board boxes are introduced which are lined with parchment paper.

Latest packaging material that are being used are Shallow, 1-2 mil thick Al-foil trays with heat sealable PVDC-cellophane or other suitable barrier material. Aluminium PVDC/PS cups can also be used for butter. Butter chiplets are packed in lacquered Aluminium foil.

The standards for vegetable parchment paper used for the butter packing are:

Grammage: 41-45

Bursting strength: $1.8 \pm 0.2 \text{ kg/cm}^2$

Packaging Of Dairy Products

Wet strength: $0.8 \pm 0.2 \text{ kg/cm}^2$

Grease resistance: Should pass the turpentine oil test

Acidity: 0.02% as H_2SO_4

pH of H_2O extract: not less than 5.0

Brightness: 79.

20.4 GHEE

It is usually 100 per cent fat with little moisture ($< 0.3 \%$), obtained by boiling butter at 110°C till all water is evaporated with a grainy texture and a characteristic flavour.

The product needs to be protected from chemical spoilage and rancidity caused by oxygen, light, heat, moisture and metal ions.

20.4.1 Characteristics of Ghee:

1. Easy to absorb flavour from its environment
2. Easily prone for oxidation
3. Prone for adulteration.

20.4.2 Packaging Material Should Have

1. Good fat resistance
2. Barrier properties against oxygen and moisture.
3. It shall be temper proof.

A major portion of ghee is packed in lacquered tinplate containers of capacities ranging from 250 litres to 15 litres / kilograms. Since the product is very sensitive to oxygen, the tinplate containers are filled to the brim without any air gap. Ghee packed in tinplate containers is fairly stable and has a shelf-life of about one year.

Alternate packages, which are plastic based, are now gradually replacing tins. For shorter shelf-life, 200 ml, 500 ml and 1 litre capacity pouches made of polyethylene film, multi – layer co-extruded films of LDPE/HDPE are used, which are economical. Aluminium foil laminate standy pouches are also commonly used for packaging ghee.

IS: 11352-1985 specifications for flexible packs for the packing of edible oils and vanaspati have been recommended for this purpose.

For long – term storage, stainless steel containers or tinplate cans are desirable. Ghee is also marketed in lined cartons with flexible laminated plastics as inner liner materials and in tetrapaks. In both these packs long shelf-life is achieved. Laminated pouches of metallised polyester based films are also used. Generally, plastic pouches are filled on automatic FFS machines. However, if the sealing surface is contaminated with the product, sealing of the pouch becomes difficult.

Recently it is packed in certain laminates and Bag - in - Box containers which comprises of a pre-sealed bag made of polyethylene and polyamide laminates fitted with a spout and cap housed in a CFB / Duplex board box. The bag consists of two plies which is sealed together on all four sides and the spout and cap assembly is heat sealed onto it. The bag is vacuum filled and inserted manually into the box. Seven layer Nylon containing self standing pouch with closure is also used. A laminate of HDPE / LDPE is used for packing ghee.

Another form is consisting of a multi-ply collapsible bag with a tap which can be housed in a rigid outer container. The container can be a box, a crate or a drum whose capacity varies between 3 and 200 liters. The bags and boxes are in collapsible form.

Nylon/ Styrene-based laminates, EVOH and EVAL are also being experimented as these materials could provide a fairly long shelf-life.



Lesson-21

Coagulated and Desiccated Indigenous Dairy Products and their Sweetmeats

21.1 INTRODUCTION

Traditionally, Indian dairy products have been manufactured by individual sweet makers-“halwais” and small entrepreneurs. Very little attention is paid to sanitary handling and packaging of these products.

Traditionally, indigenous products have been packed in leaves, paper cartons or paper-board boxes. These materials do not provide sufficient protection to the product from atmospheric contamination and manual handling. Consequently, the sweets soon lose their typical body and texture, absorb foreign odours, lose their aroma characteristics and show mold growth. Moreover, the products are stored in open metal trays.

21.2 PACKAGING OF COAGULATED INDIGENOUS AND FERMENTED DAIRY PRODUCTS

Cultured milk products have various textures and viscosities, i.e. when liquid they are considered as beverages (Butter milk) and when semisolid they are spoonable products (Yoghurt)

The material used for packaging must be compatible with the special physical chemical and bacteriological properties of fermented milk. The packaging materials used are glass, polyethylene, complex card, LD / LLDP, HDPE cups, Co extrusion plastic complexes, polystyrene- EVOH (polyvinyl alcohol and ethylene co polymer, Polystyrene –PETG (polyethylene glycol terephthalate), tetrapack.

21.2.1Packaging of yoghurt: Yoghurt has become very popular in many nations. In the United States yoghurt is packed in coated paper board containers. The product is automatically filled in polystyrene tubs and covered with 0.005mm aluminium foil. The inherent brittleness of polystyrene may become a problem. The terpene containing aroma of fruit yoghurt has an effect on polystyrene. Fruit acids may also cause pitting

of unlacquered aluminium lids. A polystyrene tub is an excellent package for yoghurt. It is economical, practical and widely used. Yoghurt is also being sold in expanded polystyrene foam tubs. Each tray holds 20 tubs of yoghurt. Trays are stackable and serve not only as display holders and light weight shippers but also hold during fermentation of yoghurt. This saves extra handling and repacking cost.

21.2.2 Packaging of fermented milks (Buttermilk, sour cream, lassi): LDPE sachets, polystyrene cups, polypropylene cups are used. Wax coated paper cups are used. Recently buttermilk, lassi and sour cream are packed in aseptic tetra packs. HIPS for stored products must never be employed as free fatty acids may lead to cracking of the material.

21.2.2.1 Packaging of dahi/lassi: The traditional pack so far was the earthenware pot with a loose cover of glassine or greaseproof paper. The earthenware pots are very heavy, easily breakable and because of oozing of water from its body, the product inside develops shrinkage cracks. Recently, injection moulded polystyrene and Polypropylene/ HIPS cups have been introduced with aluminium foil based peelable lids. These cups are available in capacities of 200 grams and 400 grams and provide a shelf-life of about 10 days under refrigeration. The plastic cups are light in weight, easy to handle and are hygienic. Some private dairies are also packing dahi in LDPE pouches of 200ml capacity.

21.2.2.2 Butter milk: Butter milk is another most popular indigenous fermented milk product. It is packed in 200 ml polyethylene sachets. Recently some dairies are marketing butter milk in tetra packs.

21.2.2.3 Lassi: Lassi which is a sweetened butter milk product is packed in polystyrene cups with coated aluminium foil lids. The packaging materials such as earthen wares give firmness to product. Others are glass jars, PS / PP cups, PVC lined HDPE. Tetrapak / Brick are recommended for Lassi, Basundi, Kheer

21.2.2.4 Shrikhand: Shirkhand is packed in polystyrene/PP Cups. HIPS are more common for 100 gm to 1 kg size which are sealed/capped/lined with Al-PE foil. Small manufacturers use lined (Glassine) paper board boxes. HDPE containers with lid of

Packaging Of Dairy Products

LDPE made by injection moulding are also in use. PP or PE bags, Glassine paper lined containers are also used.

21.2.3 Packaging of cheese: Packaging requirements for natural cheese: Any material to be used for packaging natural cheese must give general protection, prevent moisture loss, improve appearance, protect against micro organisms and prevent oxygen transmission.

Cheese is essentially a product with high fat and moisture content. Therefore, package used for cheese should prevent oxidation and mould growth. It should also have fat and grease resistance and be able to protect against micro organisms. Oxygen is eliminated by packing cheese in hermetically sealed containers in vacuum or inert gas atmosphere. Processed cheese is usually packed in aluminium foil in cubes with different shapes. Tinsplate cans are used for 200 gms and above quantity. PVDC coated plastic films are suitable for cheese packaging as they provide good oxygen and moisture barrier properties.

Cream cheese is packed in foil lined card board boxes of heat stable plastic packs. Saran is used as wrapping material for Neufchatel cheese. Air evacuation and gas flushing is used for cottage cheese, green cheese is packed by waxing and paraffining or alternatively vacuum packed in polyethylene or chyvovac. Ripened cheese is packed in laminated cellophane film or pliofilm. Cheese consumer packs are generally consists of Lacquered metal cans of laminated consisting of Nylon / PVDC / Copolymer or polyster/ PVDC / copolym or Nylon / Polyethylene.

Processed cheese is packaged hot metallic containers. Wax coated cellophane, A.P foil , polypropylene, PE, PVDE material is also used for packing processed cheese.

21.2.4 Packaging of Ice cream: The chief requirements of packages for ice cream are protection against contamination, attractiveness, ease of opening and reclosure and ease of disposal, protection against moisture loss and temperature fluctuations is desirable. Bilk ice cream is packed and hardened at a low temperature. Shaped bars are hardened prior to packaging.

21.2.4.1 Package forms: Most bulk ice cream is packaged in a liner less bleached sulphate board carton, coated with wax or polyethylene wax blends for protection from moisture and oxygen. Once the carton is opened it is difficult to reclose and the paper board tends to warp. Although economic considerations favour the simple rectangular paper board carton, improved packaging often leads to higher sales and a marginal price differential may be offset by higher throughput.

1. Aluminium foil cartons
2. Cylindrical containers
3. Plastic containers.

21.2.5 Packaging of chhana: Chhana requires protection from heat, light, O₂, microbial contamination, moisture loss, odour absorption, acid resistance, oil and grease resistance. Therefore the package should have barrier properties and possible for heat sealing.

21.2.5.1 Packaging materials used for packing chhana:

- Vegetable parchment: chhana can keep well 3-4 days at 21-27°C, 10 days at refrigerated storage.
- Vegetable paper parchment treated with Na-propionate increases the keeping quality of chhana.
- Wax/plastic coated paper: 55-60 gsm / 0.02 mm ---0.009-0.02 mm
- Poster paper/Al-foil/LDPE - 150 gauze
- MST Cellulose (300)/LDPE - 150 gauze
- Poster paper/Al-foil (0.02 mm)/LDPE
- Al-foil 0.009 mm, 4-5°C 100% RH Poster paper laminate (0.02 mm)
- Al-foil 0.009 mm is found superior to MST-300/LDPE which has minimum keeping quality.

21.2.6 Paneer: All the properties of packaging material as required for Chhana are also required for Paneer. Vegetable parchment paper and PE bags are generally used. PE gives greater keeping quality (7 days at 5°C) than that given by vegetable parchment Paper. The Cryovac system using shrink film is being successfully used. Retortable tins are also used. Long life can be given by Metallized polyester or Nylon - PET / METPET/ PE or Aluminium foil or Nylon or LDPE/LLD.

Paneer is packed in tins along with the brine. These tins are sterilized and it may be having a slight cooked flavour and maillard browning which will increase with storage period. Paneer is also vacuum packed in laminated pouches to have an extended shelf

Packaging Of Dairy Products

life. Paneer is also packed in EVA/EVA/PVDC/EVA film under vacuum which may have a shelf life of 3 months under refrigeration

21.2.7 Rasogolla: Tin cans with resistant lacquer + SO₂ (100 ppm maximum) are generally used which gives highest shelf life to the product. Earthen pots which may be lined with leaves are also used in some areas of the country. HIPS or PP cups are also used along with heat sealable caps. Retailers use HIPS / polypropylene cups with press on lids.

21.3 PACKAGING OF DESICCATED INDIGENOUS DAIRY PRODUCTS

21.3.1 Packaging of khoa: Under existing trade practice, producers and traders do not employ any packaging for khoa. By employing proper packaging the shelf life of khoa can be enhanced. Hot packaging of khoa in pre-sterilized cans can improve the shelf life up to 14 days at room temperature and 75 days under refrigerated temperatures. Three times increase in shelf life was claimed by packing khoa in rigid polypropylene containers with lid and khoa packed in pre-sterilized laminate pouches (paper, Polyethylene and aluminium foil). Vacuum packaging and packing in Cryovac Shrink wrap pouches will prevent growth of aerobic micro organisms. However, these two packaging methods do not offer protection against bacteria growing inside khoa. Bulk packaging of khoa is done in PP buckets.

21.3.2 Packaging of peda: Peda is generally packed in paper board containers lined with parchment paper or grease proof paper. However, plastic trays, tubs can be used to pack peda to enhance its marketability. Paper board lined with PE or PP liner or glassine can be used. Glassine can also be used. Peda packed in multilayer transparent laminate pouches under modified atmospheric packing of Nitrogen and CO₂ has a shelf life of 15 days at room temperature and 30 days at 20 °C. Peda samples packed with oxygen scavenger exhibited a shelf life of 2 month at 37 °C and 6 months at 20 °C.

21.3.3 Packaging of kalakand: Glassine or parchment wrapper and packed in card board boxes / PE is used.

21.3.4 Packaging of burfi: Burfi is packed in paper board boxes inner lined with parchment paper in sizes of 500 gm, 1 kgs and 2 kgs.

Materials used are:

- LDPE, MSAT, HDPE, MSAT+HDPE,
- Glassine
- PE lamination: Saran/Cellophane/Saran/PE & Paper /Al-foil

The shelf life of burfi is about 10-15 days at room temperature

21.3.5 Packaging of Sandesh: Traditional studies are carried out with LDPE pouches. The packaging material used is similar to Chhana – 0.038 cm folding paper board cartons. 079, 0.08, 0.008 cm with Parchment liner having PS, HDPE bags, Nylon-6 and Tin cans 0.041 cm are used.

Tin cans, Nylon-6 and recent material CXA 148/LDPE is used. Folding paper board: PS/ HDPE/ Nylon-6, Tin. Earthen Pots are also used.

Leaves of Banana, etc. heat pressed to give shape are still in use in some rural areas of our country.

21.3.6 Packaging of Kulfi: Traditional Kulfi is packed in plastic or aluminium moulds which are partially thawed by dipping in fresh water to remove the Kulfi prior to serving. Kulfi is frozen as a cylindrical block, which is covered by an insulating cloth, and then sliced for serving by vendors. It may also be produced on stick.



Lesson-22

Concentrated and Dried Milks Including Baby Foods

22.1 INTRODUCTION

The shelf life of a dehydrated product is influenced to a large extent by the packaging, which must conform to certain special criteria.

These are:

- Protection of the dehydrated product against moisture, light, air, dust microflora, foreign odour, rodents etc.
- Strength and stability to maintain original container properties through storage, handling and marketing.
- Size, shape, appearance to promote marketability of the product.
- Composition of the container must be approved for use in contact with foods.
- Lower cost.

22.2 SELECTION OF PACKAGING MATERIALS

Dehydrated dairy products are generally hygroscopic in nature and even slightest increase of the moisture content will decrease the shelf life considerably. Hence, the packaging material should be impervious towards water vapour and such property is to be considered important for packing such products. When retention of low moisture content is the limiting factor of the shelf life of the product, the tests required to be made for determining the shelf life are: determination of

- The normal moisture content of the product
- The moisture content of the product at which the product becomes unacceptable to the consumer and
- The R.H. and temperature of the surrounding atmosphere at which the equilibrium moisture content is maintained in the product. Initial level to the level of unacceptability is calculated. From this data along with requirement for gas permeability etc. and utilizing the published data for different packaging material, the suitable packing material is selected.

22. 3 PROPERTIES OF DRIED MILK PRODUCTS RELEVANT TO PACKAGING

1. **Hygroscopicity** is the principal requirement which is important in small packs size where ratio of pack surface area to product is high. In tropical countries because of the high humidity prevailing, this is the important factor.
2. **Cohesivity** or the Cohesion of product is the serious stickiness problem particularly in high speed packaging lines. In case of powder, observations made on cohesivity are
 1. Cohesion increases with decreasing particle size.
 2. It is independent of fat content in the range of 20-40% Fat.
 3. A small amount of surface fat is sufficient to give cohesion to WMP.
 4. Increasing the moisture from 2 to 4%, cohesion first decreases and beyond 4% cohesion increases very fast.
3. **O₂ Sensitivity**: Preheating releases the -SH groups which protect against oxidization. However still there are chances of oxidation. Therefore for Fat containing products prevent the gas diffusion by employing either Vacuum or N₂ flushing.
4. **Light sensitivity**: Powder exposed to light for long period bleaches the surface and thereafter it accelerate Fat oxidization.
5. **Heat sensitivity**: Affect Flavour and Solubility. Ideal storage conditions are 18-19°C temperature and dry atmosphere.
6. **Bulk Density** is very important because Packaging size is affected. The Free flowing properties improves with increased Bulk Density.
7. **Odour pick up**: Product containing Fat is prone to pick up odour. High Fat powders pick up odour from packaging materials, surrounding atmosphere, stores, water and houses. The off flavour problem is encountered from kraft paper, PE film, CFB, fiber board cases and even from rubber sealing compositions.

8. **Static electricity:** The problem is difficult to resolve. The plastic packaging materials are also important where antistatic agents are added e.g. Glycol alkyl esters (prevent electrical charge accumulated on the film surface).
9. **Bacterial aspects:** Powders of normal moisture and RH do not give rise to bacterial problem.

22.4 REQUIREMENTS OF PACKAGE FOR DRIED MILKS

1. **Adequate mechanical strength** to withstand damage during packaging, handling, transportation and storage is necessary.
2. **Resistance to climatic hazards:** The material should be resistant to damage by exposure to high / low temperature and humid atmosphere. This is more important in tropical countries.
3. **Convenient closure:** Sealing is of supreme importance. Simple, effective re-closure is also desirable.
4. Bulk packages should be **light in weight, easy to handle and stack** during transport and storage. Empty packages should occupy minimum storage space before use.
5. **Very low Water vapour and gas permeability:** Dried milk absorbs moisture very easily. Powder with > 5 % moisture gets deteriorated during storage. The stale and gluey flavours result from Maillard reaction. It results in losses of solubility, colour change; lumping and free flowing properties are affected. For long storage, vacuum and N₂ flushing is essential especially in hot climate. An impervious container is needed which should also be odour-proof.
6. Impermeability to light: To avoid surface bleaching and fat oxidation.
7. Inertness, durable, safe, utilizing minimum space, identification of product and directions for use, easy availability at reasonable cost are the other requirements.

22.4.1 Packaging materials available:

1. Glass: Bottles, barrels, jars, etc.
 2. Metal: Cans, barrels, drums, bins, etc.
 3. Wood: Drums, bins, cask, barrels, etc.
 4. Paper and paper derivatives
 5. Metal foils
 6. Thermoplastics and their derivatives
 7. Composite films
- Co-polymer film
 - Coated film
 - Co-extruded plastic film
 - Laminates

22.4.2 Flexibles for powder:

1. Cartons lined with Al-foil-PE:
 - a. Bag-in-box: Coated Al-PE bag or plastic coated paper inside cartons.
 - b. Modified Atmosphere Packaging -80% N₂ and 20% CO₂ where O₂ content is reduced to 3.0%.
2. Long storage: Lacquer/print/print pre-lacquer, Al-foil (10 gsm)/Adhesive coated paper (40 gsm)/PE (30 gsm).
3. Shorter Keeping quality: Al-foil may be omitted. Paper thickness increased to ~ 70 gsm and coated with PVDC (30 gsm).
4. Bulk Packaging: Sacks made of craft paper laminates, parchment, polyethylene, Al, Cellophane, bitumen, wax or paraffin. Even cast films now are used recently.
Most common types:
 - WMP: Laminates of paper, PE, Foil, Metallized, BOPP/PE or PET.
 - SMP: HDPE or LDPE or Laminates of HD, LD, LLD, Nylon, Saran (coating), EVA. PE coating or wrinkling- Bag-in-box paper board/lined with paper, Al or Metallized/PE
5. Powder packaging materials:
 1. Number of Kraft paper layers for strength required is 3-6 for 25 kg wt.
 2. Outer Kraft paper bag strength 70 gsm, Second Kraft paper bag with paper alone. PE lined (95 gsm).
 3. WMP: 4-6 ply kraft paper, 3 mm PE
 4. SMP: 2-4 ply kraft paper 2 mm PE
 5. Separate PE liner/inner bag – 0.04 mm for 25 kg & 0.05 mm for 50 kg.
 6. PE varies in thickness from 0.02 to 0.08 mm as inside layer.

22.4.3 Retail packages:

1. Thick laminated paper (45 gsm) – Al-foil (9 μ) – PE (25 μ) having Bursting strength 179 KPa (1.83 kg.f/ cm²) and very low WVTR & GTR.
2. PET (12.5 μ)/Al-foil (9 μ) / PE (64 μ), Bursting strength 290 KPa (2.95 kg.f/ cm²).

Packaging Of Dairy Products

- Form – Fill – Seal: 17 μ PET / 9 μ PE – 9 μ foil – 70 μ PE
- Metallized film is also used. Lined cardboard – Adhesive / Coating of PVDC or RHC – Metallized PET / Al-foil / PE.
- Metal/Plastic laminate – Retain O₂ content of 0.5 % even after 13 numbers.
Bulk: Heavy gauge PE used mainly for sea voyage (passing through tropics).

3. PE is used to much lesser extent as a separate bag within or as a liner for (a) Card board cartons, (b) Calico bags, (c) Jute bags with paper, (d) Liner between jute and PE.

4. Alternative material to PE:

- Multi walled paper sack may incorporate one layer of waxed paper which is more satisfactory than paper alone but is inadequate for long storage.
- Multi wall sack may include a layer of bituminized paper, often the outer layer with 4-5 inner kraft layers. This is a good packaging material used even for export but is slightly inferior to PE.

5. Perfect closure is required:

- Metal is completely impervious but closure is a weak point.
- Sack is sealed by sewing threads which makes holes and therefore it is covered by H₂O proof tape.
- Gas packaging by mixture of N₂ + H₂ + Palladium as a catalyst and if kept impervious can have up to 10 years of storage life.

22.5 WHOLE MILK POWDER AND BABY FOOD

Generally packed in Lacquered tins under N₂ gas packaging. Whole milk powder is packed in 15 kg tins. For retail milk powder s packed in laminate bags made of PET /Al / PE.

22.6 SKIM MILK POWDER

Skim milk in bulk quantities of 25 kg is packed in kraft paper bags with inside polyethylene bag. Skim milk powder for retail is packed in HDPE bottles and HDPE bags.

22.7 MALTED MILK FOOD

The malted food beverage industry is popularly known as the health beverage sector. Historically, malted beverage has a strong association with milk. The Indian health beverages market is divided into white and brown health drinks. White beverages contribute about 65% of the market.

Malted milk foods are highly sensitive to moisture and are prone to oxidative changes in the presence of light, heat and oxygen. Aroma retention of the product and prevention of moisture and oxygen ingress are important and therefore are very critical in protecting the product, and in selection of the right packaging material.

Malted milk foods are packed in quantities of 200 grams to 1 kilogram in a variety of packages. The types of packages used conventionally are glass jars, tinplate containers, which are now slowly being replaced by plastic containers and flexible laminated pouches. Though glass containers are hygienic and safe and offer the advantage of a long shelf-life, it has the disadvantage of being heavy, fragile and costly. Tinplate containers though provide good protection from gases and moisture, are likely to rust at body welding or at top and bottom seams. Tinplate containers are also expensive.

The plastic containers used are blow moulded HDPE or HM- HDPE or stretch blow moulded PET containers / jars, for brown and white malted milk food products for capacities ranging from 200 grams to 2.5 kilograms. The plastic containers are light weight, sturdy, unbreakable and hygienic, and have a good shelf appeal.

Besides the plastic containers, the trend is also to use flexible pouches, which may be with or without paperboard cartons. This type of pack has an advantage of low cost compared to plastic bottles. Moreover, the storage space requirement is low and the filling operation is comparatively faster.

Some of the typical structures of flexible materials used are:

1. 50 and 100 grams
 - a. 12 μ PET/12 μ metallised PET/38 μ LDPE

Packaging Of Dairy Products

2. 500 grams
 - a. 12 μ PET/20 μ metallised BOPP/50 μ LDPE
 - b. 12 μ PET/12 μ metallised PET/50 μ LDPE
3. 1000 grams
 - a. 12 μ PET/12 μ metallised PET/65 μ LDPE

22.8 PRECAUTIONS BEFORE PACKAGING

Protection against moisture pick up: The low moisture products must be packaged as soon as possible after removal from the dehydrator. Each product has its individual need with regard to moisture uptake.

22.8.1 In-package desiccation: In-package desiccation has been used successfully for many dried products, particularly powders. The desiccant compound is placed in the container inside a small envelop made out of a moisture permeable material which does not allow the contamination of the product with desiccant, Calcium oxide or silica gel are usually used for this purpose. When in package desiccant is used, the dried product can be stored at higher moisture content without caking than in the absence of a desiccant. However, this is not used for milk powders.

22.8.2 Anticaking agents: Anticaking agents are mixed with the low moisture product usually during the milling operation. Calcium Stearate is the most commonly used Anticaking agent in dehydrated products. This is also not used in case of milk powders.

22.8.3 Packaging of condensed milk and evaporated milk:

In the early days sweetened condensed milk in bulk is packed in barrels made of gumwood. Later white oak, paraffin lined barrels were used 50 to 300 kg.

For industrial purposes steel drum containers with removable lids are used which are suited for re-use.

For retail marketing, sweetened condensed milk is packed in lacquered hermitically sealed tin can (400 gm)/ FK can. Most tins used are open top tins, the top end of which is clinched on to the can after filling. The tins are filled in automatic filling machines. The tins should be filled as completely as possible to ensure that as much

as less space remains in the head space. The temperature of filling room is maintained around 16° C. the tins and lids should be sterilized by super heated steam/ hot air or U.V radiation before use.

Aluminium cans filled with condensed milk will not be subsequently sterilized, strict sanitary conditions should be observed during filling by process sealing.

Evaporated milk is packed in cans before sterilization.



Lesson-23

Vacuum and Modified Atmosphere Packaging (MAP)

23.1 INTRODUCTION

Modified Atmosphere packaging (MAP) is a technique that is being used to extend the shelf life of fresh foods such as meat, fish and cut fruit, as well as of various bakery products, snack foods and other dried foods. In this method of packaging air in a package is replaced with a gas composition that will retard microbial growth and slow down chemical deterioration of the food.

Modified atmosphere packaging (MAP) is defined as 'the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air.

MAP is the alteration of the gaseous environment produced as a result of respiration (passive MAP) or by the addition and removal of gases from food packages (active MAP) to manipulate the levels of O₂ and CO₂.

23.2 HISTORICAL DEVELOPMENT

The first commercial application of modified gas atmospheres was for Controlled Atmosphere Storage (CAS) of fruits and vegetables. Scientific investigations on the effect of gases on extending the shelf life of foods were conducted in 1930 on fresh meat. Fresh carcass meat was exported from New Zealand and Australia under CAS in the early 1930s. Numerous researchers have reported the increase of shelf life of meat products when they were stored in an atmosphere of CO₂. Commercial retailing of fresh meat in MAP tray systems was introduced in European market in the early 1970s.

In the past few years, there has been a considerable increase in the range of foods packed in modified atmospheres for retail sale including meat, poultry, fish, bacon, bread, cakes, and cheese products packed under MAP.

The three main gases used in MAP are O₂, CO₂ and N₂. The choice of gas is totally dependent upon the food product being packed. Used singly or in combination, these gases are commonly used to balance extension of shelf life with optimal organoleptic properties of the food. Experimental use of carbon monoxide (CO) and sulphur dioxide (SO₂) has also been reported. The exact composition of the gas used will depend entirely on the type of food being packaged and the biological process being controlled.

Modified atmosphere packaging is generally used in combination with refrigeration to extend the shelf life of fresh, perishable foods. Depleted O₂ and/or enriched CO₂ levels can reduce respiration, delay ripening, decrease ethylene production, retard textural softening, slow down compositional changes associated with ripening, thereby resulting in extension of shelf life. Generally, 3–8% CO₂ and 2–5% O₂ are recommended for fruits and vegetables for MAP storage (Farber, 1991).

Gaseous atmosphere is modified by

1. Direct injection of gases (often CO₂ or nitrogen) into a package,
2. Evacuating air from the package and filling with required gas.

Modified atmosphere packages have an atmosphere different from ambient air but, that atmosphere can change over time. In the case of produce, package atmosphere is affected by the transmission rates of the packaging material and changes in storage temperatures. Higher temperatures lead to higher respiration rates, creating lower O₂ levels in the package atmosphere and higher concentrations of CO₂. Hence, the atmosphere inside the package is modified but not controlled.

Most MAP foods are packaged in transparent film to allow the retail customer to view the food. One of the most widely used packaging film for MAP is low density polyethylene (LDPE).

Packaging materials that are in use for MAP are

- Ethylene vinyl alcohol (EVOH)
- Polyethylenes (PE)
- Polyamides (PA)
- Polyethylene terephthalate (PET)
- Polypropylene (PP)
- Polystyrene (PS)

Packaging Of Dairy Products

- Polyvinyl chloride (PVC)
- Polyvinylidene chloride (PVDC)

Selection of these plastic packaging materials are based on the following attributes

1. Food contact approval
2. Gas and vapour barrier properties
3. Optical properties
4. Antifogging properties
5. Mechanical properties
6. Heat sealing properties

23.2.1 Advantages of MAP

1. Fresh appearance
2. Potential shelf life increase by 50-400%
3. Product can be distributed to long distances
4. High quality product
5. User friendly

23.2.2 Disadvantages of MAP

1. Added cost
2. Temperature control is necessary during storage.
3. Special equipment is required

23.3 DAIRY PRODUCTS PACKED BY MAP

MAP has the potential to increase the shelf life of a number of dairy products like fat-filled milk powders, fat spreads and cheeses.

Whole milk powder is particularly susceptible to the development of off-flavours due to fat oxidation. Commercially, the air in the pack is removed under vacuum and replaced with 100% N₂ or N₂/CO₂ mix and the powder is hermetically sealed in metal cans where in product will have low levels of residual O₂ (<1%). Use of O₂ scavengers may also be used.

Cheddar cheese is traditionally vacuum packed while MAP is being used with high concentration of CO₂ gas mixes and it is important to maintain the balance of correct CO₂ level in the gas mix so as to avoid excessive pressure being put on the pack seal. The cottage cheese is a high-moisture, low-fat product that is susceptible to a number

of spoilage organisms including *Pseudomonas* spp. Use of N₂/CO₂ atmospheres showed significant extension of the shelf life of cottage cheese. Gas mixtures containing CO₂:N₂ in the proportion of 40:60 can increase the shelf life of cottage cheese significantly.

23.4 VACUUM PACKAGING

An alternative to controlling or modifying the atmosphere is vacuum packaging, where all of the gas in the package is removed. This can be a very effective way of retarding chemical changes such as development of oxidative rancidity, but care needs to be taken to prevent the growth of the pathogen, *C. botulinum*, which grows under anaerobic conditions. A specific pasteurisation process, referred to as the *psychrotrophic botulinum* process, is applied to the packaged food to reduce its numbers to commercially acceptable levels. By using vacuum packaging, and chilled storage, greatly extended shelf-lives have been achieved. This was the basis of *sous-vide* cooking, which originated in France as a method of manufacturing high-quality meals for restaurant use with up to 42 days shelf life when stored below 3 °C. The thermal process has evolved since the original *sous-vide* concept of pasteurising at 70 °C for 40min, and the target process is now 90 °C for 10min. Cleanliness of the packaging materials is a key requirement to achieve the extended shelf life.

Table 23.1 Shelf life of vacuum packaged foods

Food	Stored In	Normal Shelf Life	Shelf Life of Vacuum packaged product
Cheese	Refrigerator	1-2 weeks	4-8 months
Cookies, crackers	Room temperature (periodically opening)	1-2 weeks	3-6 weeks
Flour, sugar, rice	Room temperature	6 months	1-2 years
Nuts	Room temperature	6 months	2 years
Oils with no preservatives, like safflower, canola, corn oil	Room temperature	5-6 months	1-1.5 years



Lesson-24

Eco Friendly Packaging

24.1 INTRODUCTION

Packaging is an essential component in the complex distribution system. The main aim of packaging is to safeguard the food material from microbial attack and other contaminants and prevent damage during the distribution. There is huge demand for the packaging material, which will be causing huge environmental concerns as they are majorly plastics which will degrade very slowly. In order to overcome this problem “**Biodegradable Packaging**” has emerged.

24.2 DEFINITION OF BIO-PACKAGING MATERIALS

“Biobased food packaging materials are materials derived from renewable sources. These materials can be used for food applications”. The renewable sources are from plants, marine life and animals.

24.3 DEGRADABLE PLASTIC

Plastic designed to undergo significant change in its chemical structure under specific environmental conditions, resulting in loss of some properties that may be measured by standard methods appropriate to the plastic and application in a period of time that determines its classification.

24.4 BIODEGRADABLE PLASTIC

Degradable plastic in which the degradation must result from the action of naturally occurring micro organisms.

24.5 COMPOSTABLE PLASTIC

Plastic that undergoes biological degradation during composting to yield carbon dioxide, water, inorganic compounds and biomass at a rate consistent with other

known compostable materials and leaves with no visually distinguishable or toxic residues.

24.6 POLYMERS DIRECTLY EXTRACTED FROM BIOMASS

These are the material, which find their origin from the marine and agriculture, animals and plants. They are having very good “**Gas barrier property**”. These materials are hydrophilic, by nature and are crystalline, because of which they cause problems to certain extent, mainly in the Packaging of **moist food products**.

24.6.1 Polysaccharides: The polysaccharides of interest from Packaging material point of view are cellulose, starch, gums, and chitosan. The more complex polysaccharides produced by fungi and bacteria such as xanthan, curdlan, pullan and hyaluronic acid are of greater interest in the future.

24.6.2 Starch and its Derivatives: The principle source of starch is Corn and Potatoes. The starch is a very competitive material as compared to the other plastics. As a packaging material, starch alone does not form films with adequate mechanical properties unless it is first treated by either plasticization, blending with other materials, genetic or chemical modification or combinations of the above approaches.

24.6.3 Cellulose and its derivatives: Cellulose is the most commonly available polymer on the earth. Because of its regular structure and array of hydroxyl groups, it tends to form strongly hydrogen bonded crystalline microfibrils and fibres and is most familiar in the form of paper or cardboard in the packaging industries. Cellulose is a cheap raw material, but difficult to use because of its hydrophilic nature, insolubility and crystalline structure.

24.7 THE BIOBASED POLYMERS AND THEIR SOURCES

24.7.1 Biobased Polymers: Cellophane film; it is very hydrophilic in nature and has good mechanical Properties. In order to improve the **barrier properties** of the packaging material the cellophane is coated with other plastic materials like Saran etc.

24.7.2 Nitrocellulose, wax or PVC or PVDC (Poly Vinylidene chloride)

Cellulose acetate (C.A), is the most commonly used Packaging material in food industry.

24.7.2.1 Uses of packaging material in foods

- Baked Goods.
- Processed Meat.
- Cheese and its products.
- Candies.

24.7.3 Chitin: Chitin is chemically composed of repeating units of 1,4-linked deoxy-2-acetoamido-D-glucose, and chitosan refers to a family of partially N-acetylated 2-deoxy-2-amino-.glucan polymers derived from chitin. It is the second most abundant polysaccharide material available after cellulose.

24.7.4 Chitosan: Chitosan also readily forms films and, in general, produces materials with very high gas barrier properties. It is widely used for the production of edible coating. The cationic properties of chitosan offer good opportunities to take advantage of electron interactions with numerous compounds during processing and incorporating specific properties into the material. The advantages of this material include antimicrobial property and their ability to absorb the heavy metals. The application of laminates made of chitosan, cellulose, and polycaprolactone in Modified Atmospheric Packaging (MAP) have been tested and was effectively performed.

24.7.5 Proteins: A protein is considered to be a random copolymer of amino acids and the side chains are highly suitable for chemical modification which is helpful to the material engineering, for getting required properties of the Packaging material. The proteins can be divided into two categories, 1) Plant origin and 2) Animal origin.

- Plant origin: Gluten, Soya, Pea, Potato.
- Animal origin: Casein, Whey, Collagen, Keratin.

The Properties of Proteins used in Packaging material:

1. High gas barrier property.
2. Efficient and suitable application for packaging of foods.

The major drawback of these protein polymers is their sensitivity to relative humidity.

24.7.6 Animal Origin:

24.7.6.1 Casein: Casein is a milk-derived protein. It is easily processable due to its random coil structure. Upon processing with suitable plasticizers at temperatures of 80- 100°C, materials can be made with mechanical performance varying from stiff and brittle to flexible and tough performance. Casein melts are highly stretchable making them suitable for film blowing. In general, casein films have an opaque appearance. Casein materials do not dissolve directly in water. The main drawback of casein is its relatively high price. Casein was used as a thermoset plastic for buttons in the 1940's and 50's.

24.7.6.2 Whey: Whey proteins are by-products from the cheese production. They have relatively high nutritional value, are available in large amounts worldwide and have been extensively investigated as edible coatings and films. Whey proteins are readily processable and have some potential as exterior films, if, used with gelatin, suitable modification strategies can be developed to reduce moisture sensitivity.

24.7.6.3 Collagen: Collagen is a fibrous, structural protein in animal tissue, particularly skin, bones and tendons. Collagen is a flexible polymer. However, because of its complex helical and fibrous structure, collagen is very insoluble and difficult to process. Collagen is the basic raw material for the production of gelatine, a common food additive with potential for film and foam production. Gelatine is a very processable material, but it is extremely moisture sensitive.

24.7.6.4 Keratin: Keratin is by far the cheapest protein. It can be extracted from waste streams such as hair, nails and feathers. Due to its structure and a high content of cysteine groups, keratin is also the most difficult protein to process. After processing, a fully biodegradable, water-insoluble-plastic is obtained. However, mechanical properties of this plastic are still poor compared to the proteins mentioned above. The main drawback of all protein plastics, apart from keratin, is their sensitivity to relative humidity. Either blending or lamination can circumvent this problem.

24.7.7 Plant Origin:

24.7.7.1 Gluten: Gluten is the main storage protein in wheat and corn. Gluten plastics exhibit high gloss (polypropylene like) and show good resistance to water under certain conditions. They do not dissolve in water, but they do absorb water during immersion. Due to its abundance and low price, research on the use of gluten in edible films, adhesives, or for thermoplastic applications is currently being carried out.

24.7.7.2 Soy Protein: Soy proteins are commercially available as soy flour, soy concentrate and soy isolate, all differing in protein content. Soy protein consists of two major protein fractions referred to as the 7S (conglycinin, 35%) and 11S (glycinin, 52%) fraction. Both 7S and 11S contain cysteine residues leading to disulphide bridge formation and processing is, therefore, similar to gluten with similar mechanical properties. The best results are obtained with soy isolate (approx.90% protein). This behaviour in water is similar to that of gluten plastics. The most successful applications of soy proteins are paper coatings.

24.7.7.3 Potato: Potato starch produces a more translucent plastic. The potato starch plastic display significantly greater water absorption than those made from other sources.

24.7.7.4 Zein: Zein comprises a group of alcohol soluble proteins (prolamines) found in corn endosperm. Film-forming properties of zein have been recognized for decades and are the basis for most commercial utilization of zein. Films may be formed by casting, drawing or extrusion techniques (Reiners et al., 1973). The films are brittle and need plasticizers to make them flexible. Zein-based films show a great potential for uses in edible coatings and biobased packaging.

24.8 POLYMERS PRODUCED FROM CLASSICAL CHEMICAL SYNTHESIS FROM BIOBASED MONOMERS

Using classical chemical synthesis for the production of polymers gives a wide spectrum of possible “bio-polyesters”. To date, polylactic acid is the polymer with the highest potential for a commercial major scale production of renewable packaging

materials. However, a wide range of other bio polyesters can be made. In theory, all the conventional packaging materials derived from mineral oil today can in the future be produced from renewable monomers gained by e.g. fermentation.

24.8.1 Polylactic Acid (PLA): Lactic acid, the monomer of polylactic acid (PLA), may easily be produced by fermentation of carbohydrate feedstock. The carbohydrate feedstock may be agricultural products such as maize, wheat or alternatively may consist of waste products from agriculture or the food industry, such as molasses, whey, green juice, etc.

PLA is polyester with a high potential for packaging applications. The properties of the PLA material are highly related to the ratio between the two meso-forms (L or D) of the lactic acid monomer. Using 100% L-PLA results in a material with a very high melting point and high crystallinity. If a mixture of D- and L-PLA is used instead of just the L-isomer, an amorphous polymer is obtained with a T_g (Temperature gradient) of 60°C, which will be too low for some packaging purposes. A 90/10% D/L copolymer gives a material which can be polymerized in the melt, oriented above its T_g and is easy processable showing very high potential of meeting the requirements of a food packaging. Furthermore, PLA may be plasticized with its monomer or, alternatively, oligomeric lactic acid and the presence of plasticizers lower the T_g.

24.9 POLYMERS PRODUCED DIRECTLY BY NATURAL OR GENETICALLY MODIFIED ORGANISMS

Polyhydroxyalkanoates (PHAS) are the polyester compounds that are accumulated by a major group of bacteria as carbon reserve (Energy source), of which the main polyester is Polyhydroxybutyrate (PHB). Two more PHAS were discovered namely 3-hydroxy butyrate (PHB) and 3-hydroxyl valerate (PHBV). As these both are known for their compositability and biodegradability they are generally used for packaging material production. The very important property of the PHAS, is their low water vapour permeability which is essential requirement in food packaging. Medium chain length PHAS, behave as elastomers with crystals acting as physical crosslinks and, therefore, can be regarded specific of its mechanical properties. Elongation to break up to 250-350% has been reported and a Young's modulus up to 17 MPa. These materials

Packaging Of Dairy Products

have a much lower melting point and T_g than their PHBS. The major application of medium chain length PHAS are biodegradable cheese coatings and biodegradable rubbers.

24.9.1 PHAS from bacteria:

The major packaging compounds of the bacteria are “Bacterial Cellulose”. Strains of *Acetobacter xylinum*, *Acetobacter pasteurianus* are capable of producing cellulose (*homo* \hat{a} *1-4 glucane*). The cellulose thus produced from bacteria is processed at ambient conditions where the degree of *polymerization* is 15000, crystalline in nature. This technique is not that successful on the economic terms as its production cost is very high.

24.10 BIO PACKAGING OF FOODS

Most commonly used food packages clearly fall into primary, secondary or tertiary packaging categories. For a variety of food products, however, conventional packaging does not provide optimal conditions for product storage and a number of approaches are used to design packages for specific products. Such product-specific packaging includes applying of edible films and coatings, active packaging, modified atmosphere packaging (MAP), and using combinations of packaging materials. Of these packaging techniques specified above bio films or *edible films* are of importance.

24.10.1 Edible Films:

Edible coatings and films comprise a unique category of packaging materials differing from other biobased packaging materials and from conventional packaging by being edible. Edible coatings are applied and formed directly on the food product either by addition of a liquid film-forming solution or molten compounds. They may be applied with a paintbrush, by spraying, dipping or fluidising. Edible coatings form an integral part of the food product, and hence should not have impact on the sensory characteristics of the food. Edible films, on the other hand, are freestanding structures, formed and later applied to foods. They are formed by casting and drying film-forming solutions on a levelled surface, drying a film-forming solution on a drum drier, or using traditional plastic processing techniques, such as extrusion. Edible

films and coatings may provide barriers towards moisture, oxygen (O₂), carbon dioxide (CO₂), aromas, lipids, etc., carry food ingredients (e.g. antimicrobial, antioxidants, and flavour components). Edible films and coatings may be used to separate different components in multi-component foods thereby improving the quality of the product.

They may be used to reduce the amount of primary synthetic packaging material used in a product or allow conversion from a multi-layer, multi-component packaging material to a single component material. Edible coatings may also help maintain food quality by preventing moisture and aroma uptake or loss, etc. after opening of the primary packaging.

Biobased packaging materials must meet the criteria that apply to conventional packaging materials associated with foods. These relate to barrier properties water, gases, light, aroma, optical properties, strength, welding and moulding properties, marking and printing properties, migration requirements, chemical and temperature resistance, disposal requirements, antistatic properties besides being user-friendly and cheap.

Biobased packaging materials must also comply with food and packaging legislation, and interactions between the food and packaging material must not compromise food quality or safety.

24.11 APPLICATION OF BIODEGRADABLE PACKAGING IN DAIRY INDUSTRY

The potential biobased packaging materials which are tested for dairy products are as follows:

1. Cheese and Varieties: The packaging materials which can be used are starch laminates and nitrocellulose lacquered cellophanes as they have good moisture and gas barrier properties.
2. Yoghurt, Fermented foods: The packaging material can be Biodegradable plastics, PLA, as they have good mechanical, CO₂ and moisture barrier properties.
3. Butter and Fat rich products: The packaging material can be Laminate, Butter paper, PLA, PLA + PCL which possess good moisture and Light barrier properties.
4. Ice Cream: The packaging materials which can be used are Acetylated monoglycerides as they possess good moisture barrier properties.

24.12 RECENT TECHNOLOGIES FOR PRODUCING BIODEGRADABLE PLASTICS

Bio – degradable plastics are being produced from plants by Fermentation, Recombinant DNA engineering etc.



Lesson-25

Active Packaging

25.1 INTRODUCTION

Active packaging refers to the incorporation of certain additives into packaging film or within packaging containers with the aim of maintaining and extending product shelf life (Day, 1989). Packaging may be termed active when it performs some desired role in food preservation other than providing an inert barrier to external conditions (Rooney, 1995; Hotchkiss, 1994).

Active packaging includes additives or *freshness enhancers* that are capable of scavenging oxygen; adsorbing carbon dioxide, moisture, ethylene and/or flavour/odour taints; releasing ethanol, sorbates, antioxidants and/or other preservatives; and/or maintaining temperature control

Packaging material itself plays an active role in improving the shelf life of product by holding the growth of spoilage microorganisms and such packaging is called “active”, “smart”, “functional”, and “freshness preservative packaging”. Various kinds of active substances can be incorporated into the packaging materials to improve its functionality and give it an extra function. Such active packaging technologies are designed to extend the shelf life of foods while maintaining their nutritional quality and safety.

“Active packaging technologies involve interactions between the food, the packaging materials and the internal gaseous atmosphere and its main objectives are :

1. Shelf life extension
2. Easier handling
3. Preserve quality of the product

Active packaging is not synonymous with intelligent or smart packaging, which refers to packaging that senses and informs.

25.2 ACTIVE PACKAGING SYSTEMS

There are many varieties of active packaging techniques that are being followed. A list of techniques followed is being enlisted in the table 25.1 and are discussed in this chapter.

Table 25.1 Selected examples of active packaging systems

Active packaging system	Mechanisms	Food applications
Oxygen Scavengers	<ol style="list-style-type: none"> 1. Iron based 2. Metal/acid 3. Metal (e.g. platinum) catalyst 4. Ascorbate/Metallic salts 5. Enzyme based 	Bread, Cakes, Cooked rice, Biscuits, Pizza, Pasta, Cheese, Coffee, Snack foods, Dried foods and Beverages
Carbon Dioxide Scavengers/Emitters	<ol style="list-style-type: none"> 1. Iron oxide/calcium hydroxide 2. Ferrous carbonate/metal halide 3. Calcium oxide/activated charcoal 4. Ascorbate/sodium bicarbonate 	Coffee, Nuts and other Snack food products and Sponge cakes
Ethylene Scavengers	<ol style="list-style-type: none"> 1. Potassium permanganate 2. Activated carbon 3. Activated clays/zeolites 	Fruit, Vegetables and Other horticultural products
Preservative Releasers	<ol style="list-style-type: none"> 1. Organic acids 2. Silver zeolite 3. Spice and herb extracts 4. BHA/BHT antioxidants 5. Vitamin E antioxidant 6. Volatile chlorine dioxide/ sulphur dioxide 	Cereals, Bread, Cheese, Snack foods, Fruit and Vegetables
Ethanol Emitters	<ol style="list-style-type: none"> 1. Alcohol spray 	Pizza crusts, Cakes, Bread, Biscuits, Bakery products

	2. Encapsulated ethanol	
Moisture Absorbers	1. PVA blanket 2. Activated clays and minerals 3. Silica gel	Snack Foods, Cereals, Dried foods, Sandwiches, Fruit and Vegetables
Flavour/Odour Adsorbers	1. Cellulose triacetate 2. Acetylated paper 3. Citric acid 4. Ferrous salt/ascorbate 5. Activated carbon/ clays/ zeolites	Fried Snack foods, Cereals, Dairy products and Fruits
Temperature Control Packaging	1. Non-woven plastics 2. Double walled containers 3. Hydrofluorocarbon gas 4. LIME/water 5. Ammonium nitrate/water	Ready meals and Beverages

25.2.1 Oxygen scavengers: Oxygen scavengers were first marketed in Japan in 1976 by the Mitsubishi Gas Chemical Co. Ltd under the trade name Ageless™. Oxygen scavengers are the most commercially important among active packaging. The common most well known oxygen scavengers are applied in the form of small sachet containing various iron based powders combined with a suitable catalyst which have capability of reducing oxygen levels to less than 0.01% in the pack. Non-metallic scavengers use organic reducing agents such as ascorbic acid, ascorbate salts or catechol. Enzymic oxygen scavenging systems are also used with either glucose oxidase or ethanol oxidase which could be incorporated into sachets, adhesive labels or immobilised onto packaging film surfaces.

Some examples of oxygen scavengers used in food industry are

1. Laminate containing a ferrous oxygen scavenger which can be thermoformed into a tray which has been used commercially for cooked rice
2. Oxygen scavenging plastic (PET) beer bottles

3. Light activated oxygen scavenger plastic packaging materials for Beverage industry

25.2.2 Carbon dioxide scavengers/emitters: There are many commercial sachet and label devices which can be used to scavenge or to emit carbon dioxide.

The use of carbon dioxide scavengers is particularly used in packing fresh roasted or ground coffees that produce significant volumes of carbon dioxide. A mixture of calcium oxide and activated charcoal has been used in polyethylene coffee pouches to scavenge carbon dioxide. Dual-action oxygen and carbon dioxide scavenger sachets and labels are more common and are commercially used for canned and foil pouched coffees in Japan and USA.

Carbon dioxide emitting sachet and label devices can either be used alone or combined with an oxygen scavenger.

Dual action oxygen scavenger/carbon dioxide emitter sachets and labels are also developed, which absorb oxygen and generate an equal volume of carbon dioxide.

The main food applications for these dual-action oxygen scavenger/carbon dioxide emitter sachets and labels have been with snack food products, e.g. nuts and sponge cakes.

25.2.3 Ethylene scavengers: Ethylene (C_2H_4) is a plant growth regulator which accelerates the respiration rate and subsequent consequences of horticultural products such as fruits, vegetables and flowers.

Potassium Permanganate ($KMnO_4$) immobilised on an inert mineral substrate such as alumina or silica gel. $KMnO_4$ oxidises ethylene to acetate and ethanol and in the process changes colour from purple to brown and hence indicates its remaining ethylene scavenging capacity.

Activated carbon-based scavengers with various metal catalysts can also effectively remove ethylene.

25.2.4 Ethanol emitters: Ethanol is an antimicrobial agent particularly effective against mould but can also inhibit the growth of yeasts and bacteria. Ethanol can be sprayed directly onto food products just prior to packaging. A practical and safer method of generating ethanol is through the use of ethanol-emitting films and sachets. All of these films and sachets contain absorbed or encapsulated ethanol in a carrier material which allows the controlled release of ethanol vapour.

25.2.5 Preservative releasers: There is a potential use for antimicrobial and antioxidant packaging films which have preservative properties for extending the shelf life of a wide range of food products. Some commercial antimicrobial films and materials have been introduced, primarily in Japan. One widely reported product is a synthetic silver zeolite which is in contact with packaging film that release slowly antimicrobial silver ions into the surface of food products.

The anti microbial agents generally used on packaging materials include organic acids, e.g. propionate, benzoate and sorbate, bacteriocins, e.g. nisin, spice and herb extracts, e.g. from rosemary, cloves, horse radish, mustard, cinnamon and thyme, enzymes, e.g. peroxidase, lysozyme and glucose oxidase, chelating agents, e.g. EDTA, inorganic acids, e.g. sulphur dioxide and chlorine dioxide and antifungal agents, e.g. imazalil and benomyl. The major potential food applications for antimicrobial films include bread, cheese, fruits and vegetables.

25.2.6 Moisture absorbers: Excess moisture cause food spoilage which can be reduced by using various absorbers or desiccants which in turn helps in maintaining food quality and extending shelf life by inhibiting microbial growth and moisture related degradation of texture and flavour.

Several companies manufacture moisture-drip absorbent pads, sheets and blankets which consist of two layers of a microporous non-woven plastic film, such as polyethylene or polypropylene, between which is placed a superabsorbent polymer capable of absorbing up to 500 times its own weight of water which is used for foods such as meats, fish, poultry, fruit and vegetables. Typical superabsorbent polymers include polyacrylate salts, carboxymethyl cellulose (CMC) and starch copolymers which have a very strong affinity for water.

Packaging Of Dairy Products

Moisture drip absorber pads are commonly placed under packaged fresh meats, fish and poultry to absorb unsightly tissue drip exudate. Larger sheets and blankets are used for absorption of melted ice from chilled seafood during air freight transportation, or for controlling transpiration of horticultural produce.

Microporous sachets of desiccant inorganic salts such as sodium chloride have been used for the distribution of tomatoes in USA. Another example is an innovative fibreboard box which functions as a humidity buffer on its own without relying on a desiccant insert which is used for fruits or vegetables

25.2.7 Flavour/odour adsorbers: The interaction of packaging with food flavours and aromas has long been recognised. Commercially, very few active packaging techniques have been used to selectively remove undesirable flavours and taints, but many potential opportunities exist.

Debittering of pasteurised orange juices by using cellulose triacetate or acetylated paper into orange juice packaging material. is one of the example for such methods.

BMH™ powder can be incorporated into packaging Removal of aldehydes such as hexanal and heptanal from package headspaces has its applications in foods such as snack foods, cereals, dairy products, poultry and fish.

Another packaging material which is paper-based, which absorbs odorous aldehydes in the pore interstices of the powder is manufactured by EKA Noble in co-operation with Dutch company Akzo.

25.2.8 Temperature controlled packaging: Temperature control active packaging includes the use of innovative insulating materials, self-heating and self-cooling cans.

Self-heating aluminium and steel cans and containers for coffee, tea and ready meals are heated by an exothermic reaction which occurs when lime and water positioned in the base are mixed. Self-cooling cans have also been marketed in Japan. The endothermic dissolution of ammonium nitrate and chloride in water is used to cool the product.

25.2.9 Quality indicators: Time / temperature indicators may be fixed to the package which monitors the product temperature exposure throughout the supply chain. They will indicate how long the food product was above the threshold temperature. They provide a non-reversible record of temperature exposure that is accurate and easy to interpret.

Uses: 1. Time / temperature indicators are available in a variety of time and temperature ranges and may be used to monitor the cold chain for perishable food products.

2. To monitor the temperature exposure of sensitive food products during transportation and storage.



Lesson-26

Different Methods of Package Sterilization, Importance of such methods and Principles

26.1 INTRODUCTION

Sterilization of packaging material is a very important operation to free the surface from microorganisms before filling the product.

26.2 CHARACTERISTICS OF GOOD STERILANT /STERILIZING AGENT

1. Rapid sporicidal activity
2. Ease of application and compatibility with packaging machinery.
3. Compatibility with packaging material
4. Ease of removal of residues
5. No detrimental effects of residues on the package/ product
6. Should be economical
7. Easy to Handle.

26.3 METHODS OF PACKAGE STERILIZATION

Many methods are presently in use. They are briefly discussed here in this chapter.

26.3.1 Dry Heat: The packaging material is heated in a hot air oven for a specified minimum temperature for a stated time. Various combinations of temperature and time are recommended depending on the type of the material being sterilized; for example, the usual recommended minimum holding times and temperatures are 180 °C for 30 minutes for glassware.

26.3.2 Super Heated Steam systems: Metal containers were the first used in aseptic operations and are still in use today. In this system, sterilization of the metal container and its closure is accomplished by the application of heat using super heated steam. The advantage of this system is that it can achieve high temperatures at atmospheric pressure; however micro organisms are more resistant to superheated steam than saturated steam.

26.3.3 Hydrogen peroxide systems: A number of systems are utilizing hydrogen peroxide in combination with heat and *I* or other adjuncts. In this system, the

packaging material is not metal and it comes in rolls rather than in preformed containers. The rolls are continuously fed into a vertical machine which sterilizes, forms, fills, and seals the package. Sterilization is accomplished with a combination of hydrogen peroxide and heat.

A second system is similar to the one just discussed. The main difference is in how the heat is applied to the package surface. This system provides the heat necessary for sterilization by means of a heated stainless steel drum. A thin film of peroxide is applied to the product contact surface. This surface is then rolled over the heated drum. Contact with the drum heats the peroxide and effects sterilization.

A third system also uses packaging material which comes in rolls. The rolls are continuously fed into the machine which forms, fills, and seals the package. Sterilization is accomplished with a combination of hydrogen peroxide and heat. The packaging material travels through a bath of hot hydrogen peroxide which softens the material for forming. Cups are then formed, filled and sealed with a lid which also travels through a hydrogen peroxide bath.

A fourth system utilizes preformed cups to which a lid foil is heat-sealed after filling. The cups are fed into the machine where they are sterilized by applying a spray of peroxide followed by heating. The lid material is sterilized by being passed through a bath of hydrogen peroxide

Another system which can utilize preformed carton sprays low concentration hydrogen peroxide solution on the inside of the carton. This sprayed carton then passes under a UV light source which acts synergistically with the hydrogen peroxide in destroying micro organisms.

26.3.4 Low-Temperature Hydrogen Peroxide Gas Plasma (LTHPGP) sterilization:

Low-temperature hydrogen peroxide gas plasma (LTHPGP) sterilization is a relatively new technology, marketed under the trade name Sterrad® by ASP is used mainly for rapid sterilization of medical instruments without leaving toxic residues.

26.3.5 Exposure to Gaseous Ethylene Oxide: Some material which cannot be sterilized by dry heat or autoclaving may be sterilized by exposure to gaseous ethylene

oxide. The method can be carried out at low temperatures and damages relatively few materials. It is however difficult to control and use of ethylene oxide. Compared to other methods of sterilization, the bactericidal efficiency of ethylene oxide is low.

26.3.6 Sterilization by chemicals:

26.3.6.1 Per-acetic acid: Per-acetic acid is a liquid sterilant which is effective against spores of aerobic and anaerobic bacteria and is effective at low temperatures than hydrogen Peroxide. But it is toxic. Hence this is used in pre-sterilization of packaging materials.

26.3.6.2 Ethyl alcohol: At 80% concentration, ethyl alcohol is effective in sterilization of packaging materials. However, it is ineffective against spores. Hence it is not generally used.

26.3.7 Sterilization by irradiation: Sterilization may be effected by exposure to high energy electrons from a particle accelerator or to gamma radiation from sources such as cobalt⁶⁰ or caesium¹³⁷ employing energies below 10 Mev. In irradiation sterilization, radiations of energies well below 10 Mev are usually employed and hence no radioactivity is induced in the material so sterilized.

Advantages:

- Irradiation sterilization is a single process.
- Irradiation sterilization is a clean process – No residual chemicals
- Irradiation sterilization is a reliable process
- Irradiation sterilization is a cold process and hence less damage to packaging materials occurs.
- Irradiation sterilization is an energy saving process.
- Irradiation sterilization is a cost effective and economic process

26.3.7.1 Irradiation with ultra - violet rays: They are generally recommended for use with sterilization of contaminated surfaces and disinfection of aseptic handling rooms or boxes. The disinfection capacity of UV rays in air is affected by moisture, dust concentration etc. Despite this limitation, UV radiation is a powerful disinfectant. Its sterilizing power arises from its capacity to get selectively or reasonably absorbed at 228 nm and 265 nm wavelength by the peptide bonds of nucleic acid in the cells of microbial organisms.

UV rays are produced by mercury discharge tubes fitted with quartz windows for transmission of UV rays with minimum absorption. These units are relatively inexpensive. UV radiation is harmful to man particularly to the skin. Direct exposure to UV rays must be avoided.

26.3.7.2 Irradiation with gamma rays: Gamma radiation is the most widely used form of ionizing radiation sterilization and in fact, gamma irradiation has become the industry standard for high-energy sterilization due to the convenience, low cost, and good sterilization results. Gamma irradiation involves the bombardment of photons from a ^{60}Co source. Because of the excellent penetrating ability of gamma rays, a wide range of packaging materials may be gamma-sterilized including those composed of multiple resins. Pre-packaged articles may also be gamma-sterilized since many materials such as cellophane, polyethylene, and nylon can be penetrated by gamma rays. Gamma rays have five times the penetration capability than electron beam radiation. Gamma radiation sterilization usually employs ^{60}Co as the radioisotope source with a dosage of generally 2.5 megarads, although higher levels are sometimes used, and maximum temperatures usually are in the range of 30°C–40°C.

26.3.7.3 Electron beam (E-beam): Electron beam irradiation is the bombardment of high-energy electrons. Sterilization is quick but with limited penetration. Less is known about the e-beam sterilization effects on the physical properties and colour stability of thermoplastics compared with gamma sterilization. Doses for e-beam irradiation for the sterilization of medical disposable items are in the 1–6 megarad range. Doses for packaging where the contained food is to be pasteurized are in the 0.1–1 megarad range. There are several differences between e-beam and gamma sterilization. The e-beam process uses no radioactive source and employs lower energy radiation than gamma sterilization. It is claimed that electron beam sterilization causes less material degradation than gamma, thus reducing the risk of product damage. Exposure time for e-beam is shorter than exposure in gamma radiation. Plastic parts sterilized by electron beam are only exposed for minutes versus hours or days with gamma rays. However, the penetration capability of e-beams is poor, resulting in the need for many e-beam sterilized pieces to be irradiated from multiple sides to ensure complete sterilization.

26.4 Packaging materials / forms sterilized by different methods:

Packaging material/ form Sterilization method

1. Milk pouch film UV rays
2. UHT packaging film Chemical – H_2O_2
3. Metal cans Heat
4. Plastic bottles, cups Chemical – H_2O_2

Lesson-27

Different Methods of Coding and Standards of Labeling of food packages

27.1 INTRODUCTION

Most of the packaging related regulatory initiatives are concerned to the Product quality, Public Health and Hygiene, Safety, Export Promotion, Transportation and Consumer protection.

The international markets are governed by various packaging rules and regulations that make it mandatory for an exporting country to abide by them. Therefore, packaging for exports should comply with global norms to match with international standards. Government of India has instituted various laws and regulations. All these legislations are classified into two types i.e. Compulsory and Voluntary Standards.

To ensure product quality and provide safety to the consumer, it is important to regulate manufacturing, distribution, marketing and retailing of packaged products. This can be achieved by mandating rules and regulations. Food laws in India have been enforced in the country since, 1899. The Food Safety and Standards Act, 2006 which consolidates various acts and orders that have handled food related issues in various Ministries and Departments. FSSAI has been created for laying down science based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption. The Indian Parliament has passed the *Food Safety and Standards Act, 2006* that overrides all other food related laws. It was followed by Food safety and Standards Rules 2011 & Food safety and Standards Regulation 2011.

27.2 The Legal Metrology (Packaged Commodities) Rules, 2011: These rules may be called “The legal metrology (packaged commodities) Rules, 2011. They shall come into force from 1st March 2011. The commodities specified in the second schedule

shall be packed for sale, distribution or delivery in such standard quantities is specified in that schedule.

Declaration to be made on every package:

1. The name and address of the manufacturer
2. The common generic names of the commodity contained in the package
3. The net quantity in terms of standard unit of weight or measure of the commodity
4. The month and year in which the commodities is manufactured
5. The retail sale price of the package
6. Such other matter as are specified in these rules

Maximum permissible errors on net quantity declared by weight or volume.-

(1) The maximum permissible error, in excess or in deficiency, in the net quantity by weight or volume of any commodity shall be as specified below:-

S.No	Declared quantity	Maximum permissible error in excess or in deficiency	
		As percentage of declared quantity	g or ml
1	Upto 50	9	-
2	50 to 100	-	4.5
3.	100 to 200	4.5	-
4.	200 to 300	-	9.0
5.	300 to 500	3.0	-
6.	500 to 1000	-	15.0
7.	1000 to 10000	1.5	-
8.	10000 to 15000	-	150.0
9.	More than 15000	1.0	-

Commodities to be packed in specified quantities:

Commodity	Quantities in which to be packed
Baby food	100gms,200gms,300gms,400gms,500gms,600gms,700gms,800gms

Packaging Of Dairy Products

	900 gms, 1 kg, 2kg, 5kg and 10 kg.
Uncanned packages of butter and margarine	25 gms, 50 gms, 100 gms, 200gms, 500gms, 1kg, 2kg, 5kg and thereafter in multiples of 5 kg
Ghee & butteroil	50 gms, 100 gms, 200gms, 500gms , 1 kg, 2kg, 3 kg, 5 kg.
Milk powder	Below 50 gms no restriction, 50 gms, 100gms, 200gms,500gms, 1 kg and thereafter in multiples of 500 gm.

27.3 Package of Food to Carry a Label: Every package of food shall carry a label and unless otherwise provided in these rules, there shall be specified on every label:

- (a) The name, trade name or description of food contained in the package;
- (b) The names of ingredients used in the product in descending order of their composition by weight or volume as the case may be;

Provided that in the case of artificial flavouring substances, the label may not declare the chemical names of the flavours, but in the case of natural flavouring substances or nature-identical flavouring substances, the common name of flavours shall be mentioned on the label. Provided also that whenever Gelatine is used as an ingredient, a declaration to this effect shall be made on the label by inserting the word "Gelatine-Animal Origin."

In case of packages of confectionery weighing 20 gm or less, which are also exempted from the declaration of ingredients, will be exempted from the declaration of "Animal Origin" even if it contains Gelatine provided that such declaration shall be given on the multi- piece package in such a manner that the same is readable even without opening the package.

(2) The maximum permissible error specified as percentage shall be rounded off to the nearest one-tenth of a g or ml, for a declared quantities less than or equal to 1000 g or ml and to the next whole g or ml for declared quantities above 1000 g or ml.

Provided also that when any article of food contains whole or part of any animal including birds, fresh water or marine animals or eggs or product of any animal origin, but not including milk or milk products, as ingredient.-

- (a) A declaration to this effect shall be made by a symbol and colour code so stipulated for this purpose to indicate that the product is Non-Vegetarian Food. The symbol shall consist of a brown colour filled circle having a diameter not less than the minimum size specified in the Table given below, inside the square with brown outline having side double the diameter of the circle, as indicated in clause (16) of sub-rule(ZZZ) of rule 42;

Table 27.1 Area and Diameter of Non-vegetarian symbol to be printed on package

S. No.	Area of principal display panel	Minimum size of diameter in mm
1	Upto 100 cms square	3
2	Above 100 cms square upto 500 cms square	4
3	Above 500 cms square upto 2500 cms square	6
4	Above 2500 cms square	8

(b) The symbol shall be prominently displayed

1. On the package having contrast background on principal display panel,
2. Just close in proximity to the name or brand name of the product, and
3. On the labels, containers, pamphlets, leaflets, advertisements in any media;

Provided also that where any article of food contains egg only as Non-Vegetarian ingredient, the manufacturer, or packer or seller may give declaration to this effect in addition to the said symbol.

Provided further that the provisions of these rules shall not apply in respect of any Non-Vegetarian Food which is manufactured and packed without the symbol before the commencement of the Prevention of Food Adulteration (Fourth Amendment) Rules, 2001.

Provided also that for all Vegetarian Food –

Packaging Of Dairy Products

(a) A declaration to this effect shall be made by a symbol and colour code so stipulated for this purpose to indicate that the product is Vegetarian Food. The symbol shall consist of a green colour filled circle, having a diameter not less than the minimum size specified in the Table given below, inside the square with green outline having size double the diameter of the circle, as indicated in clause (17) of sub-rule (ZZZ) of rule 42;

Table 27.2 Area and Diameter of Vegetarian symbol to be printed on package

S. No.	Area of principal display panel	Minimum size of diameter in mm
1	Upto 100 cms square	3
2	Above 100 cms square upto 500 cms square	4
3	Above 500 cms square upto 2500 cms square	6
4	Above 2500 cms square	8

(b) The symbol shall be prominently displayed,

1. On the package having contrast background on principal display panel,
2. Just close in proximity to the name or brand name of the product, and
3. On the labels, containers, pamphlets, leaflets, advertisements in any media;

Provided further that the provisions of these rules shall not apply in respect of any Vegetarian Food which is manufactured and packed without the symbol before the commencement of the Prevention of Food Adulteration (9th Amendment) Rules, 2001.

Provided also that the provisions of the these rules shall not apply in respect of mineral water or packaged drinking water or carbonated water or liquid and powdered milk.

Provided further that when statement regarding addition of colours or flavours is displayed on the label in accordance with rule 24 and rule 64 BB respectively, addition of such colours or flavours need not be mentioned in the list of ingredients.

Provided also that in case both colour and flavour are used in the product, one of the following combined statements in capital letters shall be displayed just beneath the list of ingredients on the label attached to any package of food, so coloured and flavoured, namely:

(I) CONTAINS PERMITTED NATURAL COLOUR (S) AND ADDED FLAVOUR(S)

OR

(II) CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S) AND ADDED FLAVOUR(S)

OR

(III) CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S) AND ADDED FLAVOUR (S)

OR

(IV) CONTAINS PERMITTED NATURAL*/AND* SYNTHETIC* COLOURS AND ADDED FLAVOURS (For the period up to and inclusive of 1st September, 2001

NOTE: A specific name shall be used for ingredients in the list of ingredients:

Provided that for ingredients falling in the falling in the respective classes the following class titles may be used, namely in dairy industry:

Table 27.3 Declaration of Additives like fat, oil etc are used in food.

Name of the Classes	Class names
Animal fat/oil, other than milk fat	Give name of the source of fat, Lard and beef fat or extracts thereof shall be declared by specific names.
All type of cheese where cheese or mixture of cheeses constitutes an ingredient of another food and provided that the labelling and presentation of such food does not refer to a specific type of cheese.	Cheese
All milk and milk products derived solely from milk	Milk solids

Provided further that for food additives falling in the respective classes and appearing in lists of food additives permitted for use in foods generally, the following class titles shall be used together with the specific names or recognized international numerical identifications:

Acidity Regulator, Acids, Anticaking Agent, Antifoaming Agent, Antioxidant, Bulking Agent, Colour, Colour Retention Agent, Emulsifier, Emulsifying Salt, Firming Agent, Flour Treatment Agent, Flavour Enhancer, Foaming Agent, Gelling Agent, Glazing

Packaging Of Dairy Products

Agent, Humectants, Preservative, Propellant, Raising Agent, Stabilizer, Sweetener, Thickener.

Provided also that for declaration of flavours on the label the class of flavours namely, Natural Flavours and Natural Flavouring Substances or Natural-Identical Flavouring Substances or Artificial Flavouring Substances as the case may be, shall be declared on the label.

(c)

- (i) The name and complete address of the manufacturer and the manufacturing unit, if these are located at different places and in case the manufacturer is not the packer or bottler, the name and complete address of the packing or bottling unit as the case may be;
- (ii) Where an article of food is manufactured or packed or bottled by a person or a company under the written authority of some other manufacturer or company, under this or its brand name, the label shall carry the name and complete address of the manufacturing or packing or bottling unit as the case may be, and also the name and complete address of the manufacturer or the company, for and on whose behalf it is manufactured or packed or bottled;
- (iii) Where an article of food is imported into India, the package of food shall also carry the name and complete address of the importer in India.

Provided that where any food article manufactured outside India is packed or bottled in India, the package containing the such food article shall also bear on the label, the name of the country of origin of the food article and the name and complete address of the importer and the premises of the packing or bottling in India.

- (d)** The net weight or number or measure of volume of contents as the circumstances may require, except in the case of biscuits, breads, confectionery and sweets where the weight may be expressed in terms of either average net weight or minimum net weight.

Note: In declaring the net quantity of the commodity contained in the package, the weight of the wrappers and materials other than commodity shall be excluded.

Provided that where a package contains a large number of small items of confectionery, each of which is separately wrapped and it is not reasonably practicable to exclude from the net weight of the commodity, the weight of such immediate wrappers of all the items of the confectionery contained in the package, the net weight declared on the package, containing such confectionery or on the label thereof may include the weight of such immediate wrapper if, and only if the total weight of such immediate wrapper does not exceed:

- (i) 8 per cent where such immediate wrapper is a waxed paper or any other paper with wax or aluminium foil under strip; **or**
- (ii) 6 per cent in the case of any other paper, of the total net weight of all the items of confectionery contained in the package minus the weight of immediate wrapper.
- (e) A distinctive batch number or lot number or code number, either in numerical or alphabets or in combination, representing the batch number or lot number or code number being preceded by the words 'Batch No'. or "Batch" or Lot No" or, Lot or any distinguishing prefix.

Provided, that in case of canned food, the batch number may be given at the bottom, or on the lid of the container, but the words "Batch No", given at the bottom or on the lid, shall appear on the body of the container.

- (f) The month and year in which the commodity is manufactured or prepacked;

Provided that in case of package weighting 20 g or less and liquid products marketed in bottles which are recycled for refilling, particulars under clause (b) need not be specified.

Provided also that such declarations shall be given on the label of multipiece package either on the label of multipiece package or in a separate slip inside the multipiece

Packaging Of Dairy Products

package in such a manner that the same is readable even without opening the package.

Provided further that in case of carbonated water containers and the packages of biscuits, confectionery and sweets, containing more than 60g, but not more than 120g, and food packages weighing not more than 60g. Particulars under clauses (d) and (e) need not be specified.

Provided also that in case of packages containing bread and milk including sterilised milk, particulars under clause (e) need not be specified.

“Provided also that in case of any package containing bread or liquid milk, sterilized or Ultra High Temperature treated milk, Soya milk, flavoured milk, any package containing dhokla, bhelpuri, pizza, doughnuts, khoa, paneer or any uncanned package of fruits, vegetables, meat, fish or any other like commodity which has a short shelf life, the date, month and year in which the commodity is manufactured or prepared or prepacked shall be mentioned, on the label:

Provided that in case of wholesale packages the particulars under clauses (b), (f), (g), and this clause need not be specified.

Provided further that in case of package or bottle containing sterilised or Ultra High Temperature treated milk, soya milk, flavoured milk, any package containing bread, dhokla, bhelpuri, pizza, doughnuts, khoa, paneer, or any uncanned package of fruits, vegetable, meat, fish or any other like commodity, the declaration be made as follows:

"BEST BEFORE.....DATE/MONTH/YEAR"

OR

"BEST BEFORE DAYS FROM PACKAGING"

OR

"BEST BEFOREDAYS FROM MANUFACTURE"

"BEST BEFORE UPTO.... DATE/MONTH/YEAR

OR

"BEST BEFORE WITHINDAYS FROM THE DATE OF
PACKAGING/MANUFACTURE"

Note: (i) Blank be filled up

(ii) Month and Year may be used in numerals.

(iii) Year may be given in two digits.

Provided also that in case of a package containing confectionery weighing 20g or less, the particulars under clause (i) may not be specified.

Provided also that the above declaration of best before consumption shall not be applicable to the Packages of Aspartame and Infant milk substitute and Infant food".

“Provided also that in case of any bottle containing liquid milk or liquid beverage having milk as an ingredient, soft drink, carbonated water or ready-to-serve fruit beverages, the declarations with regard to addition of fruit pulp and fruit juice as well as the “dated of manufacture” and “best before date” shall invariably appear on the body of the bottle.

Provided also that in case of returnable bottle which are recycled for refilling where the label declarations are given on the crown, the declaration referred to in the above proviso, with regard to addition to fruit pulp and fruit juice shall be enforced as per the Schedule given below. The bottles on which the year of manufacture is not embossed the dated of replacing such bottle shall be the 1st day of April, 2008

Table 27.4 Schedule

S.No.	Year of manufacture	Date of enforcement of the declarations referred to in the first proviso by replacing old bottles with new bottles
1	2002 and beyond but before the commencement of the Prevention of Food Adulteration (8th Amendment) Rules 2002	1.4.2008
2	2001	1.4.2007
3	2000	1.4.2006
4	1999	1.4.2005
5	1998	1.4.2004
6	1997 and before	From the date of commencement of the Prevention of Food Adulteration (8th Amendment) Rules, 2002

Provided also that the returnable new glass bottle manufactures and used for packing of such beverages on the date of commencement of the Prevention of Food Adulteration (8th Amendment) Rules 2002 shall carry these declarations on its body”

Provided also that the above provisions except date of manufacture and “best before date” shall not apply in respect of carbonated water (plain soda) potable water impregnated with carbon dioxide under pressure) packed in returnable glass bottles.

Explanation- I: The term 'label' means a display of written, marked, graphic, printed, perforated, stencilled, embossed or stamped matter upon the container, cover, lid or crown of any food package.

Explanation- II: Complete address (omitted)

Explanation-III: For the purpose of declaration of month and year of manufacture, the provision under the rule 6(B) of Weights and Measures (Packaged Commodities) Rules, 1977 shall apply.

Explanation-IV: A Batch Number or Code Number or Lot Number is a mark of identification by which the food can be traced in manufacture and identified in distribution.

Explanation-V: 'Multipiece package' means a package containing two or more individually packaged or labelled pieces of the same commodity of identical quality, intended for retail either in individual pieces or package as a whole.

Explanation-VI: "Wholesale package" means a package containing.

- a) A number of retail packages, where such first mentioned package is intended for sale, distribution or delivery to an intermediary and is not intended for sale direct to a single consumer; or
- b) A commodity of food sold to an intermediary in bulk to enable such intermediary to sell, distribute or deliver such commodity of food to the consumer in smaller quantities.

Explanation VII- Prepacked commodity with its grammatical variations and cognate expressions means a commodity of food with or without the purchaser being present, is placed in a package of whatever nature so that the quality of the commodity contained therein has predetermined value and such value cannot be altered without the package or its lid or cap, as the case may be, being opened or undergoing a perceptible modification.

Explanation VIII-

- (i) **Best Before**" means the date which signifies the end of the period under any stated storage conditions during which the product will remain fully marketable and will retain any specific qualities for which tacit or express claims have been made. However, provided that beyond the date the food may still be perfectly satisfactory.
- (ii) In addition to the date of best before, any special conditions for the storage of the food shall be declared on the label if the validity of the date depends on such storage.

Note - The expression 'package', wherever it occurs in these rules, shall be construed as package containing prepacked commodity of food articles".

Explanation IX- Non-Vegetarian Food' means an article of food which contains whole or part of any animal including birds, fresh water or marine animals or eggs or products of any animal origin, but not including milk or milk products, as an ingredient.",

Explanation X- "Vegetarian Food" means any article of Food other than the Non-Vegetarian Food as defined in Explanation IX of this rule;

32-A. Nutritional Food: The food claimed to be enriched with nutrients such as minerals; proteins or vitamins shall give quantities of such added nutrients on the label.

33. Languages of the Particulars or Declaration on the Label: The particulars of declaration required under these rules to be specified on the label shall be in English or Hindi in Devnagri script:-

Provided that nothing herein contained shall prevent the use of any other language in addition to the language required under this rule.

34. Declaration to be Surrounded by Line: There shall be a surrounding line enclosing the declaration and where the words ["unsuitable for babies"] are required to be used there shall be another such line enclosing these words.

35. Distance of Surrounding Line:

The distance between any part of the words ["unsuitable for babies;"] and the surrounding line enclosing these words shall not be less than [1.5mm.].

36. Principal Display Panel, its Area, Size and Letter, etc,

(1) **Principal Display Panel** means that part of a label which is intended or is likely to be displayed, presented or shown or examined by the customer under normal and customary conditions of display, sale or purchase of the commodity of food contained in the package:

(2) The area of the principal display panel shall not be less than-

- (a) in the case of a rectangular container, forty percent of the product of height and width of the panel of such container having the largest area:
 - (b) in case of cylindrical or nearly cylindrical, round or nearly round, oval or nearly oval container, twenty percent of the product of the height and average circumference of such container; or
 - (c) in the case of a container of any other shape, twenty percent of the total surface area of the container except where there is label, securely affixed to the container such label shall have a surface area of not less than ten percent of the total surface area of the container.
- (3) In computing the area of the principal display panel, the tops, bottoms, flanges at top and bottoms of cans, and shoulders and necks of bottles or jars shall be excluded.
- (4) In the case of package having a capacity of five cubic centimeters or less, the principal display panel may be card or tape affixed firmly to the package or container and bearing the required information under these rules.
- (5) The height of any numeral in the declaration required under rules, on the principal display panel shall not be less than.
- (i) As shown in Table-27.5 below if the net quantity is declared in terms of weight or volume.

TABLE -27.5 Height and Size of Letters to be printed for net quantity declared in terms of weight or volume on label

Sr. No.	Net quantity in weight/volume	Minimum height of numeral in mm	
		Normal case	When blown, formed, moulded or perforated on container
1	Up to 50g/ml	1	2
2	Above 50g/ml up to 200g/ml	2	4
3	Above 200g/ml up to 1kg/litre	4	6
4	Above 1kg/litre	6	8

(ii) As shown in Table-27.6 below if the net quantity is declared in terms of length, area or number.

TABLE-27.6 Height and Size of Letters to be printed for net quantity declared in terms of length, area or number on label

Sr. No.	Net quantity in length, area or number, Area of Principal display panel	Minimum height in mm	
		Normal case	When blown, formed, moulded or perforated on container
1	Up to 100 cm ²	1	2
2	Above 100 cm ² , Up to 500 cm ²	2	4
3	Above 500 cm ² , Up to 2500 cm ²	4	6
4	Above 2500 cm ²	6	8

(6) The height of letters in the declaration under sub-rule (5) shall not be less than 1 mm height. When blown, formed, moulded, embossed or perforated, the height of letters shall not be less than 2mm. Provided that the width of the letter or numeral shall not be less than one third of its height, but this provision shall not apply in the case of numeral '1' and letters 'i, I and l'. Provided also that the size of letter specified under this rule shall be applicable to declaration made only under rule 32 or 32-A of these rules.

(7) Every declaration which is required to be made on package under these rule shall be-

- Legible, prominent, definite, plain and unambiguous;
- Conspicuous as to size number and colour, and
- As far as practicable, in such style or type or lettering as to be boldly, clearly and conspicuously present in distinct contrast to the other type, lettering or graphic material used on the package, and shall be printed or inscribed on the package in a colour that contrasts conspicuously with the background of the label.

Provided that -

- Where any label information is blown, formed or moulded on a glass or plastic surface or where such information is embossed or perforated on a package, that information shall not be required to be presented in a contrasting colour;
- Where any declaration on a package is printed either in the form of a handwriting or hand script, such declaration shall be clear, unambiguous and legible.

(8) No declaration shall be made so as to require it to read through any liquid commodity contained in the package.

(9) Where a package is provided with an outside container or wrapper such container or wrapper shall also contain all the declarations which are required to appear on the package except where such container or wrapper itself is transparent and the declarations on the package are easily readable through such outside container or wrapper."

37. Labels not to Contain False or Misleading Statements :

A label shall not contain any statement, claim, design, device, fancy name or abbreviation which is false or misleading in any particular concerning the food contained in the package, or concerning the quantity or the nutritive value or in relation to the place of origin of the said food:

[Provided that this rule shall not apply in respect of established trade or fancy names of confectionery, biscuits and sweets such as Barley Sugar, Bulls Eye, Cream Cracker, or in respect of aerated waters such as Ginger Beer or Gold Spot or any other name in existence in international trade practice.]

37-A. Manufacture of Proprietary Foods and Infant Foods:

1. An article of infant milk substitutes/ infant foods whose standards are not prescribed in Appendix 'B' shall be manufactured for sale, exhibited for sale or stored for sale only after obtaining the approval of such article of food and its label from Government of India.
2. In case of proprietary foods the name of the food or category under which it falls in these rules shall be mentioned on the label.

37-B. Labelling of Infant Milk Substitute and Infant Food:

(1) Without prejudice to any other provisions relating to labelling requirements contained in these rules, every container of infant milk substitute or infant food or any label affixed thereto shall indicate in a clear, conspicuous and in an easily readable manner, the words, "IMPORTANT NOTICE" in capital letters and indicating there under the following particulars, namely:

- (a) A statement "MOTHER'S MILK IS BEST FOR YOUR BABY" in capital letters. The types of letters used shall not be less than five millimetres and the text of such statement shall be in the Central Panel of every container of infant milk substitute or infant food or any label affixed thereto. The colour of the text printed or used shall be different from that of the background of the label, container or the advertisement, as the case may be. In case of infant food, a statement indicating "infant food shall be introduced only after six months and up to the age of two years" shall also be given.
- (b) A statement that infant milk substitute or infant food should be used only on the advice of a health worker as to the need for its use and the proper method of its use;
- (c) A warning that infant milk substitute or infant food is not the sole source of nourishment of an infant;
- (d) A statement indicating the process of manufacture (spray or roller dried) except in case of infant foods, instruction for appropriate and hygienic preparation including cleaning of utensils, bottles and teats and warning against health hazards of in-appropriate, as under:-

“Warning/caution-Careful and hygienic preparation of infant foods/infant milk substitutes is most essential for health. Do not use fewer scoops than directed since diluted feeding will not provide adequate nutrients needed by your infant. Do not use more scoops than directed since concentrated feed will not provide the water needed by your infant”

(e) The approximate composition of nutrients per 100/gms. Of the product including its energy value in Kilo Calories/Joules;

(f) The storage condition specifically stating “store in a cool and dry place in an air tight container” or the like;

(g) The feeding chart and directions for use and instruction for use and instruction for discarding left over feed;

♥ Instruction for use of measuring scoop (level or heaped) and the quantity per scoop (scoop to be given with pack);

(i) Indicating the Batch No. Month and Year of its manufacture and month and year before which it is to be consumed,

(j) The protein efficiency ratio (PER) which shall be minimum 2.5, if the product other than infant milk substitute is claimed to have higher quality protein.

(2) No container or label referred to in sub-rule (1) relating to infant milk substitute and any advertisement relating thereto shall have a picture of infant or woman or both. It shall not have picture of other graphic materials or phrases designed to increase the saleability of the infant milk substitute. The terms “Humanised” or “Maternalised” or any other similar words shall not be used. The package and/or the label and / or the advertisement of infant foods/infant milk substitute shall not exhibit the words “Full protein food” “energy food” “complete food” or “Health Food” or any other similar expression.

Packaging Of Dairy Products

- (3) The containers of infant milk substitute meant for low birth weight infant (less than 2500gm) or labels affixed thereto shall indicate the following additional information, namely:
- (a) The words “**Low Birth weight** (Less Than 2.5 kg)” in capital letters along with the product name in central panel;
 - (b) A statement “the low birth weight infant milk substitute shall be withdrawn under medical advice as soon as the mother’s milk is sufficiently available”, and
 - (c) A statement “TO BE TAKEN UNDER MEDICAL ADVICE” in capital letters.
- (4) The product which contains neither milk nor any milk derivatives shall be labelled “Contains no milk or milk product” in conspicuous manner.
- (5) The container of infant milk substitute for lactose intolerant infants or label affixed thereto shall indicate conspicuously “LACTOSE FREE” in capital letters and statement “TO BE TAKEN UNDER MEDICAL ADVICE”.

38. Labels not to Contain Reference to Act or Rules Contradictory to Required Particulars:

The label shall not contain any reference to the Act or any of these rules or any comment on , or reference to or explanation of any particulars or declaration required by the Act or any of these rules to be included in the label which directly or by implication, contradicts, qualifies or modifies such particulars or declaration.

39. Labels not to use Words Implying Recommendations by Medical Profession:

There shall not appear in the label of any package containing food for sale the words "recommended by the medical profession" or any words which imply or suggest that the food is recommended, prescribed, or approved by medical practitioners 2or approved for medical purpose.

40. Unauthorized Use of Words Showing Imitation Prohibited:

(1) There shall not be written in the statement or label attached to any package containing any article of food the word "imitation" or any word, or words implying that the article is a substitute for any food, unless the use of the said words is specifically permitted under these rules.

(2) Any fruit syrup, fruit juice, fruit squash, beverage or cordial or crush which does not contain the prescribed amount of fruit juice, shall not be described as a fruit juice, fruit squash, fruit beverage or cordial or crush, as the case may be, and shall be described as a synthetic product. Every synthetic product shall be clearly and conspicuously marked on the label as 'SYNTHETIC' and no container containing such product shall have a label, whether attached thereto or printed on the wrapper of such container or otherwise, which may lead the consumer into believing that it is a fruit product. Neither the word "FRUIT" shall be used in describing such a product nor shall it be sold under the cover of label which carries picture of any fruit..... Carbonated water containing no fruit juice or pulp shall not have a label which leads the consumer into believing that it is fruit product.

(3) Any fruit and vegetable product alleged to be fortified with vitamin C shall contain not less than 40 mg of ascorbic acid per 100 gm of the product.

41. Imitations not to be marked "pure":

The word "pure" or any word or words of the same significance shall not be included in the label of a package that contains imitation of any food.

42. Form of Labels:

(A) Condensed Milk or Desiccated (Dried)Milk:

(i) Every package containing condensed milk or desiccated (dried) milk shall bear a label upon which is printed such one of the following declarations as may be applicable or such other declaration substantially to the like effect as may be allowed by the State Government.

Packaging Of Dairy Products

(a) In the case of condensed milk (unsweetened);

CONDENSED MILK UNSWEETENED (Evaporated milk)

This tin contains the equivalent of (x).....litres of toned milk

(b) In the case of condensed milk (sweetened);

CONDENSED MILK SWEETENED

This tin contains the equivalent of (x).....litres of toned milk with sugar added

(c) In the case of condensed skimmed milk (unsweetened):

CONDENSED SKIMMED MILK UNSWEETENED

(Evaporated Skimmed Milk)

This tin contains the equivalent of (x).... litres of skimmed milk

(d) In the case of condensed skimmed milk(SWEETENED)

CONDENSED SKIMMED MILK SWEETENED

This tin contains the equivalent of (x)..... litres of skimmed milk with sugar added

(dd) In the case of condensed milk (sweetened and flavoured):

This has been flavoured with.....

NOT TO BE USED FOR INFANTS BELOW SIX MONTHS

(ddd) In the case of condensed milk/condensed skimmed milk (unsweetened)
sterilised by Ultra High Temperature (UHT) treatment:

This has been sterilised by UHT process

(e) In the case of milk powder :

MILK POWDER

This tin contains the equivalent of (x) litres of toned milk

(ee) In the case of milk powder which contain lecithin:

MILK POWDER IN THIS PACKAGE

CONTAINS LECITHIN

(f) In the case of partly skimmed milk powder :

PARTLY SKIMMED MILK POWDER

This tin contains the equivalent of (x)litres of partly skimmed milk havingper cent milk fat

(g) In the case of skimmed milk powder:

SKIMMED MILK POWDER

This tin contains the equivalent of (x).....litres of skimmed milk

(ii) The declaration shall in each case be completed by inserting at (x) the appropriate number in figures' for example, "One and half (1/1/2)", any fraction being expressed as eight quarters or a half, as the case may be[.....]

(iii) There shall not be placed on any package containing condensed milk or desiccated (dried) milk any comment on, explanation of, or reference to either the statement of equivalence, contained in the prescribed declaration or on the words "machine skimmed" skimmed" or unsuitable for babies" except instructions as to dilution as follows :

Packaging Of Dairy Products

"To make a fluid not below the composition of toned milk or skimmed milk [***] (as the case may be) with the contents of this package, add (here insert the number of parts) of water by volume to one part by volume of this condensed milk or desiccated (dried) milk.

Sweetened condensed milk and other similar products which are not suitable for infant feeding shall not contain any instructions for modifying them for infant formula.

(iv) Wherever the word "milk" appears on the label of a package of condensed skimmed milk or of (dried) skimmed milk as the description or part of the description of the contents, it shall be immediately preceded or followed by the word "machine skimmed" or "partly skimmed", as the case may be.

(C) **Fluid Milk:** The caps of the milk bottles shall clearly indicate the nature of the milk contained in them. The indication may be either in full or abbreviation shown below:

1. Buffalo milk may be denoted by the letter 'B'.
2. Cow milk may be denoted by the letter 'C'.
3. Goat milk may be denoted by the letter 'G'.
4. Standardized milk may be denoted by the letter 'S'.
5. Toned milk may be denoted by the letter 'T'.
6. Double toned milk may be denoted by the letters 'DT'.
7. Skimmed milk may be denoted by the letter 'K'.
8. Pasteurized milk may be denoted by the letter 'P' followed by the class of milk. For example, Pasteurized Buffalo milk shall bear the letter 'PB'.

Alternatively colours of the caps of the milk bottles shall be indicative of the nature of milk contained in them, the classification of colours being displayed at places where milk is sold/ stored or exhibited for sale, provided that the same had been simultaneously intimated to the concerned Local (Health) Authority. Other media of information like Press may also be utilized;

Ice-Cream: Every dealer in ice cream or mixed ice cream who, in the street or other place of public resort, sells or offers or exposes for sale, ice-cream or ice-candy, from a stall or from a cart, barrow or other vehicle, or from a basket, phial, tray or other container used without a staff or a vehicle shall have his

name and address along with the name and address of the manufacturer, if any, legibly and conspicuously displayed on the stall, vehicle or container as the case may be.

Every package of synthetic food colour preparation and mixture shall bear a label upon which is printed a declaration giving the percentage of total dye content.

Unless otherwise provided in these rules, every package of malted milk food which contains added natural colouring matter except caramel shall bear the following label:

MALTED MILK FOOD IN THIS PACKAGE CONTAINS PERMITTED NATURAL
COLOURING MATTER

(ZZZ)(1) Every package of food which is permitted to contain artificial sweetener mentioned in table given in rule 47 and advertisement for such food shall carry the following label, namely:

(i) This..... (Name of food) contains..... (Name of artificial sweetener)

(ii) Not recommended for children.

(iii) *(a) Quantity of sugar added.....gm/100gm.

(b) No sugar added in the product.

(iv) *Not for Phenyl ketoneurics (if Aspartame is added)

(*strike out whatever is not applicable).

ZZZ)(1)(A) In addition to the declaration under rule (ZZZ)(1), every package of food which is permitted to contain artificial sweetener mentioned in table in rule 47 and an advertisement for such food shall carry the following label, namely:

Packaging Of Dairy Products

CONTAINS ARTIFICIAL SWEETENER AND FOR CALORIE CONSCIOUS

(ZZZ)(1)(B) The declaration under sub-rule (ZZZ)(1)(A) shall be provided along with name or trade name of product and shall be of the half of the size of the name/trade name. The declaration may be given in two sentences, but in the same box:

Provided that the provision of these rules shall not apply in respect of any food which is manufactured and packed before the commencement of Prevention of Food Adulteration (1st Amendment) Rules, 2004.

(ZZZ) (5) Every package containing Fat-Spread shall carry the following labels, namely

<p>(i) Milk Fat Spread</p> <p>Total Milk Fat Content..... percent by weight</p> <p>Date of Packing.....</p> <p>Use before.....</p>	<p>(i) Mixed Fat Spread</p> <p>Total Fat Content..... percent by weight</p> <p>Milk Fat Content..... percent by weight</p> <p>Date of packing.....</p> <p>Use before.....</p>
<p>(i) Vegetable Fat Spread</p> <p>Total Fat Content..... percent by weight</p> <p>Date of packing.....</p> <p>Use before.....</p>	

(ZZZ) (9) Every package of Cheese (hard), surface treated with Natamycin, shall bear the following lable namely:

Surface treated with Natamycin

ZZZ) (16) Every package of Non-Vegetarian Food shall bear the following symbol on the principal display panel just close in proximity to the name or brand name of food namely:

(ZZZ) (17) Every package of Vegetarian Food shall bear the following symbol in green colour on the principal display panel just close in proximity to name or brand name of the Food, namely:

Provided if caffeine is added in the products, it shall be declared on the body of the container/bottle.

Provided also that in case of returnable glass bottles, which are recycled for refilling the declaration of caffeine, may be given on the crown.

43. Notice of Addition, Admixture or Deficiency in Food:

(1) Every advertisement and every price or trade list or label for an article of food which contains an addition, admixture or deficiency shall describe the food as containing such addition, admixture or deficiency and shall also specify the nature and quantity of such addition, admixture or deficiency. No such advertisement or label attached to the container of the food shall contain any words which might imply that the food is pure:

Provided that for the purpose of this rule the following shall not be deemed as an admixture or an addition, namely:

(a) Salt in butter or margarine;

(b) Vitamins in food.

(2) Every package, containing a food which is not pure by reason of any addition, admixture or deficiency shall be labelled with an adhesive label, which, shall have the following declaration:

[DECLARATION]

THIS (a).....CONTAINS AN
ADMIXTURE/ADDITION OF NOT MORE
THAN (b).....PER CENT OF 3^{***} (c)

(a) Here insert the name of food.

(b) Here insert the quantity of admixture which may be present.

(c) Here insert the name of the admixture or the name of the ingredient which is deficient.

Where the context demands it, the words 'contains an admixture of' shall be replaced by the words 'contains an addition of or is deficient in';

(3) Unless the vendor of a food containing an addition, admixture or deficiency, has reason to believe that the purchaser is able to read and understand the declaratory label, he shall give the purchaser, if asked, the information contained in the declaratory label by word of mouth at the time of sale.

(4) Nothing contained in this rule shall be deemed to authorize any person to sell any article of food required under the Act or these rules to be sold in pure condition, otherwise than in its pure condition.

(5) Nothing contained in the rule shall apply in the case of sweets, confectionery, biscuits, bakery products, processed fruits, aerated water, vegetables and flavouring agents.

43-A. Restriction on Advertisement- There shall be no advertisement of any food which is misleading or contravening the provisions of Prevention of Food Adulteration Act, 1954 (37 of 1954) or the rules made thereunder.

Explanation: The term 'Advertisement' means any visible representation or announcement made by means of any light, sound, smoke gas, print, electronic media, internet or website"

Bar Code Definition: A bar code is a series of bars and spaces arranged according to the encodation rules of a particular specification in order to represent data.

Benefits of the codes: The main purpose is to represent information in a form that is machine-readable, and work can be speed and accuracy. Compared to manual key entry, capturing data automatically by reading bar code can be done in a fraction of a second. Generally the error rate is extremely low, of the order of one error per 10 lakhs readings.

Advantages:

Computer Aided Checkout.

Avoidance of over and under charging.

Self-service.

Instant inventory control.

Market survey – products sold and rate.

Ex. of Bar Code Symbols:

Code 39: The code 39 symbology introduced in 1975 is widely used for industrial applications.

ITF: Inter leaved two of five (ITF) is well adapted to materials and printing conditions frequently used on fibreboard cases.

Code 128: Code 128 was developed to address the need of a compact alpha-numeric code symbol that could be used to encode complex data, capable of being printed by existing data processing printers.

Packaging Of Dairy Products

EAN/UPC: European Article Numbering (EAN) system and Universal Products Code (UPC) system is a continuous symbology encoding fixed length number digits. Several variants exist, known as EAN-8, EAN-13, UPC-A and UPC-E. In addition, the symbology enables to encode 2 small symbols encoding 2 and 5 digits. These are called add-ons.

Two-Dimensional Symbology: PDF 417: As distinct from the linear symbology, a system such as PDF 417 is a two-dimensional stacked bar-code symbology. In this, the basic data unit or minimum segment containing interpretable data is called a codeword.

Printing and Reading of Bar Codes: Any printing technology can be of use in printing bar codes, provided it achieves enough accuracy with required quality at the right level.

There are many types of bar code readers available. They all illuminate the symbol and analyse the resulting reflectance. High reflectance areas are interpreted as spaces while areas of low-reflectance are represented as bars.

The decoder assigns binary values to the signal and forms a complete message. This is checked by the decoder and transformed into data.

Applications

The bar coding technology has numerous applications. Now a days, all packaging forms right from the ultimate consumer to biggest transport units bear one or several codes, carrying their identification number and other data relevant to agencies of shipping, carrying and receiving goods.

Scanning at retail point of sale is a major application relying on the EAN/UPC identification number and the associated bar code symbol. Scanning at point of sale enables automatically to register the sales through price-lookup files. Further extensions include inventory management, automatic re-ordering and sales analyses.

Bar coding technology is also applied to supply chain goods ready for shipment are packed and each package is numbered and bar-coded with a unique number when

processed by the receiver, the original message is matched and what has been ordered and delivered can be checked. Inventories can then be updated automatically.



Lesson-28

Scope of Aseptic Packaging and Pre-Requisite Conditions for Aseptic Packaging. Description of Equipments (Including Aseptic Tank) and Machines

28.1 INTRODUCTION

Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the containers so that re-infection is prevented. This results in a product, which is shelf-stable at ambient temperature conditions.

28.2 SCOPE OF ASEPTIC PACKAGING

There are number of limitations and disadvantages during actual application of this technology. However, we can't ignore the advantages over various lacunas of the process. Thus, it can be concluded that aseptic packaging of sterile/non sterile food and food products is the most significant innovation in the field of food science and technology and there is a big scope in this area.

28.3 MAJOR CATEGORIES OF ASEPTIC PACKAGING SYSTEMS

- *Can system:* It includes hermetically sealed cans
- *Bottle systems:* Glass containers and plastics bottles fall into this category. The bottles can further be divided into; a) Non-sterile bottles; b) Sterile blown bottles; c) Single station blowing, filling & sealing
- *Sachet and pouch systems:* This system is classified into Form-fill-seal systems and Lay flat tubing
- *Cup systems:* The aseptic packaging of food into cups can be into; Pre-formed plastic cups and Form-fill and seal cups
- *Carton systems:* This type of aseptic packaging system includes Form-fill-seal cartons and Prefabricated cartons
- *Bulk packaging systems:* This type of system classified into; Metal drum and Bag-in-box Packaging Lines for Aseptic Processing.

There are five basic types of aseptic packaging lines as given below;

- *Film & Seal:* Pre-formed containers made up of thermoformed plastic, glass or metal are sterilized, filled in aseptic environment and sealed.
- *Form, Fill & Seal:* Roll of material is sterilized, formed in sterile environment, filled and sealed. e.g. Ex tetra packs *Erect, Fill & seal:* Using knocked, down blanks, erected, sterilized, filled sealed. e.g. Ex. Gable-top cartons, Cambri-block.
- Thermoform, Fill, sealed roll stock, sterilized, thermoformed, filled, sealed aseptically. e.g. Ex. Creamers, plastic soup cans.
- Blow, Mold, Fill & Seal. e.g. Different package forms used in Aseptic UHT processing are cans, paperboards/plastic/foil/plastic laminates/flexible pouches, thermoformed plastic containers, bag in box, bulk totes.

28.4 PRE-REQUISITE CONDITIONS FOR ASEPTIC PACKAGING

- It should contain the product.
- It should prevent physical damage to packaged product.
- It should run smoothly on filling lines.
- It should withstand packaging processes.
- It should be easy to handle throughout distribution process.
- It should prevent dirt and other contamination.
- It should be able to protect the product from odours and taints.
- It should be resistant to rodent attack.
- It should be able to stop insect infestation.
- It should be biologically safe i.e. non toxic.
- It should be compatible to foodstuff.
- It should provide sterility to product.
- It should prevent ingress of microorganisms.
- It should show evidence of tampering.
- It should control moisture loss or gain.
- It should offer a barrier to oxygen.
- It should be protective against the light.
- It should maintain gas atmospheres, i.e. CO₂/N₂.
- It should communicate all the information regarding product and manufacturer.
- It should have good sales appeal.
- It should be easy to open
- It should be cost effective.

The above given pack criteria are separated into seven areas, mainly as follows:

- **Product Containment:** The need to contain the product in the sense that liquids or powders do not leak out.
- **Physical Protection:** This is required when dealing with fragile foods like eggs or snack foods, but minor impacts on fresh fruits, for example, will release enzymes and lead to browning and softening. Equally important is the adverse effects on sales of damaged packages themselves-even though the product is in good condition.
- **Food Safety:** The need to ensure that the aseptically packed food retains its sterility, through a package that prevents adventitious contamination by microorganisms. Tamper evidence is also a desirable requirement. The other aspect of food safety is the avoidance of long-term chronic effects from the food packaging materials themselves.
- **Shelf-Life:** For dried foods moisture gain is a major factor in determining shelf-life. Atmospheric oxidation, often catalyzed by light, is more critical for aseptically packed foods such as milk, fruit juices, or cream soups. Hence a good oxygen and light barrier, as provided by tinfoil or aluminum foil, is needed to ensure maximum shelf life for aseptically packed products.
- **Communication of Information:** The package should need to tell the purchaser what food is inside it and whose product it is. Apart from this, more information should be passed on to the customer, such as net

weight, list of ingredients, batch number, use-by date, nutritional information etc.

- **Sale-Appeal:** The package must look attractive and 'catch the eye' of prospective purchasers, and it should also be easy to open and dispense the product.
- **Cost-Effectiveness:** Value for money in packaging is more important than looking for the lowest price. A cheap but dimensionally variable container could cause more damage during production or an increase of 'leakers' in the market place, thereby effects the sale of the product.

28.5 ASEPTIC TANK

The aseptic tank is used for intermediate storage of UHT treated dairy products. It can be used in different ways in UHT lines, depending on plant design and the capacities of the various units in the process and packaging lines.

- If one of the packaging machines incidentally stops, the aseptic tank can take care of the surplus product during the stoppage.
- Simultaneous packaging of two products.

The aseptic tank is first filled with one product, sufficient to last for a full shift of packaging. Then the UHT plant is switched over to another product which is packed directly in the line of packaging machines. One or more aseptic tanks included in the production line offer flexibility in production planning.

Direct packaging from a UHT plant requires recirculation of a minimum extra volume of 300 litres per hour to maintain a constant pressure to the filling machines. Products which are sensitive to overtreatment cannot tolerate this and the required overcapacity must then be fed from an aseptic tank.

The optimum arrangement must thus be decided for each individual process with UHT plants, aseptic tanks and aseptic packaging machines.



Lesson-29

Micro-processor Controlled Systems Employed for Aseptic Packaging- Package Conditions and Quality Assurance Aspects of Aseptic Packaging

29.1 INTRODUCTION

Microprocessors & microcomputers are first used in packaging machines for the first time in 1973. Microprocessor-based equipment controls were first used in 1977. Microprocessor-controlled packaging machinery were first commercially used in 1978. Microprocessor-based aseptic packaging has capability of monitoring one or more process variables simultaneously.

Main operations that are taken care by microprocessors are

- Feeding of film to the machine
- Converting of film into required shape of specific dimensions
- Filling the product with specific volume of product
- Heat sealing
- Collecting up of specific no of packs and shrink wrapping them into one single pack.

All these operations are taken care by Microprocessors.

29.2 STERILIZATION OF PACKAGING MATERIAL

Whatever the choice of packaging material used, it must be pre-sterilized prior to filling. Sterilization of the packaging material should not impair that material. Methods commonly used for sterilization of packaging materials or packages include steam (saturated or superheated), hot air, hydrogen peroxide, ultraviolet light, irradiation, or the heat generated during the co-extrusion of certain films.

29.2.1 Precautions to be taken: Since aseptic packaging systems are complex, there is considerable scope for packaging faults to occur, which will lead to spoiled products.

- Packages should be inspected regularly to ensure that they are airtight, again focusing upon those more critical parts of the process, such as start-up,

shutdown, product changeovers and, for carton systems, reel splices and paper splices.

- Pipes, storage tank, and surfaces of the packaging machine come into contact with the sterilized product have to be sterilized.
- Sterilization procedures should be verified.
- The seal integrity of the package should be monitored as well as the overall microbial quality of packaging material itself.
- Care should be taken to minimize contamination during subsequent handling. All these could result in an increase in spoilage rate.
- Rinsing, cleaning and disinfecting procedures are also very important, especially the removal of fouling deposits, which may provide a breeding ground for the growth of micro-organisms, especially thermophiles.

29.3 QUALITY ASSURANCE ASPECTS OF ASEPTIC PACKAGING

- Aseptic packaging has to be meticulously checked.
- Not only must the packaged product be examined, but so must all preceding steps, as well as the operators, which are potential carriers of pathogens.
- If just one bacterium reaches the product, and that bacterium is pathogenic and can proliferate (for example, *Staphylococcus aureus*), the result could be disastrous.
- In addition to regular sampling during production, further samples should be taken at the times or in situations known to be associated with an increased risk of contamination. It is advisable to incubate these samples long enough, in most cases from 5 to 7 days at 30°C to allow sub-lethally damaged bacteria also to grow to detectable counts. The products should only be delivered if the result of the shelf-life test is Satisfactory



Lesson-30

Microbial Standards, Packaging material as Sources of Contamination

30.1 INTRODUCTION

Modern packaging can be defined as a means of ensuring safe delivery of a product to the consumer in sound condition at minimal overall cost. Packaging materials contain the product and protect it from environment. It also provides important information to the consumers and enables convenient dispensing of food. In simple the functions of the packaging materials are containment, protection, preservation, identification and convenience.

30.2 MICROBIAL STANDARDS

Microbial characteristics of food that influence package selection are based on foods which can be divided into 3 types:

- Perishable: Milk
- Semi perishable: Dried Milk
- Non perishable canned, sterilized

Spoilage of foods by microorganisms is influenced by: pH, moisture content and microbial growth rate which is affected by water activity and Storage temperature. Selection is based on type of spoilage considered i.e. whether microbial or chemical.

Packaging materials play an important role on the microbiological quality of milk and milk products.

The effect of two types.

1. Directly influences the microbial load due to the presence of microbes on their surfaces.
2. Indirect influence due to their permeable character to the access of microbes

Packaging Of Dairy Products

Important factors in choosing a packaging unit may depend on:

- Degree of protection needed against light, humidity, temperature, micro-organisms /insects, protection for Protein, Fat, Characteristic Flavour and Water in products. The Price, Sales appeal, Ease in handling, Mechanical hazard and handling by consumers are also the determining factors.

The two important factors that control the influence of packaging materials on milk products are

1. Exposure to high temperature during the fabrication of packaging materials to keep them sterile.
2. Care during subsequent handling and storage of these materials and avoiding the contamination.

30.2.1 Proposed Microbiological Standards

- SPC : 10 / 100 cm² or 10 per 100 ml capacity among which about 3% are spores.

o Laminated paper has been shown to contain, say, 10 organisms per 100 cm², The inner surface of a 1-liter carton is about 800 cm² and will thus on average be contaminated by about 2.5 spores. These spores are the most heat resistant, and hence their number must be reduced to less than 10⁻⁵ per package. Furthermore, the packages should be aseptically closed; an atmosphere with overpressure and sterile air is usually applied.

- Coliforms : Nil per cm² or Nil per 100 ml capacity

For aseptic packaging the packaging material should be sterile. Such material is allowed to pass through 15-35.5 % of H₂O₂ before packing.

At present methods of packaging of certain dairy products are undergoing a revolution. Liquid milk cheese and ice cream are the products that are most affected. The main trend is towards plastics such as plastic bags, plastic lined cartons and plastic containers. This substitution for glass will eliminate problems of foreign bodies and glass fragments in

containers. An ideal pack should be virtually, but may not be absolutely, oxygen and moisture proof.

Testing of packaging materials for microbial quality:

- A specified area of the packaging material is cut and placed on a solid agar medium in a Petri dish and over laid with medium.
- Incubate the plates and count the colonies on both sides of the medium
- This technique is for the non absorbent packaging material such cardboard, plastics and aluminium foil

The packaging materials for the presence of pin holes are tested by using the bacterial suspension of *Bacillus polymyxa*. The packages are immersed in the chilled suspension of *Bacillus polymyxa* under slightly induced vacuum in the packages. The bacteria penetrate the pin holes and cause spoilage on incubation.



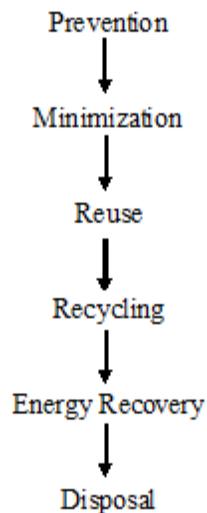
Lesson-31

Disposal Methods of Waste Packages

31.1 INTRODUCTION

After product usage, the empty packages have to be discarded, and these constitute a fair proportion of the solid waste produced by the community. In developed countries 4 lb of municipal waste is created by each person in one day. Out of this, packaging accounts for nearly 1/3rd of the volume. The collection and proper disposal of the waste is done by ministerial or public health authorities. Glass, paper, plastics and tin cans are the main packaging materials which get mixed with the city refuse and present problem of their proper disposal. The non - disposable nature of many packaging materials make it much more complicated problem.

31.2 THE HIERARCHY OF WASTE DISPOSAL



- **Prevention** – Waste prevention is a primary goal. Packaging should be used only where needed. Proper packaging can also help prevent waste.
- **Minimization** – The mass and volume of packaging can be measured and used as one of the criteria to minimize during the package design process. Usually “reduced” packaging also helps minimize costs. Packaging engineers should continue to work toward reduced packaging.

- **Reuse** – The reuse of a package or component for other purposes shall be encouraged. Returnable packaging has long been useful and economically viable.
- **Recycling** – Recycling is the reprocessing of materials (pre- and post-consumer) into new products. Emphasis is focused on recycling the largest primary components of a package. i.e. Steel, aluminium, papers, plastics, etc. Small components can be chosen which are not difficult to separate and do not contaminate recycling operations.
- **Energy recovery** – Waste-to-energy and Refuse-derived fuel in approved facilities are able to make use of the heat available from the packaging components.
- **Disposal** – Incineration and placement in a sanitary landfill are needed for some materials. Material content should be checked for potential hazards to emissions and ash from incineration and leach out from landfill. Packages should not be littered.

31.3 METHODS OF WASTE DISPOSAL

There are various methods of waste disposal

31.3.1 Open dumping: By this method only those packaging materials which would not be expected to contribute to public health hazards can be disposed. Disadvantage: Discarded food packages may contain residual food products and moisture which can harbour insects and bacteria that may cause public health concern.

31.3.2 Sanitary landfill method: The most popular method of disposing the package waste is the landfill method. Here the trouble free waste packaging material is stored after compressing and piling. The waste is spread layer by layer and each layer is covered by earth. Degradability due to bio-physical agents or chemical oxidation is the common feature in sanitary landfill. Disadvantage: Leaking of contaminants and then polluting ground water and production of methane gas are the commonly encountered problems in this method. In general, packaging materials are not easily degradable. Bio degradable material produces methane gas. Plasticizers used in PVC will evolve from waste as emissions. Lead and calcium compounds used in pigments pose a problem of ground water pollution.

31.3.3 Composting: This process is best suited for bio degradable packaging waste material. Disadvantage: Paper degrades in composting. Glass, metals and plastics do not degrade in composting operation.

31.3.4 Incineration: Incineration means burning of the packaging waste with or without energy recovery. This is the most hygienic method of reducing the volume and weight of solid waste.

31.3.4.1 Advantages:

- a. Incineration of packaging materials like wood, paper and plastics have significant fuel value/ energy source.
- b. Packaging is not hazardous contributor to the emissions except PVC.

Packaging Of Dairy Products

- c. Very little lead and cadmium are found in ash on incineration
- d. Most hygienic way of waste disposal.

31.3.4.2 Disadvantages:

- a. Large investment is required to construct plants.
- b. High operational cost is involved.
- c. Air pollution - Ex: release of hydrogen chloride during burning of PVC.
- d. Glass, steel and other metals are not combustible and they should be removed before incineration.
- e. Glass and plastics if not removed, create problems in incinerator due to melting and solidifying inside the equipment.

31.3.5 Recycling: Recycling means use of waste material as raw material for preparation of new products.

31.3.5.1 Two methods of recycling:

- a) Primary Re-cycling: It means the use of recycled material to produce the same material. Ex: Aluminum cans, Glass bottles.
- b) Secondary Re-Cycling: Use of recycled material to form new materials with lower specifications.

Ex: Use of food grade plastics in production of plastics for industrial use.

3.1.3.5.2 Advantages:

- 1) This method conserves resources
- 2) Reduces the waste disposal load by other methods.
- 3) There is a good demand for recycled material and they are cost effective.

31.3.5.3 Disadvantages:

- 1) Cannot dispose laminates etc which are now the commonest packaging for food due to combination of different varieties of packaging materials.
- 2) Efficient collection system should exist and the recyclable material should be separated from the rest of the waste material.
- 3) Residual food products in containers / pouches require cleaning before re-cycling.

- 4) Recycling of coloured glasses / films is a complex phenomenon.
- 5) Difficulty in collection and segregation.

31.4 THE MATERIALS THAT CAN BE RECYCLED

- (A) Steel cans
- (B) Aluminum cans
- (C) Glass bottles/containers
- (D) Plastics
- (E) Paper

31.5 RECENT DEVELOPMENTS

Recent developments in packaging waste disposal include grinding of glass before land filling, more sophisticated combustion techniques to eliminate fouling problems of plastics. Bio-degradable, solar-degradable plastics are under development. PE, PET, PP etc can be added to coal tar while melting and use of this coal tar gives water resistance for the road laid. The laminates of Aseptic packs can be compressed into ply boards which are used for industry lamination.



Lesson-32

Description of Equipments and Machines of Different Packaging Systems

32.1 INTRODUCTION

Packaging is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use.

32.2 PACKAGING MACHINE

Choice of packaging machinery depends as

- technical capabilities, labor requirements
- worker safety
- maintainability
- serviceability
- reliability
- ability to integrate into the packaging line
- capital cost
- floorspace
- Flexibility (change-over, materials, etc.)
- energy usage
- quality of outgoing packages
- Qualifications (for food, pharmaceuticals, etc.)

- throughput
- efficiency
- productivity
- Ergonomics, etc.

Packaging machines may be of the following general types:

1. Blister packs, skin packs and Vacuum Packaging Machines
2. Bottle capping equipment, Over-Capping, Lidding, Closing, Seaming and Sealing Machines
3. Cartoning Machines
4. Box, Case and Tray Forming, Packing, Unpacking, Closing and Sealing Machines
5. Cleaning, Sterilizing, Cooling and Drying Machines
6. Conveyors, Accumulating and Related Machines
7. Feeding, Orienting, Placing and Related Machines
8. Filling Machines: handling liquid and powdered products
9. Package Filling and Closing Machines
10. Form, Fill and Seal Machines
11. Inspecting, Detecting and Check weighing Machines
12. Palletizing, Depalletizing, Unit load assembly
13. Product Identification: labeling, marking, etc.
14. Wrapping Machines
15. Converting Machines

Other specialty machinery include slitters, perforating machines etc.

32.3 PACKAGING MACHINERY

32.3.1 Filling Machine

There are two Types (a) Filling by gravitation (b) Mechanical filling.

32.3.1 Filling by Gravitation: Filling by gravity is used for filling thin liquids like milk into glass bottles/plastic bottles. In gravitational filling, the filling process is stopped when the pre-calibrated filling height has been reached. This system is suitable for filling milk in glass bottles. However, packaging milk in bottles is outdated in India. In volumetric filling process, fixed volume of milk is filled.

32.3.2 Mechanical Filling: In this type milk powders are metered filled by using screw conveyors. The conveyors are used as metering and dosing devices. However, due to variation in bulk densities of milk powder, care must be exercised to ensure even delivery of the product and which shall be equal in weight from package to package.

32.3.3 Over Wrapping Machines: Over wrapping the product with a film or foil is commonly employed for cheese and butter. Generally these machines work as the push – through principle i.e. the portion to be wrapped is pushed onto the film. In these machines, a measured amount of foil or film is pressed by a piston through a folding channel into a mould. The product shape that is generally packed is either rectangular or triangular. After the piston is drawn, the product is filled into the wrapper, situated in the mould by means of a dosing device. The wrapper is finally folded by the folding equipment. The finished pack is pushed out of the mould.

32.3.4 Cup Filling Machines: Ice Cream, yoghurt, Shrikand ,Dahi, Lassi etc are some of the products packed in cups. Plastic cups either preformed, from a film in the machine itself or ready made cups when used are placed in the stacker of the machine. Automatic packaging machines which work aseptically are in use for the production of long life products. In these machines the film is passed through a bath of Hydrogen peroxide and then goes to a sterile tunnel in which it is sterilized by either exposure to high temperature or exposure to excess

pressure of air. The remaining stage like cup moulding, filling and sealing with lid takes place in the sterile tunnel.

32.3.5 Form Fill and Sealing Machine: Form fill sealing machine (FFS) is a type of automated assembly-line product packaging system, commonly used in the packaging of milk, buttermilk, ghee etc.. The machine constructs plastic bags out of a flat roll of plastic film, while simultaneously filling the bags with product and sealing the filled bags.

- The typical machine is loaded with a continuous flat roll of plastic film, which has had labeling and artwork applied to the exterior or interior of the film. LDPE or LLDPE is the most commonly used packaging material
- For some products the film may first be fed through a sterilizing chemical bath and dryer prior to use in the packaging system.
- The film approaches the back of a long hollow conical tube, and when the center of the plastic is near the tube, the outer edges of the film form flaps that wrap around the conical tube. The film is pulled downward around the outside of the tube and a vertical heat-sealing bar clamps onto the edges of the film, bonding the film by melting the seam edges together.
- To start the bagging process, a horizontal sealing bar clamps across the bottom edge of the tube, bonding the film together, and cutting off any film below. The sealed tube end is then lowered onto a precision weighing table and the product to be bagged is dispensed through the long conical tube in the center of the bag.
- When the tare weight of the product-filled bag is reached, filling stops, and the horizontal sealing bar seals the top of the bag, and simultaneously forms the bottom of the next bag above. This bag is then cut off from the tube and is now a sealed package, ready to advance onward into the product boxing and shipping processes.

32.3.6 Packaging in cans and tubes: Cans made of tin plate are used for sweetened condensed milk, evaporated milk, canned Rasogolla and canned gulabjamoons. The cans open at the back are loaded into the machine which fills the product in to the cans. Then the lids are applied and closed by either simple or double seaming depending on the product. Cans with seam-on lids are also used for cream, ghee and milk powder.

Aerosol cans are used for the packaging of whipped cream. In these, the product is filled with a propellant which is under pressure.

Flat bottomed collapsible tubes made from aluminium are used for packing cream.

After the product is filled from the back of the tube, the head space in the tube is filled with inert gas and the tube is then closed by folding. Polyethylene collapsible tubes are presently used for packing cheese spread/cheese food.

32.3.7 Shrink wrapping machines: Shrink wrapping cannotes packing of one or several articles with a thermoplastic film which when subjected to heat shrinks and form a tight wrap around the object. Shrink wrap, also shrink-wrap or shrink film, is a material made up of polymer plastic film. When heat is applied to this material it shrinks tightly over whatever it is covering. Heat can be applied with a hand held heat gun (electric or gas) or the package can pass through a heat tunnel on a conveyor. Shrink wrap is commonly used as an overwrap on many types of packaging, including cartons, boxes, beverage cans and pallet loads. A variety of products may be enclosed in shrink wrap to stabilize the products, unitize them, keep them clean, add a degree of tamper resistance, etc. It can be the primary covering for some foods such as cheese and Paneer.

The most commonly used shrink wrap is polyolefin. It is available in a variety of thicknesses, clarities, strengths and shrink ratios. The two primary films are either crosslinked, or non crosslinked. Other shrink films include PVC and several other compositions like LDPE, LLDPE, PP, EVA etc. Coextrusions and laminations are available for specific mechanical and barrier properties for shrink wrapping food.

In shrink-wrap machine a loose plastic film pouch is made on a wrapping machine. The product is placed in this pack which passes through a heated tunnel in which the film shrinks and adheres closely to the product. The film is generally heated by hot air, infrared rays or hot water. Shrink wrapping is also used to hold together several singly wrapped products/ packages in a multiple unit package.

Advantages of shrink wrap packaging:

1. All types of items of regular / irregular shapes and sizes can be shrink wrapped.
2. Small items can be utilized and stacked one on top of the other
3. Requires minimum packaging material and operation.
4. Simple operation
5. Easy stacking
6. Enable unit packaging or packaging in groups.

32.3.8 Stretch wrapping: Stretch wrap or stretch film is a highly stretchable plastic film that is wrapped around items. The elastic recovery keeps the items tightly bound. In contrast, shrink wrap is applied loosely around an item and shrinks tightly with heat. It is frequently used to unitize pallet loads but also may be used for bundling smaller items. Types of stretch film include bundling stretch film, hand stretch film, extended core stretch film, machine stretch film and static dissipative film.

32.3.8.1 Materials: The most common stretch wrap material is linear low-density polyethylene or LLDPE, which is produced by copolymerization of ethylene with alpha-olefins, the most common of which are butene, hexene and octene. Other types of polyethylene and PVC can also be used. Many films have about 500% stretch at break but are only stretched to about 100 – 300% in use. Once stretched, the elastic recovery is used to keep the load tight. Other properties such as break strength, cling, clarity, tear resistance, static discharge, etc. are also important.

32.3.8.2 Functions

In pallet unitizing, stretch wrap can have several functions:

- improved stability of products or packages, forming a unit load
- more efficient handling and storage of unit loads
- some degree of dust and moisture protection
- some degree of tamper resistance and resistance to package pilferage
- Stretch wrapping is the most cost-effective way to keep loads secured on a pallet.
- Stretch wrapping can be applied manually with small rolls (perhaps 5-inch wide) of film. Dispensers are also available for larger rolls. Machinery is available to automate the operation. This controls the amount of material used, controls the stretch, and controls the application pattern. It is important not to apply too much tension or too many layers: the stress can damage the vertical edges of the boxes and significantly reduce stacking strength.

32.3.9 Inert gas packing: Inert gas packing using nitrogen, carbon dioxide or a mixture of the two is done by passing the gasses around the product prior to sealing ex: Cheese. Whole milk powder packed in tins with a pin hole is evacuated under vacuum. The vacuum is then broken by the inert gas (usually N₂) and the pin hole is sealed immediately.

32.3.10.Vacuum Packaging: Vacuum packaging is done for products like cheese blocks, panner etc, where there is problem of microorganisms growing on the surface. The product is placed in a plastic pouch and placed in the vacuum packaging machine for the creation of vacuum in the pack and subsequent sealing takes place in the machine itself.

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