UNIT 16 FOOD PACKAGING

Structure

16.0 OBJECTIVES

After reading this Unit, we shall be able to:

- characterize different types of packaging materials for foods;
- reflect upon need and importance of packaging of foods;
- explain new modern packaging concepts;
- outline salient features of modified atmosphere packaging and active and intelligent packaging;
- undertake labelling and Bar coding in food packaging;
- specify advantages, requirements and materials for edible packaging films.

16.1 INTRODUCTION

Packaging is the 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. Packaging of foods is perhaps one of the most challenging industrial activities, since safety of the foods we eat is dependent upon it. Packaging is heavily integrated into our daily lives, we see it all around us, on everyday items such as chocolate bars and potato chip (crisp) packets. As explained below, the main use for packaging is protection of the goods inside, but packaging also provides us with a recognizable logo and information, so that we instantly know what goods are inside.

Packaging can be defined as a tool that protects and contains our goods with the aim of minimizing the environmental impact of our consumption. Ideal packaging can be compared with that of a banana, orange peel, coconut and eggshell- the packaging provided by Mother Nature.

I think the best definition of packaging, is by Mr. Robert Rausina, founder of Tetra Pak Sweden. According to him "a good packaging is one that saves more than it costs, including refrigeration, transportation, storage, handling, labour, etc."

Considerable advancements have taken place in area of food packaging. A major change has been our ability to protect and preserve products with packaging. We have ensured the availability of products out of season, over long distances in various forms, fresh as well as processed. Today, the consumer has a wider selection of food items. Armed with disposable income, he is keen to try new products.

Packaging has become a modern socio-scientific discipline having the following roles:

- Containing and safety of product that is of paramount importance.
- Facilitating the handling, storage and distribution.
- Protecting against biological, chemical and distribution damages.
- Providing convenience.
- Informing through the medium of labeling.
- Security through a tamper evident design.
- Contribution to the product image through structural and graphic design.
- Increasing the shelf-life and ensuring longer availability.
- As a marketing and advertising tool.
- Environment protection by taking responsibility of empty packaging material after its use.

The packaging industry in India is a heterogeneous mix of both organized and unorganized sectors. The industry comprises of manufacturers of basic materials, converted package forms, ancillary materials and packaging machinery. The packaging conversion machinery and ancillary materials production units are primarily in the small-scale sector and being gradually updated to reach international standards. The packaging lines generally occupy 50% of the floor space, and the packaging and related activities engage about 60% of the 5 million labor force concerned with the Indian food industry.

16.2 NEED FOR PACKAGING OF FOODS

Packaging and package labelling have several objectives:

- **Physical protection** - The objects enclosed in the package may require protection from, among other things, shock, vibration, compression, temperature, etc.
- **Barrier protection** - A barrier from oxygen, water vapor, dust, etc., is often required. Package permeability 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.
- **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 flowables need containment.
- **Information transmission** - Information on how to use, transport, recycle, or dispose of the package or product is often given on the package or label. With pharmaceutical, food, medical, and chemical products, some types of information are required by legislation.
- **Marketing** - The packaging and labels can be used by marketers to encourage potential buyers to purchase the product. Package design has been an important and constantly evolving phenomenon for dozens of years. Marketing communications and graphic design are applied to the surface of the package and (in many cases) the point of sale display.
- **Security** - Packaging can play an important role in reducing the security risks of shipment. 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, Radio Frequency Identification (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.
- **Convenience** - Packages can have features which add convenience in distribution, handling, display, sale, opening, reclosing, use and reuse.
- **Portion control** - Single serving or single dosage packaging 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 is also aids the control of inventory: selling sealed one-liter-bottles of milk, rather than having people bring their own bottles to fill themselves.

16.3 TYPES OF PACKAGING

Individual packaging: This means the packaging of individual items of goods and includes the technique of application of appropriate materials and containers, etc. to protect each individual item of goods, or to increase the

merchandise value as well as the conditions of the goods to which those techniques are applied. This could also be called as 'Primary Packaging'.

Inner packaging: This means the inner packaging of packaged goods, the techniques of application of the appropriate materials or container, etc., with consideration of the protection of goods against water vapour, light, heat, impact, etc. as well as the condition of the goods to which these techniques have been applied. This could also be called as 'Secondary Packaging'.

External packaging: This indicates the outer packaging of packed goods, in other words, the techniques of placing the goods in a box, bag or other container such as a barrel or can, etc., or bundling without the use of a container, and adding markings to identify the goods as cargo; as well as the conditions of application of these procedures. This could also be called as Tertiary Packaging.

In case of food packaging, the word 'goods' can be substituted by 'food'.

Another classification of food packaging is into `Rigid Containers` like cans, glass bottles etc.; semi-rigid containers like standi-packs, Tetra-bricks and plastic bottles, etc. and Flexible packages like LDPE milk pouches, laminates containing spices and Tetrafino pillow pouches etc.

16.4 FORMS OF PACKAGING

Metal cans: These can be classified into round, square, oval or pill-shaped, flat, etc. Cans are often classified into 2-piece or 3-piece cans. The latter uses tin-plate as its basic material, and the can is joined by soldering or welding. In the case of tin-free-steel (TFS) cans, body making is done by using an organic adhesive agent. 2-piece cans include cans punched out by a press machine, aluminium can is made by impact extraction, D1 cans ironed after contraction process and DR cans are manufactured by carrying out contraction process two or more times. D1 cans are used where high internal pressure resistance is required. Bonded and welded cans may be used as alternative to conventional soldered cans.

Glass bottles: Glass bottles and containers are available in many different shapes such as large "free-size" bottles, small "one-shot" styles, light-weight bottles for soft drinks, heavy-weight "hand-crafted" type liquor bottles returnable bottles, etc.

Stretch-wrap packaging: In this method, food is placed in a tray and film is stretched over the food to cover it. Stretchable PVC films, PE films, etc. are used as packaging materials. Shrink packaging is a form of packaging in which one or more items are covered with film, which shrinks when heated. The film is shrunk using either dry or moist heat. Films that are used for this application include PVC, PP and PE.

Flexible pouches: A pouch is a container made of a flexible packaging material, such as plastic film, aluminium foil, paper, etc. which is used either singly or in continuation.

Bag-in-box packages: Bag-in-carton or bag-in-box containers have double construction, with both an inner and an outer package. The former type is used for several food items including liquids while the latter is used for institutional use and for bulk shipment. The external package provides mechanical strength, while the inner bag protects the contents against water vapour, gases and volatiles. This can be made of single substance or multi-layer structure.

Cups/trays: The types of cups used as containers include thermo-formed, air-pressure formed and expanded plastic sheets. Recently, a cup with a barrier layer manufactured using pressurized air with laminated sheet and a composite cup with an inner layer of aluminium foil has been introduced. Paper cups, with PE, PP or PET inserts, thermo-formed are also being used.

Paper-board containers: The 'pure-pak'/`tetra-pack` type of containers, with its distinctive gable-top and the 'brick-type' smaller containers are the predominant packages used for milk products. Paper laminated to PE is used for ordinary milk while for long-life milk, fruit drinks, etc. laminated aluminium foils are used.

16.4.1 Choosing an Appropriate Packaging Material

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

- The specific sensitivities of the contents, e.g. moisture, oxygen, etc.
- Factors changing the contents viz. temperature, RH, pH, and the reaction mechanism involved.
- Weight and shape of container.
- Effect on filling and sealing speeds.
- Contamination of food by constituents of the packing material.
- Storage conditions- How long the product needs to be protected.
- Bio-degradability and recycling potential.
- Most of the food production has been in the rural pockets of the country, while the major markets are in the urban areas. So the need for its transportation over long distances has become a necessity.
- Dairy and fruit products being highly perishable products, utmost care is needed in its preservation during storage, handling and transportation.
- Food products spoil fast at high temperatures, in the presence of oxygen and other contaminating agents present in the atmosphere.
- There are many more peculiarities, which could be identified under the following headings for determining the packaging of processed food products.
  -> Product range
  -> Market
  -> Consumer needs
  -> Operating margins

In India, there are 12 different types of thermoplastics used as raw materials for manufacturing of plastic products along with separate standard on positive list of constituents that have been formulated. These standards prescribe requirements, methods of test and sampling for respective materials, vis-à-vis positive list of constituents of respective material such as homopolymer, polymer, etc. The standards are used for food contact application and to be used in combination to provide a system of control to the plastic manufactures as well as fabricators of thermoplastic packaging material to derive maximum benefits.

Bureau of Indian Standards (BIS) has formulated guidelines on suitability of plastics for food packaging (IS 10171). It provides guidance to the food packer

in selecting the specific thermoplastic material to design an acceptable food packaging system. Since there is always the possibility of transfer of a part of packaging material to the contents of packed material due to intimate contact, it is essential that formulation of the package should be selected to ensure that any such transfer is at minimum and substances which migrate from the package to the packed material are within limits and cause no toxic hazards when consumed.

16.4.2 Packaging and consumer needs

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

- Well-packed food products are associated with quality.
- Packaging is expected to make food products safe.
- Increasing mobile lifestyle.
- Time has become a precious commodity.
- The younger generation is looking for health and wellness foods and beverages.
- The consumer is ready to try new products.
- Concern for freshness.
- Seeking a home-meal dining experience. The traditional family meal is fast becoming a rarity in urban India.
- For children, innovative or fun flavoured fortified foods and beverages.

16.4.3 Attributes that Consumers Appreciate

– Product quality and protection with a great emphasis on freshness.
– Easy to open, dispense, reseal and store.
– Appealing product presentation is gaining prominence.
– Durable and eco friendly is being viewed together.
– Leak and spillage proof is a must for the producer as well as the consumer.
– Reusable packaging.
– Less hassles, more convenience.
– Selection from a wider choice of available sizes.

16.4.4 Packaging Materials for different Food Products

Let us now get familiar with packaging materials that are normally used for common food items. The following table 16.1 should effectively familiarize you with some commonly used materials and terminology:

Table 16.1: **List of Food** P**roducts and Normal Packaging Materials.**

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

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

Legend :-

LDPE : Low density Polyethylene
LLDPE : Linear LDPE
Poly : Polythene
Alu Foil : Aluminium foil
PET : Polyethylene teripthallate
BOPP : Biaxially oriented Polypropylene

We must appreciate that packaging is a constantly evolving, dynamic subject and major changes keep occurring in the food industry with respect to packaging.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

(1) Can you recapitulate the practical definition of good packaging given by Mr. Rausina?

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(2) Please list out some of the major roles played by packaging in the farm to fork journey of foods the important types of paper and paper board.

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(3) Which are the two types of major metal cans used for food packaging?

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(4) There are professionals who think glass may the packaging material of the 21st century – why?

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(5) Please list out some of the major factors that decide the most appropriate packaging materials for specific foods

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(6) Please list out some of the attributes that consumers appreciate when it comes to food packaging.

16.5 PACKAGING MATERIAL

The packaging material used for food products can be classified into three categories i.e. Flexible, rigid and semi rigid. Different materials under these three categories are discussed below:

16.5.1 Flexible Packaging Materials

It has been estimated that there would be average growth of 20-25% of consumption of flexible packaging materials by the end of 2010 A.D. These materials are not rigid. They are soft and elastic in nature Different types of Flexible material used for packaging of food products are enumerated here.

16.5.1.1 Paper and Paper Board

Paper could be simply explained as a combination of fibres, joined together by means of binding agent. However, a number of chemicals are also used to improve different properties of paper like brightness, opacity, strength properties, etc. Paper and paper boards can be clearly differentiated by considering the grammage (gms/ sq.metre). More than 180 grammage papers are called as paper board. Paper boards are having certain improved properties like high stiffness, high bending resistance and less water absorption, etc.

Types of Paper and Paper Boards: Depending upon the properties, there are different types of paper and paper boards which have got wide application in packaging of dairy products. The details are as follows:

Paper: Tissue paper, Coated paper (Varnish coated, wax coated, plastic coated), Glassine paper, Art Paper, Kraft Paper, VPI paper, High Gloss Paper, Vegetable parchment paper and Grease proof paper (G.P.P). Kraft paper is a strong paper which is used for 25-30 kgs, multi-wall sacks for powders, flours, sugar, fruits and vegetables.

Paper Boards: Duplex Board, Clay coated board, Triplex Board, Kraft Board, Coated board, Chip Board, Asphalted board, Straw board, Grey Board and Mill board.

Properties of Paper: Paper is used for the packaging due to the following advantages: (1) Flexible in nature, (2) Easy amenable to printing, (3) Easy amenable to any kind of coating, (4) Good temperature resistance either high or low, (5) Excellent properties towards recycling, (6) High strength properties (7) Good insulation properties, (8) High gloss properties on smooth side (i.e. felt side), (9) Could be manufactured with high brightness properties, (10) Excellent folding endurance properties, (11) Good tear resistance properties and (12) Compatibility with other packaging materials for lamination.

Properties of Paper Board: (1) Paper boards are having all the properties of paper, (2) In addition, these materials are having good dead fold characteristics, (3) High stiffness properties, (4) Amenability to fabricate folding cartons, display carton, etc. and (5) Less cobb value as compared to paper.

16.5.1.2 Aluminium Foils

What is Aluminium Foil?

Aluminium foil is a continuous web/sheet of aluminium metal rolled to thickness/gauges ranging from 0.005mm to 0.2mm. It is produced from commercial purity aluminium with aluminium content of not less than 98% purer metal with 99.8% content is of more interest to the electrical industry. It is available as free unsupported or unlaminated or laminated to paper or film. It is available in plain, coloured, coated, lubricated and embossed forms.

Properties of Aluminium Foils: The important properties are as follows:

(i) Impermeable, (ii) Non Toxic, (iii) Stable, (iv) Light and heat barriers and (v) Tasteless and Odourless.

Advantages of Foil: The advantages are: (1) Tearing properties facilitates to use as sealing surface in the blister pack. (2) Extensively used for lamination due to impermeable properties.

16.5.1.3 Plastic Materials

"A plastic material is solid at ordinary temperatures and allows appreciable and permanent change of form without losing its coherence on the application of pressure and heat." Plastic materials are perhaps the most versatile group of materials used in packaging. The plastic resins are generally categorized in two ways i.e. thermo set and thermoplastic resin. Some of the important thermoplastic materials which have got extensive application in packaging are like polyethylene, polypropylene, polyvinyl chloride, polyester, nylon or polyamide, polystyrene etc. These polymeric materials are normally classified into different group based on the polymerization process and molecular structure like

(a) Polyolefins - Polyethylene and Polypropylene (PP)
(b) Polyvinyl group - Polyvinyl Chloride (PVC)
(c) Condensation - Polyester(PET), Nylon-6 or Polyamide (PA)
(d) Styrene Polymers - Polystyrene (PS) and Expanded polystyrene (EPS)
(e) Carbonate group - Polycarbonate (PC)

(a) Polyolefins Groups : The properties of different polymeric films are as follows:

(i) **Low-density Polyethylene (LDPE) film:** Density ranges from 0.910 – 0.925 gms/cc, Average molecular weight is 3 x 10^5, Resistance to heat is about 180 – 212^{0}F, Translucent type of clarity, Water absorption is 0.015%, Permeability to gas is 1.0 cc/m^2/ 24hrs at 27^{0}C & 1 atmospheric pr., Good tensile strength properties & high percentage of elongation, Good dart impact resistance, Resistance to the effect of weak acids and alkalies and Good barrier to moisture vapours, but has a relatively high gas permeability.

(ii) **Linear Low-density Polyethylene (LLDPE):** High film tensile strength properties as compared to LDPE, High percentage of elongation as compared to LDPE, High tear strength properties, Better stress crack resistance and low temperature brittleness, Improved stiffness properties, Excellent Puncture resistance and Excellent heat seal properties.

(iii) **Medium-density Polyethylene (MDPE) film:** Density varies from 0.926 – 0.940 gm/cc, Average molecular weight is 2 x $10^{5,}$ Resistance to heat is 220 – 250^{0}F, Translucent type of clarity, Percentage of water absorption is 0.01, Permeability to gas is 1.33 cc/m^2/24 hrs at 27^0 & 1 atms. Pressure, Very resistance to the effect of weak acids, alkalies etc. Exposure to sunlight turn its colour to yellowish.

(iv) **High-density Polyethylene (HDPE) film:** Density varies from 0.941 – 0.965 gm/cc, Average molecular weight is 1.25 x 10^5, Resistance to heat is 250^{0}F, Opaque in nature, High barrier to moisture vapour, Permeability to gas is less as compared to other polyethylene film and exposure to sunlight turn it yellowish.

(v) **High molecular high-density polyethylene film (HMHDPE):** High mechanical strength in both directions, Has got pleasant translucence in clarity, High tear resistance properties, Does not impart any taste or odour, Suitable for food contact application, Less elongation as compared to other polyethylene film and Excellent moisture barrier properties.

(vi) **Polypropylene (PP) film:** High tensile strength, High chemical resistance and high temperature performance than HDPE.

Very low permeability to moisture vapour and gas compared to polyethylene, High transparency, Chemical inertness and High softing point.

(b) Polyvinyl Chloride (PVC): It is hard, brittle and transparent materials, Low GTR, Moderate WVTR and good resistance to fat and oil, Glass like clarity, Good mechanical strength, Retention of flavour, Excellent printability, Lower weight/ volume ratio and Resistance to chemicals.

(c) Condensation Polymer: The properties of polyester and polyamide are as follows:

(i) **Polyester film:** It has got excellent gloss & thus enhance sales appeal; Very Low moisture and gas permeability; High mechanical strength; Resistance to tear, puncture; burst and flex crack; Dimensionally stable over a wide range of temperature from 70C^0 to + 130^{0}C; Excellent machinability; Excellent printability; Light in weight & thus economise

the transport expenditure; Free from all kinds of additives and thus does not contribute off flavours; Good surface properties for metallization.

(ii) **Polyamide or Nylon-6 film:** High mechanical strength, High elongation capability, Excellent resistance to cutting, perforation, abrasion and bursting, High chemical resistance to oils and fats, Outstanding impermeability to gases and vapours, Easy printability, Easy metallising, Economical (considering best yield/kg) and Could be biaxially oriented.

(d) Styrene Polymers: The important characteristics are:

(i) **Polystyrene (PS):** Polystyrene is not flexible in nature unlike LDPE and PP and is mostly used as rigid containers in the field of packaging. The important features or properties of this polymer are as follows:

Crystal clarity of containers, Availability in attractive light or dark colours, Lustrous finish, Rigidity and dimensional stability, Resistance to chemicals, Easy processing, Good barrier to moisture and ability to take post moulding decorations like hot stamp foiling, screen printing, inlay foil moulding etc.

(ii) **Expanded Polystyrene (EPS):** Expanded polystyrene (EPS) is neither flexible nor rigid in nature rather the materials are cushioning in nature. Normally, these materials are called as 'thermocole'. The important properties of this material are as follows:

Fully resistant to dilute acid, alkalis, alcohols, sea water but reacts with aliphatic hydro carbons, ketones etc., The density (kg/m^3) varies from 20-30, Stress at 10% compression (kg/cm^2) is 1 to 1.4, Shear strength (kg/cm^2) from 6 to 8, Flexural Strength (kg/cm^2) ranges from 2.5 to 3, Tensile strength (kg/cm^2) is from 2.5 to 3.2, Thermal conductivity at 10^0C (k. cal. m/hr. m^2 ^0C) is 0.028, Water vapour transmission rate is ranging from 0.6 to 1 gms/m^2/14hrs at 38^0C & 90% RH, Water absorption % volume after 7 days immersion is 0.6, Has no nutritive value for any known organism and does not provide a breeding ground for fungi, bacteria or insects and its contact with food stuff is perfectly safe.

(e) Multilayer Plastic Film: In order to have all the properties in a single form of polymeric materials so as to meet the requirement of processed food products especially for dairy products with desired shelf-life, a remarkable development has taken place to produce multiplayer plastic film either as laminate form or Co-extruded form.

Properties of multi layer Co-extruded Plastic films: High barrier properties to moisture and oxygen gas, improved in flexural endurance properties, dart impact strength properties is increased, no possibility of delamination of individual layer unlike laminates, Cheaper as compared to laminates and amenable to easy printing on surface.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

(1) How do you differentiate between paper and paperboard?

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(2) Indicate the important types of paper and paper board.

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(3) Explain five important properties of paper.

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(4) Explain five important properties of aluminium foil.

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(5) What are the important groups of plastic materials used in packaging?

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(6) How many types of multi layer plastic film are used in packaging?

16.5.2 Rigid Packaging Material

A wide variety of rigid packaging materials has been developed over a period of time. The most important packaging material like metal container have been widely used for the packaging of milk powder since long due to certain important properties like complete barrier to light, oxygen gas and moisture. In addition, glass bottles are also used for the packaging of flavoured milk and fresh milk. But now-a days, the application of flexible pouches have gone ahead to glass bottle for the packaging of pasteurised chilled milk. The plastic bottles are also used to a great extent for the packaging of dairy products. The corrugated fibre board boxes are considered to be the most important transport packaging materials for all processed food products including dairy products.

16.5.2.1 Glass Containers: Glass is the oldest packaging materials and used as containers for over 3000 years. The first glass container was made in Egypt in 1500 B.C. Despite of having certain inherent characteristic like fragility, tare weight, the glass containers have made an established application in packaging of dairy products.

Properties of Glass: Chemically Inert, Non – Permeable, Transparent, Mouldable, Excellent impact strength, light Weight, unlimited Supply and see through property.

Advantages of Glass Packaging: High or low temperature resistance, do not contaminate the contents with crystals or fibres, climatic variation do not affect the glass container, see through property, can be made in any size shape and capacity, does not taint, pollute or affect the quality of product, there are Various types of closures for glass container made of metal, plastic, cork or

rubber and Impermeable to moisture and gases thus suitable for processed food products.

Composition: The main constituent of glass are sand, lime stone and soda ash. The sand used is known as silica or glass sand. In some cases, arsenic, selenium and cobalt oxides in proper proportion are added to make clear glass. The green or brownish shade in glass comes from the impurities in natural sand, mainly iron. Boron from borax added to glass to make the container stronger and to increase its resistance to acids. Colours are added to glass, adding of small quantities of chromium, cobalt, iron and other colorants depending on the colour required. For amber (brown) glass, carbon and sulphide are added.

Types of Glass: The three universally accepted standard are :

Type III : All soda lime glasses are mainly Type III.

Type II : This is the same glass as Type III but the inside of the glass container is coated at the time of manufacture, usually with sulphur.

Type I : This is Borosilicate glass which has the added property of almost complete neutrality.

Application of Glass Containers: Glass containers have wide application for the packaging of pharmaceuticals, dairy, liquor, breweries, food products, soft drinks, cosmetics, chemicals, inks and other industries.

16.5.2.2 Metal Containers

Metal containers could be made from either aluminium, tinplate or tin free steel. But the tinplate container have got extensive application in packaging of food product especially dry products. There are two types of tinplate container namely:

a) **Open top sanitary can.**
b) **General line can**

a) **Open top sanitary can:** These cans are made of three pieces i.e. body, top and bottom ends. Hence, this OTS cans are also called as 3 piece can. These containers are normally round in shape, extensively used for dried products such as:

b) **General Line Container:** General line containers are ranging from tiny containers to 15 lts capacity containers for packaging of milk based biscuits or vanaspati.

Properties of Metal Cans: This materials are completely opaque, Complete barrier to moisture, oxygen gas as well as light, Amenable to print with multicolour decoration, Provides longer shelf life to dairy products, High impact strength to withstand stress during transit and Lighter in weight as compared to glass container.

16.5.2.3 Plastic Containers

Plastic containers are also used as an alternate rigid packaging materials for the packaging of dairy products mainly milk powder and ghee.

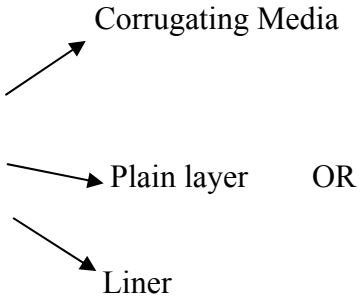
Properties of Plastic Containers: Could be manufactured in different size, shape and capacity, High barrier to moisture and oxygen gas, It is possible to manufacture the containers in different colours, Impact strength could be

improved, Plastic containers could be manufactured with handle to facilitate to carry, Could be made either opaque or transparent, Amenable to make surface printing and it is possible to make leak proof container.

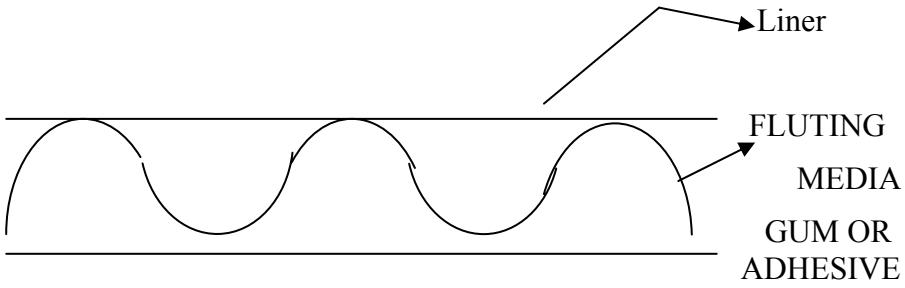
16.5.2.4 Corrugated Fibre Board Boxes

Corrugated fibre board boxes are the world's most popular and environment friendly packaging materials. The intelligent use of corrugated fibre board boxes can replace some of the use of wood, thermocole and plastics.

A single layer of kraft paper is passed through the corrugating machine to get the corrugations or fluting media and then stuck into a plain layer of kraft paper by means of adhesives or gum to form 2 layer or 2 ply corrugation roll.



Subsequently, the 2 ply corrugation roll could be converted into 3 ply corrugated fibre board by pasting another Kraft liner or facing material. In the same manner, corrugated fibre board could be made either of 3 ply or 5 ply or 7 ply by means of pasting the corrugation roll and facing material. This could be illustrated with the following diagram.



3 Ply or Single Wall Corrugated Fibre Board.

5 Ply or Double Wall Corrugated Fibre Board.

7 Ply or Triple Wall Corrugated Fibre Board.

The corrugated fibre board is converted into corrugated fibre board boxes by considering the following steps.

Scoring ⟶ Slitting ⟶ Creasing ⟶ Slotting ⟶ Stitching

Advantages of Corrugated Fibre Board Boxes: The advantages are: Availability of raw materials i.e. Kraft paper and adhesive; The technology of box making is simple; Availability of box making machineries; Cost effective; Amenable to make display package; Tare weight of box is less resulting to the reduction of freight cost; Maximum utilization of storage space due to collapsing nature of boxes; Recognised as Eco-friendly packaging materials; Facilitates to have excellent printing on the outer surface of the boxes; Easy to handle in the shop floor due to collapsing nature as compared to wooden box.

Limitations: The Limitations are: a) Strength properties are influenced by the environmental condition; b) Requires special condition for storage to maintain the strength properties; c) Shortage of best quality of kraft papers in India and d) Lack of technology in the converting machineries.

Applications of CFB Boxes: Visual merchandising, danglers and promotional material, Die-cut box for display pack, Extensively used for office stationery items like- trays, pen-stand, filing cabinets, folders for conferences etc., Explored around the world by various designers in its application in furniture item, Wide application for making educational aids, toys etc., As a unit pack for the packaging of horticultural produce, Popularly used as transport packages for all types items including dairy products.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) What are the important properties of glass?

---

2) What are the constituents of glass?

---

3) Explain the important properties of metal cans?

---

4) Indicate the important properties of plastic containers?

---

5) What are the important raw materials for making CFB box?

---

6) Mention the important steps to be followed for the manufacturing of CFB boxes?

---

7) Indicate five important advantages of CFB boxes?

16.5.3 Semi-rigid Packaging Materials

The semi rigid packaging materials are those materials which are neither rigid nor flexible in nature. The important packaging materials under this category are discussed below:

16.5.3.1 Folding Carton

The folding cartons are primarily made from duplex board or triplex board. The duplex board of having grammage ranging from 220 gsm to 300 gsm are used to convert into folding carton by means of different steps like creasing, scoring, slotting and finally gluing.

Properties of Folding Carton: Amenable to more number of colour printing, Ease of handling, distribution and storage at retail outlet under refrigeration, Amenable to make pilfer proof closing device, Stiffness nature of folding carton facilitates to stack the product easily, Empty cartons provide excellent space utilization due to collapsing in nature.

16.5.3.2 Lined Carton

The term indicates that this package is made of paper board and then lined internally with appropriate packaging materials.

Properties of Lined Carton: The properties are: a) Very economical as compared to metal containers; b) Provides excellent shelf life due to excellent barrier properties against moisture, gas, light of the internal liner material; c) Easy to stack at the outlet due to rectangle in shape; d) Could be made available at different capacity ranging from 100 ml, 200 ml, 1 kg, 2 kg.; e) Suitable to pack solid, semi solid as well as liquid product; f) Amenable to print on the outer surface; g) Easy open device in the form of knotch or spout facilitate and h) Tailor made lined cartons.

16.5.3.3 Aseptic Carton

In this system, both the package and the product are sterilized separately and then the packaging operation is carried out under aseptic (sterile) conditions. This system offers a long storage life for about three months with out any preservatives or refrigeration. The carton is formed by using three important materials like

(a) Paper board (about 80%) :- Provides mainly the rigidity and stiffness.
(b) Polyethylene (about 15%) :- Contribute to have heat seal and also provide barrier to microorganisms.
(c) Aluminium foil (about 5%):-Mainly responsible to provide barriers against air, light and off flavour.

Combining each of these three materials has enabled carton to produce a packaging material with optimal properties and excellent performance characteristics.

Properties of Aseptic Cartons: Higher degree of safety, hygiene and nutrient, retention, Preserving taste and freshness, can be kept for months, efficient device to achieve this function by using minimum quantity of material, a good example of resources efficiency and lightest packaging material.

16.5.3.4 Thermoformed Containers

The containers or packages are made by means of thermoforming techniques. The containers could be made in the form of tub or plastic cups. The containers are closed by means of plastic lid made of either polyethylene (PE) or polypropylene (PP).

Properties of Thermoformed Containers: Amenable to screen printing on the surface, Provides high barrier against moisture, gas and light, Lighter in

weight as compared to other packaging material, Resistance to low temperature and thus suitable to refrigeration, suitable to make toiler made design based on the mould, could be amenable to make coloured containers and easy to handle and are hygienic.

Check Your Progress Exercise 4

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

(1) What do you mean by folding carton?

---

(2) Indicate the important three packaging materials used in Aseptic Cartons?

---

(3) What are the different forms of Aseptic Cartons available in India?

---

(4) Explain the important properties of Aseptic Cartons?

---

(5) How do you define Thermoformed Containers?

---

(6) What are polymeric materials used for manufacturing thermo formed containers?

16.6 SOME MODERN PACKAGING CONCEPTS

Packaging, like food processing, is a multi-disciplinary subject and considerable research goes into it. As a result, the packaging scenario in the commercial food business undergoes periodic upheavals causing the packaged product quality to improve accompanied normally by lower costs and better product handling convenience. Some of the more recent packaging systems and concepts are “form, fill and seal (FFS)” system, aseptic packaging system, retortable pouches, modified atmospheric packaging (MAP), active packaging systems and intelligent packaging systems. Some of these will be described briefly below:

16.6.1 Form, Fill and Seal System

FFS system is one in which the processed food product stored in a tank is continuously fed to the packaging system and gets packaged as pouch or a semi-rigid rectangular pack. This system is suitable for liquids and/or free-

flowing solids only. In this the packaging material is purchased in the form of rolls. The machine unwinds the roll, sterilizes it by hydrogen peroxide or UV light, forms into a tube and then seals one end of it. The product is filled into this through a measuring mechanism and then the top end of the tube is sealed thereby hermetically sealing the product. The top sealing, which also acts as the bottom seal for the next package can be accompanied by a cutting action if so desired by the packer. These machine can pack 30-35 units per minute and have revolutionized the pasteurized milk packaging in the dairy industry and spices, ready mixes, etc. in other food industries.

16.6.2 Aseptic Packaging Systems

Aseptic packaging is a relatively new packaging concept aimed at developing new product group, namely pre-sterilized and aseptically packaged foods. During aseptic packaging process, a pre-sterilized product is filled under sterile conditions into sterile packages in a sterile environment and then germproof sealed.

Although both the aseptic can filling and aseptic carton filling systems became commercial during the late fifties and early sixties, only the latter found application in aseptic packaging of liquid foods, more particularly UHT milk and fruit juices. During the past few years, environmental considerations have led to the use of recyclable glass bottles instead of cartons in countries like Germany.

Requirements of aseptic packaging systems

The major requirement of an aseptic packaging unit is to prevent recontamination of the sterilized product. The principal considerations in this regard include sterilization of the filling machine and packaging material by suitable physical and/or chemical means and maintaining aseptic barriers during filling and sealing. Besides the equipment and packaging, gas used to pressurizing the filling space is one of the sources of recontamination of processed foods. Thus mechanical failures such as inadequate heating of the gas, leaks in valves and pinholes in filters may cause recontamination and must, therefore, be checked.

Types of packaging materials for aseptic packaging systems and their properties:

(a) Glass: Glass bottles have been used for packaging of many liquid foods but it has not been a commercial success with aseptic filling plants. Glass as such offers protection against oxygen and light if it has been provided with anti-actinic compounds.

(b) 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 tinplate or drawn aluminium: the solder in tinplate cans may have to be of higher melting point than normal to withstand the can sterilization temperatures.

(c) Paper board cartons: Such 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 materials; and those in which the cartons are supplied as performed 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:

- ➔ 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 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 enables sealing of the package.

Sterilization of the packaging and the filler environment: Chemical sterilization processes for the packaging film include treatment with ethylene oxide, sodium hypochlorite, peracetic acid and hydrogen peroxide (H_2O_2).Ethylene oxide is not only slow in action but its desorption requires very long time. Hence it can be used for pre-treatment of packaging, but not for final sterilization on the packaging unit. Sodium hypochlorite and peracetic acid are very effective sterilants, but removal of their residues from the packaging necessitates a sterile-water rinse. Alcohols such as glycols require high temperature (e.g. 100 degree C) application for the desired sporicidal effect. Although H_2O_2 also shows poor effectiveness at ambient temperatures, its high sporicidal effect at 80 degree C makes it useful for packaging sterilization. It is first applied on the material and then evaporated by heating through hot air or infrared radiation. The limitations of the use of H_2O_2 are: (1) the surfactant/surfactants or wetting agents used for uniform deposition on the packaging film, cannot be evaporated by heat and thus may find their way into milk, (2) the vapours of H_2O_2 must be exhausted to avoid injury to the workers, and (3) the efficacy of its removal by evaporation must be monitored through routine testing of milk.

While steam or hot water is effective in sterilization of the milk carrying tubes, hot air (300 degree C) with or without filtration, is commonly used for sterilization of the air injected in the filling space. Air at 330-350 degree C (for 30 mins) may also be used for milk tube sterilization. Sterilized at 180-200 degree C is used to evaporate H_2O_2 and when cooled to 50 degree C can be employed for pressurizing the filling chamber.

Effective use of UV radiation imposes certain stringent requirements such as perpendicular incidence of rays, dry atmosphere, smooth surface, low concentration of microorganisms, and absence of visible light to avoid reactivation of microorganisms and shields to protect the operator. Therefore, UV radiation is suitable only for a complementary treatment of already sterilized packaging. Filtration by means of depth filters (mats of compressed glass- or asbestos-fibre, or of sintered metal or ceramic) is effective in freeing air from bacteria. The filters themselves may be sterilized by fumigation, hot air or steam.

Aseptic barriers in the form of steam or circulated liquid sterilant become necessary with valves and fittings coming in contact with sterile milk.

Detection of leaks by using a dye test is imperative to check recontamination of the packaged sterile milk.

Aseptic packaging systems

Filling of commercially sterile milk and fruit juices in sterilized packages/containers in a sterile environment, and hermetically sealing the same to prevent recontamination of the milk can be achieved in two major ways: (a) using presterilized preformed containers such as bottles and cans, and (b) sterilizing the packaging material, forming it into suitable containers, filling the sterile product and sealing the package on the so called form-fill-and-seal (FFS) machines. The latter employs a multiply laminate of polyethylene, polystyrene and/or polypropylene films, paper and aluminium foil.

The Dole aseptic canning system has been used for UHT milk in the USA, but only to a limited extent. The most widely used FFS Tetrapak systems using tetrahedron cartons, and tetrabriks or hexahedron cartons are characterized by continuous formation of the package below the milk level from a paper/PE/AI laminate strip which has been continuously sterilized by H_2O_2 boiled off by radiant heat in the region immediately above the milk surface thus giving a sterile atmosphere in the packaging zone. Recently, tetra pak has introduced the so called 'pillow pak' to cut down the packaging cost of UHT milk.

Coupling of aseptic packaging with the UHT plant: In small processing units, a single flow-sterilizing plant can be connected with a single packaging plant of the matching capacity. But this system is inflexible because both the sterilizer and filler must operate simultaneously. If one stops for any reason, the other must be shut down, or in case of the filler stopping, the sterilized products must be recirculated for reprocessing. This problem can be solved by providing an aseptic tank at the interface between the two plants.

In large units, it is a general practice to feed two or more fillers from a single sterilizing plant whose capacity is equal to the total of filling capacity. So, if one of the fillers has to be shut down only a small portion of the UHT processed products will be required to be recycled. Use of a variable speed homogenizer can altogether eliminate the need of recirculation of sterilized product in such a situation. Even with a multiple filler system, aseptic tank is very useful for smooth operation of the whole system without jeopardizing the product quality. Aseptic balance tank, however, adds to the investment cost as well as cleaning and sterilization requirements. It also requires a supply of sterilized air for partial positive pressure during its use.

16.6.3 Retort Packaging for Long Shelf-life Foods

The concept of retort pouch which took shape in the 1940's, was developed again in response to the military need, as the rigid cans conventionally used by the combat forces posed problems such as difficulty in opening, injurious, and the potential to be used in makeshift explosives by the enemy. The retortable flexible packages are characterized by their structural components of heat-resistant plastic layers with or without aluminium foil and their ability to be thermo processed to result in shelf-stable food product. Its cost is also less as compared to cans. An early pioneer in proving the production reliability of the retort pouch was the US Army Natick Research and Development Center. In many developed countries, most ready-to-eat foods are packaged in retort pouches. Japan has been a pioneering country in this respect. In most recent times, focus has shifted to retortable semi-rigid trays or tubs because of their added convenience in use.

Retort pouch material

The materials used in making retort pouches should possess toughness and puncture resistance properties normally required of flexible packaging, good barrier properties for long shelf-life, and heat sealability over a wide temperature range along with the ability to with stand processing temperatures of the order of 110-140 degree C. To have all of these properties, laminated structures or co-extruded films are used.

The outer film of the composite structure is needed for strength and resistance. It should be resistant to heating temperatures, printable and be able to withstand temperatures without bursting, shrinking and delamination. The most common material used in polyethylene terephthalate (PET). It has the added advantage of being reverse printed so that ink is embossed between the outer layer and the next inner layer. In order to achieve a shelf life of one or more years, aluminium foil layer as one of the inner layers for barrier properties is essential. The thickness range of aluminium foil varies from 9 to 25μm, though a thickness of 9-10μm is most common. In Japan, retort pouches without aluminium foil layer are also very common as some products with a low shelf life of 3-6 months are also acceptable. Nylon is another material used as a barrier film in place of aluminium foil because of its low gas transmission rate and toughness. However, being transparent, nylon based laminates cannot provide protection from light unless covered with a carton or wrap. The current material most commonly used as innermost sealant layer is cast polypropylene, though high density polyethylene modified with isobutylene rubber has also been used.

Check Your Progress Exercise 5

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) What, is a FFS system for food packaging? For which types of food is it suitable?

……

……

……

2) Which is the system of packaging used for long life milk and fruit juices in modern food industry?

……

……

……

16.7 MODIFIED ATMOSPHERE PACKAGING FOR MINIMALLY PROCESSED FOODS

It has been known for over a century that the shelf-life of some foods can be extended by storage in gas environments different from that which is normally observed in the earth's atmosphere (i.e. 78.08 vol% N_2, 20.95 vol% O_2).By 1938, a significant percentage of the meat exported from Australia and New

Zealand to England was being shipped with added dry ice (solid CO_2) which improved its quality compared to crushed ice shipments. The storage of apples and pears in warehouses under reduced O_2 and elevated CO_2 conditions was also first exploited in the 1930's where it was shown to double the shelf-life of produce. Controlled atmosphere (CA) storage is the term commonly applied to these mobile or large-scale fixed enclosures in which gas concentrations are maintained via various mechanical systems.

Starting in the 1960's, packaging materials also began to be used to alter the gas makeup surrounding smaller-scale consumer and restaurant-sized food servings. Known as modified atmosphere packaging (MAP), this technology has grown substantially since then and is now used for a wide variety of food products.

MAP works on the principle of providing the ideal storage micro-atmosphere to packaged food in conjunction with or without other techniques. Fresh fruits and vegetables, meats, poultry and fish for instance require MAP with low temperature storage to maintain good quality with reasonable shelf life.

The gas atmosphere surrounding a particular food product can be altered to retard chemical and metabolic processes that are detrimental to product quality or to inhibit the growth of undesirable microbial populations. The optimal gas atmosphere inside the package depends on the composition of the contained food and the microbial contaminants that could potentially be present. The table 16.2 below lists the gas compositions commonly used for a variety of MA packaged non-respiring foods.

Table 16.2: **Gas Composition used for Modified Atmosphere Packaged Non-respiring Foods.**

Commodity	**N_2** (vol%)	**CO_2** (vol%)	**O_2** (vol%)
Oily fish	40-60	40-60	
White fish		60	40
Crustaceans		80-100	
Red meat		15-30	70-85
Poultry	70-80	20-30	
Bakery and pasta	20-50	50-80	
Cheese	30-100	0-70	
Coffee	100		
Potato chips	100		

Oxidation is a reaction that generally has a negative impact on food quality. In particular, lipid oxidation leads to rancidity, so foods with elevated fat levels (e.g. nuts, snack foods, cheese and oily fish) are usually packaged with as much oxygen removed as possible. However, there are some exceptions. Retail red meat, which contains substantial amounts of fat, is usually packaged in elevated levels of O_2 in order to maintain myoglobin's consumer-appealing bright red colour. Fresh meat has been packaged under low O_2 conditions, but this technology has been restricted to bulk industrial packaging because of the unsightly blue appearance of the meat under these conditions. Of course, O_2 levels do not strongly affect the colour of cooked meat, so these products can be packaged under low O_2 conditions. Many marine fish contain the osmoregulator trimethylamineoxide (TMAO). Spoilage organisms use this compound as a terminal electron acceptor, reducing TMAO to the unpleasant-smelling compound trimethylamine. Marine fish should be packaged in O_2 concentrations>30% in order to inhibit this reaction.

Post-harvest fresh fruit and vegetables continue to respire and thus packaged produce requires a constant supply of oxygen. Otherwise, anaerobic respiration will lead to the creation of off-flavour producing compounds such as ethanol and acetaldehyde. However, if MAP O_2 concentrations are decreased below subatmospheric levels, but are kept above levels that would induce anaerobic respiration, the rate of aerobic respiration can be significantly reduced, leading to increased shelf-life. The table 16.3 shown below provides suggested optimal O_2 concentrations for various produce stored under MAP. Some work has suggested that very high O_2 levels can have a significant antimicrobial effect with packaged produce, but more work needs to be done to determine if this packaging strategy truly has significant positive effects.

Table 16.3: **Suggested Optimal Oxygen Concentration for MAP**

Commodity	***O_2 (vol%)***	***CO_2 (vol%)***
Broccoli florets	2-3	6-7
Shredded cabbage	5-7.5	15
Carrot sticks	2-5	15-20
Chopped romaine lettuce	0.5-3	5-10
Diced onions	2-5	10-15
Potato	1-3	6-9
Apple	<1	4-12
Kiwifruit	2-4	5-10
Strawberry	1-2	5-10
Watermelon cubes	3-5	10

Because of its antimicrobial properties, CO_2 is added to a wide variety of systems. Several mechanisms have been proposed to explain this inhibitory effect (Farber, 1991). Depending on the buffering capacity of the food, CO_2 dissolution can reduce the pH of the aqueous phase, making it more difficult for some microbial species to grow (Daniels et al., 1985). CO_2can also penetrate into microbial cells, disrupting cell membrane function (Farber, 1991). Bicarbonate ion produced from CO_2 hydration and ionization is also known to be inhibitory to some important cellular metabolic enzyme (Mathew *et al.,* 1986). However, it would appear that CO_2 has, in most cases, only a moderately inhibitory effect on the aerobic respiration of fruit and vegetables. Furthermore, care must be taken with some produce like lettuce, because elevated CO_2 concentrations cause metabolic problems that lead to the formation of 'brown stain' (Brecht *et al*., 1973). The above table also provides suggested optimal CO_2 concentrations for some MAP fruit and vegetable systems.

For non-respiring foods, 100% CO_2 is rarely used and is often blended with cheaper N_2. Because of its high solubility in both the aqueous and fat phases of food, large amounts of CO_2 can dissolve in the food, reducing the pressure in the void volume, which leads to the collapse of the package and subsequent product compression. This phenomenon can be inhibited by using CO_2/N_2 mixtures. In low water activity foods that are much less susceptible to microbial spoilage, pure nitrogen is typically used. With snack food such as potato chips, the nitrogen-filled MAP can also cushion the fragile product. For less fragile foods like cooked meats, simple vacuum packaging can produce an optimal atmosphere.

16.8 ACTIVE AND INTELLIGENT PACKAGING

For a long time packaging has also had an active role in processing, preservation and in retaining quality of foods. Changes in the way food products are produced, distributed, stored and retailed, reflecting the continuing increase in consumer demand for improved safety, quality and extended shelf-life for packaged foods, are placing greater demands on the performance of food packaging. Consumers want to be assured that the packaging is fulfilling its function of protecting the quality, freshness and safety of foods. The trend to ensure the quality and safety of food without, or at least fewer, additives and preservatives means that packaging has a more significant role in the preservation of food and in ensuring the safety of food in order to avoid wastage and food poisoning and to reduce allergies.

Well accepted definitions of active and intelligent packaging are:

- ➔ Active packaging changes the condition of the packed food to extend shelf-life or to improve safety or sensory properties, while maintaining quality of the packaged food.
- ➔ Intelligent packaging systems monitor the condition of packaged foods to give information about the quality of the packaged food during transport and storage.

16.8.1 Active Packaging Techniques

Food condition in the definition of active packaging includes various aspects that may play a role in determining the shelf-life of packaged foods, such as physiological processes (e.g., respiration of fresh fruit and vegetables), chemical processes (e.g., lipid oxidation), physical processes (e.g., staling of bread, dehydration), microbiological aspects (e.g., spoilage by micro-organisms) and infestation (e.g., by insects). Through the application of appropriate active packaging systems these conditions can be regulated in numerous ways and, depending on the requirements of the packaged foods, food deterioration can be significantly reduced.

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

Table 16.4: **List of Active Packaging Systems for Foods Products.**

Packaging type	**Examples of working principle/mechanisms/reagents**	**Purpose**	**Examples of possible applications**
Oxygen absorbers (sachets, labels, films, corks)	Ferro-compounds, ascorbic acid, metal salts, glucose oxidases, alcohol oxidase	Reduction/preventing of mould, yeast and aerobic bacteria growth. Prevention of oxidation of fat, oil, vitamins and colour.	Cheese, meat products, ready-to-eat products, bakery products,

		Prevention of damage by worms, insects and insect eggs.	coffee, tea, nuts, milk powder.
Carbon dioxide absorbers (sachets)	Calcium hydroxide and sodium hydroxide or potassium hydroxide calcium oxide and silica gel	Removing of carbon dioxide formed during storage in order to prevent bursting of a package	Roasted coffee, beef jerkey, dehydrated poultry product
Ethylene absorbers (sachets, films)	Aluminium oxide and potassium permanganate (sachet) Activated carbon+ metal catalyst (sachet) Zeolite (film) Clay (film) Japanese oya stone (film)	Prevention of too fast ripening and softening	Fruits like apples, apricots, banana, mango, cucumber, tomatoes, avocados and vegetables like carrot, potatoes and brussels sprouts
Humidity absorbers (drip-absorbent sheets, films, sachets)	Polyacrylates (sheets) Propylene glycol (films) Silica gel (sachet) Clays (sachet)	Control of excess moisture in packed foods Reduction of water activity on the surface of food in order to prevent the growth of moulds, yeast and spoilage bacteria	Meat, fish, poultry, bakery products, cuts of fruits and vegetables.
Absorbers of off flavours, amines and aldehydes (films, sachets)	Cellulose acetate film containing naringinase enzyme ferrous salt and citric or ascorbic acid (sachet) Specially treated polymers	Reduction of bitterness in grapefruit juice Improving the flavour of fish and oil-containing food	Fruit juices Fish Oil-containing foods such as potato chips, biscuits and cereal products Beer
UV-light absorbers	Polyolefins like polyethylene and polypropylene doped the material with a UV-absorbent agent Crystallinity modification of nylon 6 UV stabilizers in polyester bottles	Restricting light-induced oxidation	Light-sensitive foods such as ham Drinks
Lactose remover	Immobilised lactase in the packaging material	Serving milk products to the people suffering lactose intolerance	Milk and other dairy products

Cholesterol remover	Immobilised cholesterol reductase in the packaging material	Improving the healthiness of milk products	Milk and other dairy products

The table 16.4 above shows examples of sachet, label and film type absorbing (scavenging) active packaging systems for preservation and shelf-life extension of foods or improving their quality and usability for consumers. Oxygen, carbon dioxide, ethylene and humidity absorbers have the most significant commercial use, lactose and cholesterol removers are not yet in use.

Examples of sachet and film type releasing active packaging systems for preservation and shelf-life extensions of foodstuffs or improving their quality are shown in the table 16.5 below. So far, none of these systems are in wide commercial use.

Table 16.5: **Sachet and Film Type Releasing Active Packaging Systems for Foods.**

Packaging type	**Examples of working principle/ mechanism/reagent**	**Purpose**	**Examples of possible applications**
Carbon dioxide emitters (sachets)	Ascorbic acid sodium hydrogen carbonate and ascorbate	Growth inhibition of gram-negative bacteria and moulds	Vegetables and fruits, fish, meat and poultry
Ethanol emitters (sachets)	Ethanol/water mixture absorbed onto silicon dioxide powder generating ethanol vapour	Growth inhibition of moulds and yeast	Bakery products (preferably heated before consumption) Dry fish
Antimicrobial preservative releasers (films)	Organic acids, e.g. sorbic acid Silver zeolite Spice and herb extracts; allylisothiocyanate enzymes, e.g. lyzozyme	Growth inhibition of spoilage and pathogenic bacteria	Meat, poultry, fish, bread, cheese, fruit and vegetables
Sulphur dioxide emitters (sachets)	Sodium metabisulfite incorporated in microporous material	Inhibition of mould growth	Fruits
Antioxidant releasers (films)	BHA BHT Tocopherol Maillard reaction volatiles	Inhibition of oxidation of fat and oil	Dried foodstuffs Fat containing foodstuffs
Flavouring emitters (films)	Various flavours in polymers	Minimisation of flavour scalping Masking off-odours Improving the flavour of food	Miscellaneous

Pesticide emitters (the outer or inner layer of packaging materials)	Imazalil Pyrethrins	Prevention of growth of spoilage bacteria Fungicidal or pest control	Dried, sacked foodstuffs, e.g. flour, rice, grains.

The table 16.6 below shows various examples of active packaging systems.

Table 16.6: Examples of Active Packaging Systems

Packaging type	**Examples of working principle/mechanism/ reagent**	**Purpose**	**Examples of possible applications**
Insulating materials	Special non-woven plastic with many air pore spaces	Temperature control for restricting microbial growth	Various foods to be stored refrigerated
Self-heating aluminium or steel cans and containers	The mixture of lime and water	Cooking or preparing food via built-in heating mechanism	Sake, coffee, tea, ready-to-eat meals
Self-cooling aluminium or steel cans and containers	The mixture of ammonium chloride, ammonium nitrate and water	Cooling of food	Non-gas drinks
Microwave susceptors	Aluminium or stainless steel deposited on substances such as polyester films or paperboard	Drying, crisping and ultimately browning of microwave food	Popcorn, pizzas, ready-to-eat foods
Modifiers for microwave heating	A series of antenna structures that alter the way microwaves arrive at the food	Even heating, surface browning, crisping and selective heating	As above
Temperature-sensitive films	The gas permeability of the polymer is controlled by filler content, particle size of the filler and degree of stretching of the film	To avoid anaerobic respiration	Vegetables and fruits
UV-irradiated nylon film	The use of excimer laser 193nm UV irradiation to convert amide groups on the surface of nylon to amines	Growth inhibition of spoilage bacteria	Meat, poultry, fish, bread, cheese, fruit and vegetables
Fresh pad	Releasing natural volatile oils, absorbing oxygen and excess juice	Growth inhibition of bacteria Moisture control Shelf-life	Meat

		improvement	
Surface-treated food packaging materials	Fluorine-based plasmas	Growth inhibition of bacteria	

16.8.2 Intelligent Packaging Techniques

The definition of intelligent packaging includes indicators to be used for quality control of packaged goods. They can be so-called external indicators, i.e., indicators which can be attached outside the package (time-temperature indicators), and so-called internal indicators which are placed inside the package, either to the head-space of the package or attached into the lid(oxygen indicators for indication of oxygen or package leak, carbon dioxide indicators, microbial growth indicators and pathogen indicators).

The table 16.7 below shows examples of external and internal indicators and their working principle or reacting compounds to be used in intelligent packaging for quality control of packed foods.

Table 16.7: Examples of Indicators under Intelligent Packaging Systems

Indicator	**Principle/reagents**	**Gives information about**	**Application**
Time-temperature indicators (external)	Mechanical Chemical Enzymatic	Storage conditions	Foods stored under chilled and frozen conditions
Oxygen indicators (internal)	Redox dyes pH dyes Enxymes	Storage conditions Package leaks	Foods stored in packages with reduced oxygen concentrations
Carbon dioxide indicator (internal)	Chemical	Storage conditions Package leaks	Modified or controlled atmosphere food packaging
Microbial growth indicators (internal/external) i.e., Freshness indicators	pH dyes All dyes reacting with certain metabolites (volatiles or non-volatiles)	Microbial quality of food (i.e., spoilage)	Perishable foods such as meat, fish and poultry
Pathogen indicators(internal)	Various chemical and immunochemical methods reacting with toxins	Specific pathogenic bacteria such as *Eschericchia coli* 0157	Perishable foods such as meat, fish and poultry

16.8.3 Current use of Novel Packaging Techniques

In the USA, Japan and Australia, active and intelligent packaging systems are already being successfully applied to extend shelf-life or to monitor food quality and safety. Despite this, regardless of intensive research and development work on active and intelligent packaging, there are only a few commercially significant systems on the market. Oxygen absorbers added

separately as small sachets in the package head-space or attached as labels into the lid probably have the most commercial significance in active food packaging nowadays. Also, ethanol emitters/ generators and ethylene absorbers are used, but to a lesser extent than oxygen absorbers. Other commercially significant active techniques include, e.g., absorbers for moisture and off-odour and absorbers/ emitters for carbon dioxide. With regard to intelligent packaging, time temperature indicators and oxygen indicators are most used in countries mentioned above.

In Europe, only a few of these systems have been developed and are being applied. This lag compared to the USA, Japan and Australia is partly due to the strict European regulations for food-contact materials that cannot keep up entirely with technological innovations and currently prohibit the application of many of these systems. In addition, exiguous knowledge about consumer acceptance, economic aspects and the environmental impact of these novel technologies and, in particular, the exiguous knowledge of hard evidence of their effectiveness and safety demonstrated by independent researchers have inhibited commercial usage. Furthermore, vacuum packaging and protective gas packaging (modified atmosphere packaging) have had an established position in many European countries since 1980. Vacuum packaging, gas packaging and active packaging compete with each other, at least to some extent. However, all these technologies have their own advantages and disadvantages, and the best package technology should be selected according to individual requirements case by case.

16.9 LABELLING

Different nations have their own legal requirements for labeling. It might be out of place to discuss all of them. However, some of the most common universally accepted requirements are listed below:

- **Name** – A label gives the brand name of the product contained in the package. It must also inform the customer the nature of the product. It may also be necessary to attach a description to the product name. However, there are certain generic names which must be only used for their conventional uses, for example: Muesli, Coffee, prawns.
- **Ingredients** – All ingredients of the food must be stated under the heading Ingredients and must be stated in descending weight. Moreover, certain ingredients must be identified by a specific name, such as preservatives must be identified as ‘Preservatives’, and then identified by its standardised European serial number, e.g. sodium nitrate or E250.
- **Nutritional information** – Although it is not a legal requirement to declare Nutritional information on the product, if the manufacturer makes claims that the product is ‘Low in Sugar’, it must be supported with nutritional information (normally in tabulated form). However, as a rule it is recommended to declare nutritional information as consumers more than ever are investgating this information before making a purchase. Moreover, there are two European nutritional labelling standards which must be adhered to if nutritional information is shown.
- **Medicinal or nutritional claims** – Medicinal and nutritional claims are tightly regulated, some are only allowed under certain conditions while others are not authorised at all. For example, presenting claims the food product can treat, prevent or cure diseases or other ‘adverse conditions’ are

prohibited. While claiming the food is reduced in fat or rich in vitamins require the food to meet compulsory standards and grades, in addition, the terms must be used in a form specified in regulations.

- **Date tagging** – There are two types of date tagging:
  - **Use by Date** – 'Use by Date' must be followed by a day or/and month which the product must be consumed by. To be employed on perishable foods that usually would be kept cold, for example, fish, meat, dairy products and 'ready to eat' salads.
  - **Best Before Date** – 'Best Before Date` is used as an indicator of when the product will begin to degrade from optimal quality: this includes when the food becomes stale, begins to taste 'off' or decays, rots or goes mouldy. There are also regulations on which type of best before date must be applied:
    - Best before + Day for foods with a shelf life of up to 3 months.
    - Best before end + Month for foods with more than a 3 month shelf life.
    - Best before end + Year for food with more than an 18 month shelf life.

- **Storage conditions** – If there are any particular storage conditions for the product to maintain its shelf life, these must be pointed out. However, as a rule it is recommended to always describe the necessary storage conditions for a food product.
- **Business name and address** – In addition to the business name and address, it is necessary to indicate the manufacturer or packager, if independent to the main business and the seller established within the European Union.
- **Place of origin** – The food is required to specify its place of origin, especially if the name or trademark is misleading - such as if the product is called 'English Brie Cheese' when it is produced in France.
- **Instruction for use** – This is only necessary if it is not obvious how to use or prepare the product, in which case the consumer's own initiative must be used.
- **Presentation** – The label must be legible and easy to read, also it must be written in English, however, the manufacturer may also include other languages.

1) **Lot Mark or batch code** – It must be possible to identify individual batches with a lot mark or batch code - the code must be prefixed with the letter 'L' if it can not be distinguish from other codes, however, the date mark can be used as a lot mark. Manufacturers must bear in mind that the smaller the size of a batch, the smaller financial consequences in the case of a product recall.

- **Sectioning** – All of the following must be in the same field of vision:
  - Product name
  - Date mark
  - Weight
  - Quantity
  - Alcohol strength (if applicable).

In India, the labeling requirements are governed by "The Packaged Commodities Act" and also the other Acts & Rules which govern food products. These have been dealt with separately in your study materials under "Food Laws".

16.10 BAR CODING IN PACKAGING

Definition: A bar code is a series of bars and spaces arranged according to the encodation rules of a particular specification in order to present data. Its purpose is to represent information in a form that is machine-readable.

Benefits of the codes: The main benefits are 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. Other advantages include:

- ➔ Computer aided checkout
- ➔ Avoidance of over and under charging
- ➔ Self-service
- ➔ Instant inventory control
- ➔ Market survey-products sold and rate

Bar code basics: A bar code symbology is a set of rules discussing the way bar and spaces have to be organized to encode data characters. Only a few are being used on a large scale.

Code 39: The code 39 symbology introduced in 1975 is widely used for industrial applications. It is a discrete, variable length symbology encoding the 36 numbers and uppercase alpha characters (A-Z, 0-9) and seven special characters, these being space, dollar sign ($), percent (%), plus (+), minus (-), dot (.) and slash (/). A symbol character comprises 9 elements, 5 bars and 4 spaces. An element is either wide or narrow. There are 3 wide elements and 6 narrow elements in a symbol character.

A code 39 symbol begins with a start character and ends with a stop character. It can be read either from left to right.

ITF: Inter leveled 2 of 5 (ITF) is well adapted to materials and printing conditions frequently used on fibreboard cases. It is a continuous symbology encoding only numeric digits. A pair of digits is represented by 5 bars and 5 spaces. One of the pair is represented by the dark bars and the other by the light bars. These 2 are interleaved. In addition to the digit characters, there are 2 auxillary characters used as guard bars at the beginning and at the end of the digit representation.

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. Code 128 fulfils the need with most compact, complete, alphanumeric symbology available. In addition, code 128 has been designed with geometric features to improve scanner-reading performance and to be self-checking.

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.

In the system, a symbol character is composed of 7 modules, 2 bars and 2 spaces. A bar or a space is composed of 1 to 4 modules. An EAN/UPC symbol begins and ends with a guard pattern. In EAN-8 and 13 as well as UPC-A version, a centre pattern separates the symbol into segments that can be read separately thereby making the symbol to be read omni directionally.

The EAN/UPC symbology is widely used to encode the identification number of consumer products.

National Numbering Organisation (EAN – India) is a society registered under the Societies Registration Act with objectives of promoting Article Numbering, Bar Coding and EDI (Electronic Data Interchange) in Indian trade and Industries. It is managed by a board of management comprising representatives of the Ministry of Commerce and Industry. At present it is implemented by the Global Solution 1 India, promoted by the Ministry of Commerce. The details are available at www.gs1india.org.

Printing and reading of bar code: Virtually any printing technology can be used to print bar codes, provided it is accurate enough to achieve the right level of required quality. The printing processes are of 2 categories, commercial and on-site, the choice being dependent on the nature of the information to be coded and the number of codes to be printed. If the information is of typical static type, i.e. the identification number of a product to be placed on a package, and if the number of codes to be printed is large, the traditional commercial method using film masters is appropriate. If the information is variable, e.g. different for each item or short series of items or if the quantity required is small, then on-site printing process is preferable.

Many types of devices are available to read bar codes. 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.

Fixed-beam readers depend on external motion to read the symbol. A popular reading device is the low-cost hand help contact scanner. Moving-beam readers use a mirrored moving surface to provide the illumination. The light source appears as a continuous line of light. The moving-beam reader is also called as laser scanner. Imaging devices (camera) are also used to read bar codes. The reflected image of the bar code is projected onto photodiodes composed of many photo-detectors. These in turn are sampled by microprocessors and produce a video signal that is then decoded.

Applications: The bar coding technology has gained wide acceptance in numerous applications. Today, virtually all packages from the ultimate consumer to the 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 look-up 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.

Check Your Progress Exercise 6

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1) Which are the foods that require MAP in the modern food retailing concept?

……

……

……

2) What are the essential labelling requirements on a food package under Indian laws?

……

……

……

3) What are the five benefits of going in for bar coding on the food packages?

……

……

……

16.11 PACKAGING AND ENVIRONMENT

From the environmental point of view, food packaging can at best be considered a "necessary evil". All we need is a visit to our cities (and recently even villages), where garbage is strewn on the road sides and most of the garbage happens to be empty packaging materials thrown by households. More importantly, most of these are non-biodegradable plastics and a major environmental hazard. Hill stations like Ooty have banned the use of plastics for use as carry bags. But they cannot ban foods packaged in non-biodegradable materials from the organized sector.

Now there is a strong global movement promoting environmental friendly, bio-degradable materials (i.e. materials which will decompose into harmless components in a reasonable time after disposal) for food packaging.

16.12 EDIBLE PACKAGING OF FOODS

16.12.1 Edible Packaging

Edible films and coatings are based on proteins, polysaccharides and/or lipids have much potential for increasing food quality and reducing food-packaging requirements. Edible films formed as coating or placed between food components provide possibilities for improving the quality of heterogeneous foods by limiting the migration of moisture, lipids, flavour/aromas, and colours between food components. Edible coatings also have the potential for maintaining the quality of foods even after the packaging is opened. In addition, edible films formed as coatings on foods could have an impact on

overall packaging requirements. Edible coatings also have the potential for carrying food ingredients and improving the mechanical integrity or handling characteristics of the food.

16.12.2 Advantages: The advantages are:

- ➔ Can be consumed with packaged products.
- ➔ No disposal problem, hence eco-friendly.
- ➔ Can be produced exclusively from renewable edible ingredients and anticipated to degrade more readily than polymeric materials.
- ➔ Can enhance the organoleptic properties of packaged foods by providing flavour, colour and sweetness to them.
- ➔ Can supplement the nutritional value of the foods.
- ➔ Can be applied inside heterogeneous foods at the interfaces between different layers of components.
- ➔ Can be tailored to prevent deteriorative inter-component moisture and solute migration in foods such as pizzas, pies and candies.
- ➔ Can function as carrier for antimicrobial and antioxidant agent.
- ➔ Can control the diffusion rate of preservative substance from the surface to the interior of the food.
- ➔ Can be used for microencapsulation of food flavourings.
- ➔ Can be used in multi-layer food packaging materials together with non-edible films.

16.12.3 Requirements of Edible Films and Coatings

- ➔ Should prevent product dehydration.
- ➔ Should control transmission of gasses, vapour and solutes.
- ➔ Should provide mechanical protection to foods.
- ➔ Should restrict microbial invasion.
- ➔ Should have good mechanical properties.
- ➔ Should serve as a carrier for additives, viz. antioxidants, antimicrobial agents, flavours, colouring, nutrients, etc.
- ➔ Composition should conform to the regulations those apply to the food product concerned.

These properties depend upon the types of materials used, its formation and application.

16.12.4 Materials for Edible Films

(a) Protein: There are different proteins like milk protein, wheat gluten, corn protein, soy protein, etc. that are used for film formation. Manufacture of edible films and coatings are from whey protein products, represent an effective means of increasing excess whey utilization consequently alleviating the whey disposal problem.

(b) Polysaccharide: Polysaccharides that have been used for film forming are cellulose and cellulose derivatives, starch, some hydrocolloids like carrageenan, pectin, etc. polysaccharides films have poor moisture barrier but have good mechanical properties.

(c) Lipid: Lipids like bee waxes, rice bran, paraffin wax, acetylated monoglycerides, etc. have been used for film making. Wax has been used for coating of cheese, fruit, etc. Lipids are hydrophobic and therefore act as a good moisture barriers, however, their mechanical properties are inferior to proteins and polysaccharide based films.

(d) Composite films: composite films consist of two or more components so that characteristics of the film are enhanced by individual contribution from each component, e.g. protein and polysaccharide films by themselves are fairly hydrophilic but have very good mechanical properties.

Sources: Some of the more common sources of proteins and polysaccharides which can be modified to be effective packaging materials are:

Wheat protein: Wheat protein films are brittle due to extensive intermolecular forces. Plasticizers reduce these forces and increase the mobility of the biopolymer chains and thereby improve the mechanical properties of the films. However, the resulting loose structure reduces the ability of the films to act as a barrier to the diffusion of various gases and vapours. The greatest obstacle to commercial exploitation of wheat gluten film appears to be their high water permeability. Edible food packaging films and sausages castings are made from blends of collagen and gluten using filters and softening agents.

Corn protein: Zein is the only protein that continues to be produced commercially. It is characterized by its ability to form tough, glossy, hard grease proof coatings after evaporation of the aqueous alcoholic solvent. Zein coatings for pharmaceutical tablets and candies are formed by spraying or dipping the product into aqueous ethyl alcohol or isopropyl alcohol solutions of zein. The solution also contains a FDA approved plasticizer viz. glycerin, propylene glycol or acetaldehyde glycerides. Upon evaporation of the solvent a shiny protective zein film is formed on the surface of the product.

Milk protein: Casein is the major protein of milk. Highly concentrated casein solutions are firmly gelatinized using trans-glutaminase resulting in film with favourable tensile property. Transglutamine is a calcium dependent enzyme that catalyses the formation of covalent glutamyl-lysyl cross-links. Films are insoluble in water mercaptoethanol and guanidine hydrochloride. Pure caseinate films are attractive for use in food products due to their transparent and flexible nature and solubility in water.

Polysaccharides: A new edible film made of natural polysacchrides has been developed for packaging foods. Polysacchrides films have high OTR and their tensile strength is not as great as that of plastic, yet they have wide applications in meat industry. Processed, smoked meats can be wrapped in such films prior to smoking to reduce moisture loss. They may also be used to extend the shelf-life of fresh fruits by absorbing moisture given off by fruits. An edible composition is formed by mixing glucomannan and optionally, another natural polysaccharide with a polyhydric alcohol (glycerin) and dried into a film, which may be eaten directly or serve as shell of soft fillings.

16.13 BIO-DEGRADABLE PLASTIC

Biopolymers or bioplastics are intrinsically biodegradable and their use would reduce the damage inflicted to the environment by petrochemical plastics due to their extended lifetime in the environment. They are polymers utilized by bacteria as carbon and energy reserve material and accumulated by them when other essential nutrients are depleted from the medium. Plant derived starches has been used to produce biodegradable plastic articles viz. pharmaceutical capsule by blow molding process. Further sources of biodegradable materials are poly lactic acid, poly malic acid, or poly E-caprolactones, which are synthesized chemically. In contrast, poly B-hydroxy alkanoates (PHAs) are

produced microbially from renewable, plant-derived feedstock. It can be processed by traditional techniques used in the plastic industry viz. Injection molding, PHA has the potential to become an important source material for biodegradable plastics. It has been estimated that in the year 2002 only 3% of the estimated annual 15 million tones of plastic-packaging waste was biodegradable.

Sources of biodegradable plastic are:

- ➔ Biopol polymers: produced by fermentation of carbohydrate by the bacterium *Alcaligenes eutrophbus.*
- ➔ Poly (L-lactide): derived directly or indirectly from starch or sucrose.
- ➔ Starch based materials: incorporation of starch into traditional plastics.
- ➔ Cellulose-based: microbial cellulose is mixed with chitin, chitosan, CM-cellulose guar gum, collagen, dextran and gelatin.
- ➔ Pectin-based: Reaction of pectin with polyol like glycerol, sorbitol propylene glycol and ethylene glycol.
- ➔ Pollaulan: Microbial polysaccharide is synthesized by *Aureobasidium pollulans.*
- ➔ Poly hydroxyl alkanoate (PHA): bacterial polyesters.

16.14 RECYCLING OF USED PACKAGING MATERIALS

Another excellent way to save the environment is to recycle waste and use packaging materials like glass, metals like steel and aluminium and plastics. Glass is the most amenable recyclable material out of this lot since it the easiest to recycle and the recycled glass is as good as new. Metal containers and plastics on the other hand require a much more elaborate collection and reprocessing mechanism and the recycled material may not be as good as new material and hence may have to be put to some other usage. In mainland Europe, which has a high environmental consciousness, glass, which has been one of the most ancient packaging materials, is regarded as one of the best packaging materials of the 21st century!

16.15 PACKAGING MACHINES

Packaging machinery are as important as packaging materials since they ensure that:

- the packaging can be done at high speeds with minimal breakdowns and with high energy efficiency
- the packaging is done efficiently and the packaging integrity is maintained at close to 100 %
- the wastage of packaging materials and packaged food items is kept at a very low minimum

Packaging facilities concerning food fall into 2 categories, i.e. inner packaging and external packaging. Inner packaging is intended for individual items include machines for weighing, filling, wrapping, sealing, etc. Filling operations are for solids, powders, liquids and semi-liquid or paste foods. Filling methods are classified according to container form:

(a) filling a pre-formed container with product and

(b) filling a container with contents after the container is formed from a roll-stock

The types of filling and packaging machines and their application for specific packaging types are indicated below:

Product Types	Machine Types
1. Filling and sealing machines for glass and plastic containers, metal cans 2. With supply system for flexible and pouches/bags	Container supply type filling and sealing machines Bag-supply type filling and sealing machine
3. Vertical filling and scaling machines a) Pillow-type bag making, filling and sealing b) 4 or 3 sides seals filling and sealing, horizontal filling and sealing machines. i) Horizontal pillow type sealing ii) Horizontal 4-sides and 3-sides seal, stand up pouch packing Twist seal bag making, filling and sealing machines Square bottom bag-forming, filling and sealing Tying and packing machines Lined folding carton packing Thermoforming, filling and sealing Packing machines with injection moulders for plasters	Container-forming filling and sealing machines
Folding type over-wrapping, twist-type wrapping, stretch film.	Over-wrapping machines

16.16 LET US SUM UP

Packaging is a very important as well as innovative component of the modern food industry. A good packaging not only serves as an adequate protection to the processed or raw food, but is also the interface of the food with the customer. It would be difficult to find buyers for processed food, however good it may be, unless the customer finds it attractively packaged and clearly labeled and branded.

During the 2nd world war and at the advent of modern food processing during the mid 20th century, the most popular packages were tin-coated steel cans and glass bottles. However, towards the end of the century flexible packages made from a variety of plastics had by and large edged out cans. Extruded cans made from aluminium have also gained ground by the end of last century.

These days most foods are packaged in multi-layered composites of different plastics and paper. The packaging machineries also have undergone a sea change. Form-fill and seal machinery are extensively used for liquids and powders to make optimum use of these new age packaging in large volumes. These are cost effective and are amenable for mechanical handling and

transportation. Retortable plastic pouches containing intermediate moisture (semi-cooked) foods are also gaining popularity in urban Indian markets and for defence applications.

With the well-to-do urban shopper getting habitual of his/her weekly shopping in shopping malls, UHT processing combined with aseptic packaging for milk and fruit juices is gaining ground inspite of the increased costs. Also, the modern urban consumer who is conscious of the concept of "wellness" and food as nutraceutical, is increasingly looking for minimally processed foods which in turn has given a fillip to modified atmosphere packaging (MAP).

Packaging also provides space for the food packer to declare information regarding the contents of the package. The nature of the minimum contents of labeling is governed by the laws of the land.
Bar coding on the packaging has been a great help in inventory control, invoicing/ billing, compliance to traceability requirements etc in big departmental stores because of its amenability to electronic computing.

16.17 KEY WORDS

Annealing : Regulated way of cooling an article to eliminate internal stress and thus breakage.

Breathing holes : 5 cm. diameter hole either four or more numbers in a corrugated fibre board box to provide respiration.

Blister form : A container or cup like structure packaging, made from plastic materials by means of thermoforming technique.

Bio-degradable : Degradation of any materials with the help of biological organisms.

Canning : Filling the product in the can and processing and seaming it under sterile conditions.

Composite Containers : A Container is made of two dissimilar materials where the body is made from paper and the ends are either from plastics or metal.

Eco-friendly : The packaging materials comply with the norms of environment, called eco-friendly.

Exhausting : The metal cans filled with fruit pieces and sugar syrup or cut vegetables dipped into salt solution are subjected to a chamber under 70^{o}C for 30 min. to get the vacuum at the top of cans, called as exhausting.

Flanging : Both the ends of metal cans are curled which is called as flanging.

Hermetically sealed : Completely airtight container.

HIPS : High impact polystyrene – a kind of polymeric material

Impact strength : The strength which determines the rigidity of packaging materials.

Laminate : A sandwich of either two or more packaging materials in a single form like paper with polyethylene or polyester film with polyethylene film.

Reforming	:	Normally, the metal cans are received by the processor in flattened condition. The cans are further reformed into original round shape.
Recyclable	:	Any material that could be regenerated into original materials.
Storage life	:	The life of the product till gets unacceptable for consumption
Spout	:	An opening device made of plastic normally fitted to lined carton.
Snap-On	:	A kind of lid which is placed on the thermoformed container by putting pressure downwards.
VPI	:	Vapour phase inhibitor – a kind of coating on paper to avoid corrosion

16.18 SOME USEFUL BOOKS

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16.19 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress Exercise 1

Your answer should include following points:

1. The best definition of packaging, is by Mr. Robert Rausina, founder of Tetra Pak Sweden, a leading global food packaging company. According to him, "a good packaging is one that saves more than it costs, including refrigeration, transportation, storage, handling, labor, etc."
2. Packaging protects the foods (may be raw, processed, bulk or consumer-portioned) from contamination, physical damage and deterioration. It helps in protecting the foods during transportation of raw, semi-processed or processed food from farm to processor, from processor to retail seller (through the distribution network) and from the retailer to home of consumer (refrigerator/kitchen). Packaging also provides printing space which enables the processor/packer to pass on

information/instructions on the contents of the package to the consumer. It also provides space for printing of barcodes on the package so that it becomes machine readable and aids in buying/selling. It is thus a great marketing aid as well!

3. Tin-coated steel cans and aluminium cans are the two major types of cans used for packaging foods.

4. Glass is an excellent packaging material that has proved its worth for many decades. It is made from sand, a raw material that is abundant on earth. It is inert, rigid, strong and transparent – attributes that make it ideal as a packaging material for foods. In the environmental context, it is fully reusable and recyclable and hence does not demand too much of resources or pollute the earth`s surface. Therefore, many planners, processors and packers, who are environmentally conscious consider that there is tremendous scope for reviving glass as the preferred packaging material of the 21st century.

5. Choice of an appropriate packaging material is governed by several factors such as:

- The specific sensitivities of the contents, e.g. moisture, oxygen, etc.
- Factors changing the contents viz. temperature, RH, pH, and the reaction mechanism involved.
- Weight and shape of container.
- Effect on filling and sealing speeds.
- Contamination of food by constituents of the packing material.
- Storage conditions- How long the product needs to be protected.
- Bio-degradability and recycling potential.
- Most of the food production has been in the rural pockets of the country, while the major markets are in the urban areas. So the need for its transportation over long distances has become a necessity.
- Dairy and fruit products being highly perishable products, utmost care is needed in its preservation during storage, handling and transportation.
- Food products spoil fast at high temperatures, in the presence of oxygen and other contaminating agents present in the atmosphere.
- There are many more peculiarities, which could be identified under the following headings for determining the packaging of processed food products.
  -> Product range
  -> Market
  -> Consumer needs
  -> Operating margins

6. Some of the attributes of good packaging that consumers appreciate are:

- Product quality and protection with a great emphasis on freshness.
- Easy to open, dispense, reseal and store.
- Appealing product presentation is gaining prominence.
- Durable and eco friendly is being viewed together.
- Leak and spillage proof is a must for the producer as well as the consumer.
- Reusable packaging.

- Less hassles, more convenience.
- Selection from a wider choice of available sizes.

Check Your Progress Exercise 2

Your answer should include following points:

(1)
- It is differentiated mainly by grammage
- Grammage of paper is upto 180 gsm.
- More than 180 gsm is called paperboard.

(2)
- Tissue paper, kraft papers, high gloss paper
- Grease proof paper, glassine paper
- Duplex board, Triplex board, chip board
- Clay coated board

(3)
- Flexible in nature
- Easy amenable to printing
- Good insulation properties
- Good tear resistance properties

(4)
- Impermeable
- Non toxic
- Excellent barrier to moisture, oxygen gas and light
- Resistance to low temperature
- Dead fold characteristics

(5)
- Polyolefin group – PE, PP
- Polyvinyl group – PVC
- Condensation group – polyester, nylon or polyamide
- Styrene polymer – polystyrene, high impact polystyrene
- Carbonate group – polycarbonate

(6)
- Co-extruded film – 3 layers, 5 layers
- Laminated form – 2 layer, 3 layer, 4 layer

Check Your Progress Exercise 3

Your answer should include following points:

1)
- Chemically inert
- Non – permeable
- Transparent
- Strength
- Light weight
- Unlimited supply

2)
- The main constitutes are soda, lime stone and soda ash
- Other ingredients like arsenic, selenium and cobaloxides are added to made clear glasses.
- Boron is added to make stronger
- Carbon and sulphide are added to make amber (brown) coloured glass

- Type I – Borrosilicate glass
- Type II – Sulphur coated glass
- Type III – Soda lime glasses

3)

- Can be fabricated easily
- Impermeable to light, gases and moisture
- Non-toxic
- Amenable to heat sterilization
- Amenable to printing.

4)

- Fabricate in different size, shape and capacity
- Improved impact strength properties
- Could be made either transparent or opaque
- Could be made in different colour
- Could have handle to carry.

5)

- Kraft liner, fluting media and adhesive

6)

- Scoring, slitting, slotting, joining and closing

7)

- Eco-friendly packaging material
- Manufacturing technology is very simple
- Availability of raw materials
- Availability of machinery supplier
- Space utilization in godown is excellent due to collapsing in nature.

Check Your Progress Exercise 4

Your answer should include following points:

1)

- Cartons made of either duplex board or triplex board.
- Cartons made by means of creasing, scoring, slotting, folding and then joining by means of glue.
- Used mainly as intermediate packs for dairy products like butter, indian sweets, milk based confectioneries etc.

2)

- Paper board (80%)
- Polyethylene (about 15%)
- Aluminium foil (about 5%)

3)

- Tetra Brick Aseptic (TBA)
- Tetra Classic Aseptic (TCA)
- Tetra Fino Aseptic (TFA)
- Tetra Wedge Aseptic (TWA)

4)

- Higher degree of safety, hygiene and nutrient retention in foods
- Preserving taste and freshness
- A good example of resources efficiency
- Lightest packaging materials as compared to glass, metal or plastic containers

5)

- A container is made of thermoforming technique
- Thermoplastic materials are softened by means of heat, followed by vacuum drawing to the mould and the cooling
- Extensively used for dairy products like ice cream, shrikhand, dahi etc.

6)

- Polyethylene (PE)
- Polypropylene (PP)
- High impact polystyrene (HIPS)
- Acrylo Butadiene – Styrene (ABS)
- Polyvinyl chloride (PVC)

Check Your Progress Exercise 5

Your answer should include following points:

1) FFS system or form-fill and seal system of packaging is one in which the flexible packaging material (which could be multi-layered) which is manufactured in the form of huge rolls are fed from one end of the packaging machine. The packaging material is first converted into a tube by vertically sealing the edges of the unwound roll, the lower vertical heat seal is done (FORM) and then a measured quantity of the product is filled into the partially formed package (FILL). It is finally closed by sealing the top-end of he package (SEAL). Since this is a continuous operation, such systems give opportunity for high-speed packaging of powders and liquids such as milk, milk powders, soup powders etc.

2) Asceptic FFS systems of packaging are ideally suited for packaging presterilised milk or fruit juices by UHT methods. The packaging material used is a laminate comprising a suitable plastic material in the innermost layer, followed by aluminium layer in the middle and a printed paper layer on the outside. In between there may be addition layers of plastic materials to meet the performance requirements of the package. Of late, however, a new system using presterilized glass bottles, which is also amenable for high-speed operations is also used especially in Europe.

Check Your Progress Exercise 6

Your answer should include following points:

1) It is mostly fresh fruits, vegetables, meats and fish that require MAP to preserve their freshness as well as to maintain the physical appearance of being fresh. Such products attract the consumers in the supermarkets to go in for them by their quality and appearance.

2) The requirements for food labels under the Indian laws are:

- Name (for all types of products) & brief description of the product (for proprietary products)
- Composition of the product
- Nutrition information
- Raw materials used
- Declarations reg vegetarian/halal, etc.
- Date of manufacture, batch no.
- Best before and/or expiry date

- Net weight
- Max retail price
- Name and address of manufacturer/packer
- Name and address of marketing agency

3) Some of the benefits of using barcodes in modern packaging and retailing are listed below:

The main benefits are 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. Other advantages include:

➔ Computer aided checkout
➔ Avoidance of over and under charging
➔ Self-service
➔ Instant inventory control
➔ Market survey-products sold and rate