UNIT 8 TRANSPORTATION AND PACKAGING

Structure

8.0 OBJECTIVES

By the time you have studied this unit, you should be able to:

- understand the principles and methods of transportation;
- describe the various types of packaging material and their selection for food packaging; and
- decide the suitability of different types of packaging material.

8.1 INTRODUCTION

The prevention of food losses is of vital concern to growers as well as processors, and various measures can be applied at all stages between the grower and the consumer in order to reduce wastage, improve food security and generate income and profit.

The use of appropriate packaging and transportation is one of these measures and when properly applied can have a dramatic effect, reducing losses and ensuring that products reach the customer in the best possible condition. Appropriate packaging and transportation can range from the proper use of containers in which to transport produce to local markets, through to sophisticated systems that can extend the shelf-life of a processed foodstuff for a year or more.

Essentially, packaging:

- Aims to provide protection from all types of external damaging effects;
- Is an integral part of the food processing chain and helps both producers and consumers to transport, store, sell, purchase and use foods more efficiently;
- Is a means of ensuring that the product is delivered to the user in known quantities and in the expected condition for a specified shelf-life;
- Is a means of making the food more attractive in order to promote its use and increase sales;
- Conveys information to customers about the type of food they are buying, how to prepare it, its shelf-life, and that it conforms to relevant food legislation.

Thus, at its simplest level, packaging contains and protects, while at its most sophisticated it takes on additional roles such as preserving, selling, information and enhancing the convenience element of the product.

The type of packaging required depends mainly on the nature of the product, the length of time and conditions under which it will be transported and stored before use, the final market for which it is intended and local food laws. If the food is to be consumed near to where it is produced and eaten quickly after processing, little or no packaging may be required. However, if the product is aimed, for example, at a distant export market, the packaging requirements can become extremely complicated. At the point of sale, good packaging and presentation helps to attract customers, and may provide extra convenience in use.

8.2 METHODS OF TRANSPORTATION AND THEIR SUITABILITY WITH RESPECT TO PRODUCT

Damage in transit is one of the oldest problems in packaging. The hazard that packages meet cannot be anticipated and are mostly accidents. Protection is required against the average hazard encountered and not against the most severe one. The distribution system of a consumer good in its simplest form is shown below.

Figure 8.1: Distribution system for a consumer good

The distribution hazards encountered in any system which needs to be taken care of to decide the packaging material depends on the mode of transportation, method of handling and storage. The transportation modes and hazards there in are:

8.2.1 Bullock or Horse Drawn Cart

- Used for short distance transport.
- Stacking height upto 5 feet.
- Drop height upto 5 feet.
- Bumping due to rough road surface.
- Directional placements of packages may not be possible.

8.2.2 Road-Trucks

- Used for long and short distances.
- Package dimensions should suit the body dimensions for maximum space utilization.
- Door to door service.
- Delays in journey during rainy season.
- Freight rates generally higher than that of rail.
- Lower standard packages accepted than in rail.

Hazards

- Stacking height upto 7 feet.
- Drop height upto 4 feet.
- Puncturing of fibreboard boxes by protruding bolts etc. of the sides.
- Bumping due to irregular road surfaces.

8.2.3 Rail-Goods Trains

- Tran-shipment necessary.
- Pilferage is a major problem.
- Proper handling instructions essential.
- Packages can be sent on railways risk.
- Packages are to conform to rules and regulations of the railways.
- Door to door delivery possible only by container service.
- No problem for inter-state transport.
- Less interruption of journey even in rainy season.

Hazards

- Stacking height upto 8 feet.
- Vibration due to rail joints and track conditions.
- Shunting shock.
- Very high temperature (upto 70°C) in steel wagons in summer.

8.2.4 Sea-Ship

- Packages are carried in ship holds and decks.
- Normally the journey is preceeded and followed by other modes of transport. Hence packages should conform to the regulation of other modes also.
- Require proper handling instructions in different languages and figures.
- Freight rates by Cubic volume.

Hazards

- Stacking height upto 10-15 feet.
- Manual or machine handling.
- Very high relative humidity in the holds.
- Salt spray water on the decks or on the docks.
- Vibration due to engine propeller
- Swaying due to waves.

8.2.5 Air-Cargo

- High freight charges and hence lighter packages to be used.
- Limitations on size & weight of packages.
- Less journey time.
- Better handling.
- No cooling facility available.

Hazard

- High frequency vibration due to engine.
- Low temperature and pressure when flying at high altitudes.

8.3 SPECIAL REQUIREMENTS FOR TRANSPORATION OF AGRICULTURAL MATERIALS

Agricultural materials are living and continue all the physiological functions even after harvest. Therefore, it requires special care during its handling, packaging and transportation. Fresh as well as processed products meant for

human consumption are of utmost importance keeping in view the seriousness of different health hazards associated with the contamination of foods during transportation. Most of the requirements with respect to the advantages, hazards and precautions are discussed in section 8.2 and 8.7.

8.4 TRANSPORATION COSTS

Transportation costs would depend on many factors like methods of transportation, efficiency of transportation, input costs for transportation, allowable time limit for transportation, losses during transportation, cost of the produce that is being transported and other associated costs. All these must be taken into consideration before deciding the method of transportation so as to minimize losses and optimize the profits.

8.5 ROLE OF PACKAGING OF AGRICULTURAL AND FOOD MATERIALS

Packaging is an integral part of food processing. It performs two main functions: to advertise foods at the point of sale, and to protect foods to a pre-determined degree for the expected shelf life. The main factors that cause deterioration of foods during storage are:

- mechanical forces (impact, vibration, compression or abrasion),
- climatic influences that cause physical or chemical changes (UV light, moisture, oxygen, temperature changes),
- contamination (by micro-organisms, insects or soils) and
- pilferage, tampering or adulteration.

In addition the package should not influence the product (for example by migration of toxic compounds, by reactions between the pack and the food or by selection of harmful micro-organisms in the packaged food). Other requirements of packaging are smooth efficient and economical operation on the production line, resistance to breakage (for example fractures, tears or dents caused by filling and closing equipment, loading/unloading or transportation) and minimum total cost.

The main marketing considerations are:

- the brand image and style of presentation required for the food,
- flexibility to change the size and design of the containers, and
- compatibility with the method of handling distribution, and the requirements of retailer.

In summary, the package should be aesthetically pleasing, have a functional size and shape, retain the food in a convenient form, possibly act as a dispenser and be suitable for easy disposal or re-use. The package design should also meet any legislative requirements concerning labelling of foods.

8.5.1 Packaging Functions

The functions of packaging are numerous and include such purposes as protecting *raw* or processed foods against spoilage and contamination by an array of external hazards. Packaging serves as a barrier in controlling oxygen and water levels, facilitates ease of use, offers adequate storage, conveys information and provides evidence of possible product tampering. It achieves these goals by assisting in the following manners:

- Preserving against spoilage of colour, flavour, odour, texture, and other food qualities.
- Preventing contamination by biological, chemical, or physical hazards.
- Controlling absorption and losses of O_2, water vapour and other volatile substances.
- Facilitating ease of using product contents-such as packaging that incorporates the components of a metal together in meal "kits" (e.g. tacos).
- Offering adequate storage before use-such as stockable, resealable, pourable.
- Preventing/indicating tampering with contents by tamper-evident labels.
- Communicating information regarding ingredients, nutrition facts, manufacturer name and address, weight, bar code information, and so forth via package labelling.
- Marketing-standards of packaging, including worldwide acceptability of certain colours and picture symbols vary and should be known by the processor; packages also carry such information as merchandising messages, health messages, recipes, and coupons.

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.
c) Use separate sheets where no space is provided.

1. Describe the importance of packaging and transportation in the production and processing chain of foods.

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2. Enlist the suitability and hazards related to the following modes of transport.

   i) Rail-good train
   ii) Air cargo

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3. Enlist three factors that cause deterioration of foods during storage.

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4. List any five functions of packaging.

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8.6 PACKAGING OF LOW AND HIGH MOISTURE FOODS

Packaging containers of foods both low and high moisture are classified as primary, secondary, and tertiary. A ***primary*** container is the bottle, can, drink box, and so forth that contains food. It is a direct-food-contact surface and is, therefore, subject to approval by competent authority, which tests for the possible migration of packaging materials into food.

Several primary containers are held together in ***secondary*** containers, such as corrugated fiberboard boxes (commonly, but not correctly, referred to as

cardboard), and do not have direct food contact. In turn, several secondary containers are bundled into ***tertiary*** containers such as corrugated boxes or overwraps that prepare the food product for distribution or palletizing. They offer additional food protection during storage and distribution where errors, such as dropping and denting or crushing cartons, may occur. They prevent the brunt of the impact from falling on the individual food container.

8.6.1 Packaging Materials

In choosing the appropriate packaging for their product, packers must consider many variables. For example, *canners* must make packaging choices based on cost, product compatibility, shelf life, flexibility of size, handling systems, production line filling and closing speeds, processing reaction, impermeability, dent and tamper resistance, and consumer convenience and preference. Processors who use films for their product must select film material based on its "barrier" properties that prevent oxygen, water vapour, or light from negatively affecting the food.

The most common food packaging materials include metals, glass, paper, and plastic. Some examples of these leading materials appear in the following text.

Metal

Metals such as steel and aluminum are used in cans and trays. A metal can forms a hermetic seal, which is a complete seal against gases and vapor entry or escape, and it offers protection to the contents. The trays may be reusable, or disposable recyclable trays, and either steamtab1e or No. 10 can size. Metal is also used for bottle closures and wraps.

1) **Steel** has a non-corrosive coating of tin inside, thus the name "tin can," where as **tin-free steel** (TFS) relies on the inclusion of chromium or aluminum in place of tin. Steel is manufactured into the traditional three-piece construction can, which includes a base, cylinder, and lid, and also a two-piece can, consisting of a base and cylinder in one piece without a seam, and a lid. The latter are lightweight and stackable. The five primary types of steel vacuum closures include side seal caps, lug caps, press-twist caps, snap-on caps, and composite caps.

2) **Aluminum** is easily formed into cans with hermetic seals. It is also used in trays and for wraps such as aluminum foil, which provide an oxygen and light barrier. It is lighter in weight than steel and resists corrosion.

Glass

It is derived from metal oxides such as silicon dioxide (sand). It is used in forming bottles or jars (which receive hermetic seals) and thus protects against water vapour or oxygen loss. The thickness of glass must be sufficient to prevent breakage from internal pressure, external impact, or thermal stress. Glass coatings, similar to eyeglass coatings of silicones and waxes, may be applied to glass containers in order to minimize damage-causing nicks and scratches.

Paper

It is derived from the pulp of wood and may contain additives such as aluminium particle laminates, plastic coating, resins, or waxes. These additives provide burst strength (strength against bursting), wet strength (leak

protection), and grease and tear resistance, as well as barrier properties that assure freshness, protect the packaged food against vapour loss and environmental contaminants, and increase shelf life.

Varying thicknesses of paper may be used to achieve thicker and more rigid packaging.

- Paper is thin (one layer) and flexible, typically used in bags and wrappers. Kraft (or strong" in German) paper is the strongest paper. It may be bleached and used as butcher wrap or may remain unbleached and used in grocery bags.
- Paperboard is thicker (although still one layer) and more rigid. Ovenable paperboard is made for use in either conventional or microwave ovens by coating paperboard with PET polyester.
- Multilayers of paper form *fiberboard,* which is recognized as “cardboard”.

Plastic

It has shrink, nonshrink, flexible, semirigid, and rigid applications, and varies in its degree of thickness. Important properties of the many types of plastics that make them good choices for packaging material include the following:

- Flexible and stretchable.
- Lightweight.
- Low-temperature formability.
- Resistant to breakage, with high burst strength.
- Strong heat sealability.
- Versatile in its barrier properties to O_2, moisture, and light.

8.7 PACKAGING FOR PHYSICAL DISTRIBUTION AND TRANSPORATION

Any package is functionally incomplete if the goods received at the distribution is unacceptable. Hence, the secondary and tertiary packaging, which can withstand the physical abuses during handling, transportation and storage, is also very important. The most commonly used conventional transport containers for fresh and processed food includes wooden boxes, corrugated fibreboard boxes, plastic crates, high-density polyethylene drums, steel drums and pails. Sacks are also generally used to bring fresh produce to the processing centres from the fields. The selection of a transport container is based on the characteristics of the product, the kind of handling and transportation hazards likely to be encountered at various stages of the distribution system.

8.7.1 Transportation Containers

The primary function is to contain the article. It may need to be designed to prevent pilferage during the journey between manufacturer and ultimate consumer. A third and the most important property of the shipping container is its compatibility with the product contained within it. The other important aspect of a shipping container is labelling regarding what it contains, how much it contains and when it is packed and possibly sales promotion.

Wooden Containers

Wooden containers are one of the earliest shipping container since wood was then available in plenty. But presently, use of wood is discouraged as our forests are depleting year by year. There is a stiff competition from fibreboard containers both in terms of cost and performance. Still the wood container is widely used for perishables in the domestic market. The requirement for such a purpose include:

- Aeration required for the dissipation of heat and exchange of gases.
- High stacking strength and stability.
- There should be no fungus and mould growth when stored at high relative humidity.
- Dimensional stability.

Corrugated Fibre Board Boxes (CFB)

The corrugated fibreboard is made of paperboard liners and corrugating medium. The structure of corrugated fibreboard consists of a fluting medium running in a sinusoidal wave form between the two liners, thus separate the liners by a distance to obtain good stiffness.

Unbleached virgin coniferous craft is most appropriate for liner materials. It has a high tearing resistance and stiffness and a low rate of moisture absorption from air. Other materials like straw, bagasse, bamboo etc. have lower performance particularly when exposed to higher relative humidities. In case these materials are used, their substance has to be increased at least by 50% to get the satisfactory performance.

In case of packaging for fruits and vegetables, ventilation holes for the dissipation of heat and exchange of gases are very much essential. Careful attention must be given to the number, size. shape and position of these holes without sacrificing the strength of the box.

Inserts and cushioning materials are generally used for packing glass bottles. Pouches and fresh produce. There are various types of inserts and cushioning materials that are being used.

- **'Cell pack'** – Traditional partitioning method contribute to the stacking strength of the box.
- **'Paper honey comb'** – Can be adopted to different produce size and shape.
- **'Moulded pulp trays'** – Generally used for eggs and fruit and vegetables.
- **'Expanded polystyrene inserts'** – Can be produced in short runs at reasonable costs.
- **'Thermoformed PVC trays'** – Generally used for packaging produce in single layers only.
- **'Paper wool or wood wool'** – In combination with paper tissue, gives good protection if tightly packed.
- **'Plastic foam net'** – Generally used for glass bottles and large size fruits.

Barrels and Drums

Metal and wooden barrels are commonly in use. The metal barrels include steel and aluminium. Aluminium barrels are used for storing beer. Wooden barrels are made of staves bound together with hoops and may be 'tight' or 'slack'. The tight ones are used for storing heavy solids. semisolids and liquids. The wooden barrels are also used for storage and ageing of alcoholic liquors.

A drum is a cylindrical shipping container differing from barrels in having straight sides and flat or bumped ends designed for storage and shipments as an unsupported outer package that may be shipped without boxing or crating. Drums can be either metal drums (usually from Aluminium or Steel) fibre drums, ply wood drums and plastic drums. Metal drums are single wall, with either double head, partial opening, with convex or flat head or flat full removable head construction. The capacity usually ranges from 12-110 gallons. The inner surfaces of the metal drums are coated with lacquers. The commercially used lacquers are oleoresinous types. phenolic resins, vinyls, and epoxy resins.

Fibre drums are made by fibreboard of plies not less than 0.3 mm thick. The capacity of these drums varies between 0.5 to 100 gallons. The advantages of fibre drums are they are not returnable and has good stackability, low tare weight and easy opening and closing features. Printing can improve their appearance. Care should be taken not to expose these drums at high relative humidities.

The basic types of fibre drums are;

- Plain drums – No moisture proofness.
- Liquid tight drums – has rubber or plastic gaskets.
- Water vapour proof drums – Inside laminated with asphalt paper or polyethylene.
- Lined and coated drums – Prevents direct contact between content and fibreboard.

Fibre drums are generally used for shipping semisolids having a minimum viscosity of 5000 cps. It is also used for liquid insecticides fruit juices and other food stuffs. Plywood drums are made of 3 ply veneer which laps and joined with staples. The ply wood drums are primarily used to pack dry products and have an excellent weight to strength ratio.

The polyethylene drums are rigid and self supporting. They are available between 5-55 gallons capacity. The advantages of these drums are its flexibility, non toxicity, light weight, durability, high chemical resistance. The polythene drums have good resistance to breakage.

Sacks

Sacks are generally made from flexible low cost materials like jute, textiles, papers and plastics. Paper sacks are made of two or more plies of sack krafts, which is pure sulphate paper having a substance of 70 gsm or more.

Plastic sacks are generally made from polyvinyl chloride, polyethylene and polypropylene. The advantages of plastic sacks are, it weighs only 2/3 of multiwall paper sack and has better weather and impact resistance. These sacks are made by extrusion and blowing. The closures are made by sticking or heat sealing.

Sacks made from a combination of plastic and jute are also commercially available. Fresh fruit and vegetables are generally packed in sacks for transportation from harvesting fields to packing houses and/or retail markets. Sacks do not provide support for the product against superimposed loads and also offers less resistance to impact loads. Possibilities of sifting and spilling are common.

Bag-in-Box

In this system, the bag is supported on the outside by a rigid container made of paper board or corrugated board carton. It is generally used to fill a variety of liquid and dry products like tea, instant coffee, milk foods, baby foods, glucose powder, biscuits, spices, aseptic and non-aseptic fruit juices, edible oil, ghee etc. This system is tamperproof and offers cost effectiveness. Depending on the product, wide range of plastic films, laminates, coextruded barrier films, metallised film and aluminium foil can be used for the inner construction.

There are two methods of producing bag-in-box packages:

- Lined carton system,
- Coated and laminated carton system.

In the case of lined carton system, the inner liner is made from a suitable laminate such as LDPE/Paper/HDPE, paper/foil/LDPE and polyester to give the required shelf-life protection to the product. The outer carton is made of duplex board for protection against damages.

The second method combines the carton forming/gluing operation with a lining feed mechanism. Products considered for bag-in-box packaging should be tested for compatibility with the package and performance under handling shipping conditions.

Palletisation

A pallet is a platform made to hold one or more boxes, bags, cartons etc. in a group. The pallet is one of the simplest single devices for material handling. The other advantages of palletisation are:

- Reduced labeling requirements.
- Better utilization of storage space because of higher stacking strength.
- A reduction in mechanical strains and damages.
- A reduction of the total distribution time.
- A better maintenance of produce quality.

A pallet can be made of wood, corrugated and honey comb paperboard, plastic, reinforced plastic or metal. The choice is based on the service conditions, such as weight of load, climatic environment, durability requirement, local availability and costs.

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.
c) Use separate sheets where no space is provided.

1. Define primary, secondary and tertiary packaging.

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2. Describe the suitability of plastics for packaging of foods.

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2. Describe the suitability of wooden containers and CFB box for packaging and transportation of foods.

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8.8 QUALITY TESTING OF PACKAGES AND PACKAGING MATERIALS

An essential part of any packaging programme is the testing and evaluation of the complete packaged unit, as well as the various components. It is good economics to determine the optimum design in the beginning to maintain uniform performance throughout the life of the package. A good test programme will indicate the results to be expected in the field and it will yield dividends far in excess of its original cost and good management demands an objective evaluation of every step in the packaging operation.

To predict the performance of a package, there is a necessity to use a wide array of test procedures in package performance analysis with the following aspects:

- Identification of various materials used in packaging.
- Suitability of the materials for the intended use.
- Knowledge of materials properties both when used alone and when used in combination with other packaging materials.
- Ability to evaluate the material performance in the final package form in contact with packaged product.
- Determining the durability of materials through normal or even abnormal handling and abuse (including shipping).

8.8.1 What is Testing?

A test can generally be defined as an act of determining a given property or characteristics of a product (packaging material or package) by taking one or more measurements qualitatively or quantitatively according to prescribed procedure.

8.8.2 Why Testing?

Tests on packaging materials and packages are performed mainly for the following purposes:

- Comparison with competitive material to compare the offers.
- Current checks over the uniformity of new supplies of packaging materials, i.e., to check for change in quality if any from batch to batch.
- Quality checks during the production of packaging materials or packaged commodities.
- Evaluation of the suitability of packaging materials for certain factors like protection against mechanical or climatic hazards.

8.8.3 Steps in Test Methods

- Scope: The purpose and limitations of the methods are to be elaborated to avoid ambiguity.
- Significance: Relevance, the test has with respect to actual or intended performance.
- Terminology: The technical terms and abbreviations used should be fully defined or explained when they are not in common use
- Apparatus: All the various equipments necessary should be fully described in all the details, including dimensions range and accuracies etc.
- Materials: All reagents etc. are to be given in detail.
- Sampling: Enough attention has to be paid to proper sampling since a test can be only as informative as the sample permits

- Test specimen: The test sample consists of a minimum number of specimens and these specimens are to be prepared as required for the measurement of property and to suit the requirement. Preparation of the specimens is very important for the reliability of the test results.
- Conditioning: Time, temperature and relative humidity, to which the specimen are to be preconditioned and also conditions during testing.
- Test procedure: Method of actual measurement when there are more than one procedure. The procedure to be followed is described in detail.
- Method of evaluation: This gives the method (calculations) employed to arrive at the test property from the observations (readings) taken.
- Report: This tells how the results are to be reported and includes the method of presentation, its form (tables, graphs, diagrams etc.). Some times the precision of the test is also included in the report.

8.8.4 Package Functions and Characteristics

Mostly the evaluation of packaging materials is based on package functions and the characteristics of package.

Product Protection

1. Storage life of food products: Mainly depends upon the barrier properties of the packaging materials for:
   - Humidity: Water vapour transmission.
   - Gases: Oxygen/Carbon dioxide/Nitrogen/Sulphur dioxide.
   - Aroma: Specific organic vapour and transmission rate.
2. Product damage and integrity:

   In terms of resistance to stresses in distribution.
   - Impact resistance.
   - Dart impact and Spencers impact value for the film.
   - Compression resistance for finished packages.

   In terms of resistance to bursting:
   - Bursting strength.

   In terms of resistance to repeated stresses as in vibrations:
   - Gelboflex crack resistance for films/laminates/coextruded films.
3. Product packaging compatibility:

   Chemical resistance:
   - Grease resistance.
   - Tainting.
   - Migration of constituents from packaging materials into foods.

4. Pilferage and adulteration:

   Good closure and joints required.

   - Heat seal in plastic pouches.

Machinability

1. Easy sliding on machine:

   - Reduced friction.
   - Slip of packaging material surface (kinetic coefficient of friction).

2. Resistance to stresses in packaging operations:

   - Tensile strength and elongation.
   - Resistance to tear propagation.
   - Heat seal range and hot tack

Consumer and Marketing Functions

1. Ease of opening and reclosures:

   - For flexible pouches a 'V' – notch to start tear (good with foil laminates and cellophanes) may not be suitable for polythene and Nylon films.
   - Fold retention for closures of laminate pouches

2. Ease of dispensing:

   - Wide mouth for solids and pasty foods.
   - Clean squeeze out from flexible pouches (Non stickiness to the package wall).
   - Ease of disposal – problems for the future, particularly for non-recyclable multilayer plastic packs.

8.8.5 General Common Tests for Films, Foils, Laminates and Paper and Paper Board

Thickness

Thickness is the perpendicular distance between the two outer surfaces of the material and is normally expressed in units of length. Many physical properties of packaging materials are dependent upon the thickness, e.g. WVTR and GTR of films are inversely proportional to thickness and decreases with increase in thickness. For paper board, thickness is reported in points or in mm. (1 point = 1/1000") for papers, it is in mm or inches. For films, thickness is reported in micron, mils. or in gauges (25 micron (μm) = 1 mil = 1/1000" = 100 gauge = 0.025 mm.

The Basis Weight (for paper and paper boards)

The basis weight is the average weight of an arbitrarily selected area of the paper (weight per unit area i.e. gms/ sq.metre or lbs/1000 sq.ft for paper boards). As the packaging papers are sold and purchased only in terms of weight the basis weight assumes special significance. Most of the physical properties such as burst strength; thickness and bulk are evaluated and specified in accordance with the particular basis weight involved.

Tensile Strength Test

The tensile strength of paper is defined as the force applied parallel to the plane of the specimen of specified width and length under specified condition of loading (K gms/15 mm or lbs/inch width). The test indicates the durability and serviceability of papers in many packaging operations such as wrapping, bagging. printing etc. Usually tensile strength is more in machine direction than in transverse direction and extension is less in machine direction than in transverse direction. Plastic films are normally tested at higher speeds because of higher extensibility. The stress strain curve helps in locating yield point and knowing the yield strength etc.

The Bursting Strength Test

This test measures the ability of a paper or paper board to withstand pneumatic or hydraulic pressure build up. For films, foils, laminates and papers the pneumatic type test is used. Heavy papers and paper boards are tested on hydraulic type of testers (lbs/sq.in or kg/sq. cm). The test gives a sort of combined tear and tensile properties. In many cases it serves as good index of the quality of fabrication of packaging materials. Another Associated property is Burst factor. The burst factor = Bursting strength (in gm/sq.cm)/Basis weight (in gm/sq.mt).

Water Vapour Transmission Rate

The water vapour transmission rate (WVTR) is measured as the quantity of water vapour in gms that will permeate from one side to the other side of the film of an area of one square metre in 24 hours, when the relative humidity difference between the two sides is maintained at 90% gradient at 37.8°C. The property is important to estimate the efficiency of the packaging material or a package for resistance to the flow of water vapour and is helpful in considering the selection of barrier materials for hygroscopic foods.

Gas Transmission Rate

The gas transmission rate (GTR) is normally determined by measuring the change in volume at constant pressure (atmospheric), or the change in pressure at constant volume and the quantity of gas flowing across the film is compiled as volume at NTP.

$$GTR = \frac{V.(76)x24}{At(P1 - P2)} \text{ cc/ m}^2\text{/ 24 hrs.atm} \qquad (8.1)$$

where ‘V’ is the volume (at NTP) of gas transmission through 'A' sq. metres of the test material in time 'f, when the average pressure difference between the two sides is maintained at (P1-P2) cm of Hg. The temperature of the test can be changed as per the requirement. GTR is an important property to estimate the efficiency of the packaging material or a package for resistance to the flow of gases and helps in selection of barrier materials for oxygen sensitive foods.

Grease Resistance

Grease resistance is measured by exposing one side of the test specimen creased or uncreased to a grease containing red dye. The time required for the red stain to show on the unexposed side is taken as a measure of this property. For plastic films, the test can be performed directly in pouches using groundnut oil coloured with red sudan dye.

Tearing Resistance for Papers

The papers are tested for their tearing resistance properties in two ways:

i) Internal tearing: The energy required to propagate an initial tear is measured (More followed in practice).
ii) Edge tearing: The energy required to initiate a tear is measured. The test is done on both the directions of paper. The work done in tearing is measured by the loss in the potential energy of the pendulum of the instrument. Tear Factor: is a term similar to Burst Factor, one finds in use.

$$\text{Tear factor} = \frac{\text{Tearing resistance in gms.}}{\text{Basis weight in GSM}} \times 100 \qquad (8.2)$$

Impact Tests for Plastics

These tests are designed to measure the ability of the films to withstand fracture by shock. The test is a measure of toughness of the material. It is a combination of deformation and breaking properties.

The Abrasion Resistance

This test is designed to measure the ability to withstand surface wear and rubbing. It is a measure of some mechanical properties like hard resillience. The procedure consists in abrading the sample with a wheel of standard abradent for a definite number of revolutions and finding the weight loss of the sample.

Heat Seal Strength

The test is used for heat sealable plastic packaging materials. The heat seal strength may be expressed as percentage of the tensile strength of the base material (gm/ cm width). The strength of heat seal depends upon temperature, dwell time, pressure and the type of heat sealing surfaces and each material has optimum values under these conditions. .

Environmental Stress Cracking

The purpose of the test is to study the influence of some reagents like soaps, wetting agents, oils or detergents on plastics, determined by exposing the specimens for a specific time to those environments and observing the cracks. The test report consists of the percentage of failures.

Identification of Plastic Films

Different types of plastics used in packaging differ in their properties. It becomes necessary to identify them for their proper selection. Though there is no systematic method for identifying packaging films, based on some characteristics of various films, such as appearance, odour, feel and drape, they can be identified by a few simple tests like specific gravity, solubility, burning and copper wire test etc. For laminates and coextruded films, it is difficult to identify by such simple tests. Nowadays IR spectroscopy and NMR are used to identify qualitatively as well as quantitatively.

Specific Tests

Apart from these common tests, there are some specific tests for different packaging materials which are enlisted in various standards developed by the Bureau of Indian Standards and other organizations.

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.
c) Use separate sheets where no space is provided.

1. Define testing and enlist three reasons for testing of packages.

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2. Describe two tests each for the following packaging materials.

i) Paper and foils.
ii) Plastics.

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8.9 STANDARDS FOR SAFE PACKAGING

The packaging laws and regulations affecting food products are mainly covered under:

- The Standards of Weights and Measures Act, 1976, and the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 (SWMA).
- The Prevention of Food Adulteration Act, 1954, and the Prevention of Food Adulteration Rules, 1955 (PFA).
- The Fruit Products Order, 1955 (FPO)
- The Agmark Rules

8.10 DISPOSAL OF PACKAGING MATERIALS

Indiscriminate use of different packaging materials for packaging of food products has caused a serious problem of pollution and ecological imbalance due to the problem of their disposal. Packaging waste contributes in great proportion to the increase in the volume of waste and to the saturation of landfills. The packaging sector, especially the plastics industry, is currently under some attack from the environmental point of view due to problems in waste disposal, pollution by litter and waste of resources.

At present, the following different principal methods are used to control solid waste disposal.

i) Land in-fill
ii) Incineration
iii) Composting
iv) Direct constructional use (unsorted) (v) Reuse (sorted)
v) Pyrolysis
vi) Chemical treatment

In the case of land in-fill method, the waste is reduced in particle size and then deposited in a special location, which may be excavated and covered with a minimum level. The process is hygienic and can reclaim wasteland. Incineration comprises the burning of waste till all combustible matter is fully oxidized. Composting involves biodegradation leading to a bland product, which is useful in agriculture. In direct constructional use, the waste is treated to compact, compressed with binders like bitumen and the resulting blocks are used for construction of roads, artificial islands, causeways, airfields, etc.

Packaging materials like metal, paper and glass can be segregated and reused or recycled. Pyrolysis is a method of heating material in the absence or presence of a limited amount of oxygen and the components can be separated for reuse. The chemical treatment is oriented towards a specific component of waste like hydrolysis of polyurethanes in scrap automobiles and degradation of paper to sugars or alcohols.

When the product is removed from the packed container, it becomes litter, which is harmful, polluting and expensive and this has to be disposed off quickly.

8.10.1 Recycling of Packaging Materials

Recycling of packaging materials play a very important role in saving the raw material, energy and to minimize the environmental pollution.

Recycling of tin-plate is a cumbersome process, since the lacquers / lithography and tin has to be separated from the base steel. Then the base steel can be sent to the steel-producing plant for remelting to produce fresh steel plate for reuse. The separation of steel from tin in two-piece cans and lids is easier and more economical. Similarly, chromium can be separated from the tin-free steel and the base steel can be reused for production of fresh base plate.

By recycling aluminium, more than 90 per cent of the energy can be saved by melting and reprocessing the metal. It is also claimed that the quality of recycled aluminium is better. About 50-60 per cent of the aluminium cans are recycled.

With respect to plastic packaging materials, PET can be reprocessed and used for stuffings, plates, piping, fibres, etc. Used PET bottles are not suitable for production of fresh PET bottles. Plastic-wastes are also used for recovery of energy by incineration.

8.10.2 Biodegradable Plastics

Plastics used in food packaging at present are non-biodegradable. The overflowing landfills cannot absorb the large quantity of plastic trash created in many countries. To reduce the waste, the best solution is a combination of biodegradable plastics, plastics recycling and composting. Biodegradable plastics are biodisintegratable plastics, which disintegrate into polymer chains and break down into water and carbon dioxide.

The first generation biodegradable plastics are made of polymers containing about 6 per cent starch (normally, corn starch), which biodegrades and a pro-oxidant, which enhances the reaction of the polymer with oxygen in the air. New biodegradable plastics contains up to 97 per cent starch.

Biodegradable plastics have the same strength and flexibility as commonly used petroleum-based plastics and can be melted, moulded and shaped as required. However, they are not suitable for applications requiring high-temperature resistance or impact. The same production techniques like injection moulding, extrusion blow-moulding, melt casting or spinning used for plastic-based plastics can be used without retooling the manufacturing plant. Biodegradable plastics are viable alternatives and are gradually becoming popular commercially.

Other than biodegradable plastics, chemical and photodegradable plastics have also been developed. They are chemical plastic, for which a natural catalyst like metal salt is added and the photodegradable plastic for which a light-sensitive chemical is added to or sprayed on the plastic to make it disintegrate in ultraviolet light.

8.11 SPECIAL PACKAGING

Other than the traditional packaging materials, there are some special ones, which can be selectively used for packaging of foods. Some of them are discussed in the following paragraphs:

8.11.1 Edible Films

Natural edible films extend shelf life, although for shortest time periods than synthetic non-edible packaging materials. Examples of edible films include casings, such as in sausage, and edible waxes, such as those applied to fruits and vegetables, the waxes function to improve or maintain appearance, prevent mold, and contain moisture while still allowing respiration. Food may be coated with a thin layer of polysaccharides such as cellulose, pectin, starch and vegetable gums, or proteins, such as casein and gelatin. Cut dried, fruit pieces are often sprayed with an edible film prior to their inclusion into items such as breakfast cereal.

8.11.2 Foil

These may be used in snack bags (chips, etc.) or as a laminate in aseptic packaging. It is used as a wrapping for dry, refrigerator, or freezer storage. It

provides a moisture-proof and vapour-proof barrier,

8.11.3 Laminates

These are multilayers of foil, paper, or plastics which may be utilized selectively according to the specific food packaging need, In combination, the various laminates may provide more strength and barrier protection than the individual laminate material. Laminates provide barriers useful in controlling O_2, water vapor, and light transmission, and they provide good burst strength. The laminates may resist pinholes and flex cracking. Retort pouches are examples or laminates used in packaging and contain polyester film, aluminum foil, and polypropylene.

8.11.4 Vacuum Packaging

Vacuum packaging modifies the atmosphere surrounding the food by removing oxygen, and it extends shelf life. Vacuum-packaging machines are available for small-, medium-, or large-scale production capacity and may be used to successfully package a variety of food sizes and forms such as small cheese blocks, large primal cuts of meat, or liquids. The procedure used for vacuum packaging is to place the food in a flexible-film, barrier pouch, and put it inside a vacuum-packaging chamber, where oxygen is removed. This creates a skintight package wall and protects against the entry of escape of gases such as air and CO_2, or water vapor. It assures inhibition of microbial growth, which would alter microbial and organoleptic properties such as appearance and odor. Water weight loss and freezer burn are also inhibited with this packaging method.

8.11.5 Modified Atmosphere Packaging (Map) Or Gas Flush Packaging

Modified atmosphere packaging modifies the internal package atmosphere of food. It is primarily applied to fresh or minimally processed foods that are still undergoing respiration, and it is used for the packaging of baked goods, coffees and teas, dairy products, dry and dehydrated foods, lunch kits, and processed meats in order to keep the meat pigment looking desirable. It is also used for nuts and snack food applications. MAP is one of the most widely used packaging technologies.

Modified atmosphere packaging contains the food under a gaseous environment that differs from air, in order to control normal product respiration (ethylene, CO_2, water vapor, and O_2) and growth of aerobic microorganisms. Nitrogen gas, which is odorless, tasteless, colorless, nontoxic, and nonflammable, is introduced into the food package after all atmosphere has been removed from the pouch and vacuum chamber and just prior to hermetic sealing of the package. This modification offers protection from spoilage, oxidation, dehydration, weight loss and freezer burn, and extends shelf life.

Unlike vacuum packaging, the film used for MAP remains loose-fitting, This avoids the crushing effects of skintight vacuum packaging, When used in combination with aseptic packaging, which reduces the microbial load, MAP becomes a more effective technology, Most new and minimally processed foods use MAP in combination with aseptic technology and reduced temperature.

8.11.6 Controlled Atmosphere Packaging

Both controlled atmosphere (CA) in storage environments and controlled atmosphere packaging (CAP) permit controlled oxygen and carbon dioxide exchange. Today, CAP containers control O_2, CO_2, water vapor, and ethylene concentration and, worldwide distribution of produce depends on CAP for high-quality food.

Clostridium botulinum is an anaerobic bacteria that grows in the absence of available oxygen. Therefore, it may grow in anaerobic packaging environments. To retard its growth in CAP food products, foods must have short storage times and be held at cold temperatures. Control of water activity (Aw) and salt is also necessary to prevent growth as sodium competes with the bacteria for water absorption

8.11.7 Active Packaging Technologies

Typically, packaging serves in a passive role by protecting food products from the external environment. It provides a physical barrier to external spoilage, contamination, and physical abuse in storage and distribution. Today, packaging more actively contributes to the product development, controls maturation and ripening, helps in achieving the proper color development in meats, and extends shelf life. It plays an active role in protecting foods. Examples of active packaging technologies are listed in the following:

Active packaging for fresh and minimally processed foods provide the following:

- Edible moisture or oxygen barrier (to control loss of moisture and enzymatic oxidative browning in fresh cut fruits and vegetables and to provide controlled permeability rates matched to the respiration rate of the fruit).
- Edible antimicrobial (biocidal) polymer films and coatings (which release controlled amounts of chlorine dioxide into the food, depending on temperature and humidity; or destroy E. coli 0157:H7 in meats, and prevent mold growth in fruits).
- Films that are scavengers of off-odours.
- Oxygen scavengers for low oxygen packaging.

Active packaging for processed foods provides the following

- Edible moisture barrier.
- O_2, CO_2, and odour scavenger.

Other active packaging technologies include the following:

- Microwave doneness integrators (indicators).
- Microwave susceptor films to allow browning and crispness (french fries, baked products, popcorn).
- Steam release films.
- Time-temperature indicators (TTI) which are unable to reverse their colour when the product has been subject to time-temperature abuse for frozen products.

8.11.8 Aseptic Packaging

In order to destroy any *Cl. botulinum* spores and extend the shelf life of low-acid foods, *aseptic packaging* may be utilized. Independent sterilization of both the foods and packaging material, with assembly under sterile environmental conditions, is the rule for aseptic packaging.

The container is filled with a sterile (no pathogens or spores) or commercially sterile (no pathogens, but some spores) liquid food product, and sealed in a closed, sterile chamber. Once packed, the product requires no refrigeration. Liquids such as creamers, milk, or juices may be packed in this manner. Triple or multiple packs of flavoured milk and juice, with attached straws, are available on grocery shelves. The market leaders of aseptic packages have introduced easy-open, easy-pour features into their canons. The plastic devices are injection moulded and adhere to the package tops.

8.11.9 Flexible Packaging

It is available for packaging use in the foodservice industry and is finding more applications at the retail level, including packaging for bagged cereals and sliced deli meat. Non-rigid packaging containers such as stand-up pouches or tubes and zippered bags are examples of flexible packaging used for peanuts, peanut butter, or produce such as fresh-cut lettuce and peeled baby carrots. (The packaging must also be resealable to meet consumer demands and may have zipper handles or spouts with screw-off tops.)

Flexible packaging is adequate for the plethora of low-fat/no-fat food products such as salty snack foods that are available in the marketplace. It keeps these products fresh by providing flavour and aroma barriers, which keep outside doors out and flavours in. It is used for fresh fruits and vegetables and matches respiration rate as closely as possible.

Manufacturers are offering more food products in flexible packaging and find that “cost savings and environmental concerns are two of the driving forces behind the switch to flexible packaging”. “Faster, better, stronger, cheaper… the packaging industry continually tries to improve the process. Nowhere is this more apparent than in flexible packaging”.

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.
c) Use separate sheets where no space is provided.

1. Enlist three standards for safe packaging of foods.

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2. Enlist the principal methods used to control solid waste disposal.

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3. Write short notes on the following:

i) Edible films
ii) Modified atmosphere packaging
v) Active packaging
ii) Vacuum packaging
iv) Controlled atmosphere packaging
vi) Flexible packaging

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8.12 LET US SUM UP

After studying the contents of this unit, you can appreciate that there are several options for transportation and packaging of food materials. Depending upon the location and the commodity, a rigid combinations of mode of transportation and packaging with minimum losses and at least cost.

While manual and animal drawn carts have their relevance for small distances, motorized transport is required to haul the food material over long distances. The tractor, truck, rail, sea and air transport modes have their useful mass based on the perishability, urgency, cost and benefit attributes.

The role of packaging is to facilitate handling and marketing and to ensure the minimum spoilage during storage, handling and transport. The packaging also has a criterion of consumer appeal. Besides food quality, the issue of food and environmental safety have also become important. The disposal of used packaging material so as not to cause pollution needs to be given due considerations.

8.13 KEY WORDS

Transport : It refers to the transfer of material from one place to another be it the transport of raw materials to the processing industry or the finished product from the industry to the market place.

Transmission rate of packages : It refers to the transfer of a particular component like water vapour, oxygen, etc. across the packaging material per unit area per unit time.

MAP : Modified atmosphere packaging contains the food under a gaseous environment that differs from air, in order to control normal product respiration (ethylene, CO_2, water vapour, and O_2) and growth of aerobic microorganisms.

CAP : Controlled atmosphere packaging (CAP) permit controlled oxygen and carbon dioxide exchange.

Active packaging : Packaging more actively contributes to the product development, controls maturation and ripening, helps in achieving the proper colour development in meats, and extends shelf life. It plays an active role in protecting foods.

Vacuum packaging : Vacuum packaging modifies the atmosphere surrounding the food by removing oxygen, and it extends shelf life.

Aseptic packaging : It is packaging of the food material in a sterile environment.

Biodegradable Plastics : Biodegradable plastics are biodisintegratable plastics, which disintegrate into polymer chains and break down into water and carbon dioxide.

Transportation cost : Involves all costs involved and each must be taken care to optimize profits.

CFB : The corrugated fibreboard is made of paperboard liners and corrugating medium. The structure of corrugated fibreboard consists of a fluting medium running in a sinusoidal wave form between the two liners, thus separate the liners by a distance to obtain good stiffness.

Bag-in-box : In this system, the bag is supported on the outside by a rigid container made of paper board or corrugated board carton.

Palletization : A pallet is a platform made to hold one or more boxes, bags, cartons etc. in a group.

8.14 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Appropriate packaging and transportation is one of these measures applied at all stages between the grower and the consumer in order to reduce wastage, improve food security and generate income and profit. When properly applied it can have a dramatic effect, towards reduction of losses and ensuring quality product for the customer. Appropriate packaging and transportation ranges from the proper use of containers in which to transport produce to local markets, through to sophisticated systems that can extend the shelf-life of a processed foodstuff for a year or more.

2. i) Suitability

   - Tran-shipment necessary.
   - Pilferage is a major problem.
   - Proper handling instructions essential.
   - Packages can be sent on railways risk.
   - Packages are to conform to rules and regulations of the Railways.
   - Door to door delivery possible only by container service.
   - No problem for inter-state transport.
   - Less interruption of journey even in rainy season.

   Hazards:

   - Stacking height upto 8 feet.
   - Vibration due to rail joints and track conditions.
   - Shunting shock.
   - Very high temperature (upto 70°C) in steel wagons in summer.

   ii) Suitability

   - High freight charges and hence lighter packages to be used.
   - Limitations on size & weight of packages.
   - Less journey time.
   - Better handling.
   - No cooling facility available.

   Hazards:

   - High frequency vibration due to engine.
   - Low temperature and pressure when flying at high altitudes.

3. Three factors that cause deterioration of foods during storage are:

   - mechanical forces (impact, vibration, compression or abrasion),
   - climatic influences that cause physical or chemical changes (UV light, moisture, oxygen, temperature changes),
   - contamination (by micro-organisms, insects or soils).

4. Four packaging functions are as follows:

   - Preserving against spoilage of colour, flavour, odour, texture, and other food qualities.
   - Controlling absorption and losses of O_2 and water vapour.

- Offering adequate storage before use-such as stockable, resealable, pourable.
- Preventing/indicating tampering with contents by tamper-evident labels.

Check Your Progress Exercise 2

1. A ***primary*** container is the bottle, can, drink box, and so forth that contains food. It is a direct-food-contact surface. Several primary containers are held together in ***secondary*** containers, such as corrugated fiberboard boxes (commonly, but not correctly, referred to as cardboard), and do not have direct food contact. In turn, several secondary containers are bundled into ***tertiary*** containers such as corrugated boxes or overwraps that prepare the food product for distribution or palletizing.

2. a) Different types of plastics available for food packaging.
   b) Their suitability for packaging of food materials.
   c) Their relative advantages and disadvantages.

3. a) Describe wooden containers and CFB box.
   b) The type of foods that can be packed using wooden containers and CFB box.
   c) Their advantages and disadvantages if any, over other packaging materials.

Check Your Progress Exercise 3

1. A test can generally be defined as an act of determining a given property or characteristics of a product (packaging material or package) by taking one or more measurements qualitatively or quantitatively according to prescribed procedure. Three reasons for testing of packages include the following:

   - Comparison with competitive material to compare the offers.
   - Current checks over the uniformity of new supplies of packaging materials, i.e., to check for change in quality if any from batch to batch.
   - Quality checks during the production of packaging materials or packaged commodities.

2. i) Tensile strength and tearing strength tests

   ii) Water vapour transission rate and bursting strength tests

Check Your Progress Exercise 4

1. The three packaging laws and regulations affecting food products are:

   - The Standards of Weights and Measures Act, 1976, and the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 (SWMA).
   - The Prevention of Food Adulteration Act, 1954, and the Prevention of Food Adulteration Rules, 1955 (PFA).
   - The Fruit Products Order, 1955 (FPO)

2. The principal methods used to control solid waste disposal are:

   i) Land in-fill.
   ii) Incineration.
   iii) Composting.
   iv) Direct constructional use (unsorted).
   v) Reuse (sorted).
   vi) Pyrolysis.
   vii) Chemical treatment.

3. In all the short notes the following points needs to be covered:

   i) The definition.
   ii) Use and principle.
   iii) Foods suitable for the method.
   iv) Advantages and disadvantages of the method.

8.15 SOME USEFUL BOOKS

1. Henderson, S.M. and Perry, R.L. (1976) Agricultural Process Engineering. AVI Publishing Co. West Port Connecticut.

2. McCabe, W.L., Smith, J.C. and Harriott, P. (1993) Unit Operations of Chemical Engineering. McGraw Hill, New York.

3. Vaclavik, C.A. and Christian, E.W. (1999) Essentials of Food Science. Aspen Publisher, Inc., Maryland, USA.