PACKAGING OF BEVERAGES

The beverage industry is one among the front-liners where massive investments are being made for expansion and technological upgradation. The packaging of beverages both carbonated and non-carbonated, is a complex technological branch in the Food Processing /Packaging industry. The traditional returnable glass bottle has given way to newer plastic containers as well as cartons. The current trend is to improve the conventional containers, extend their share in the large market, extend the shelf-life of the products, provide greater consumer convenience and ultimately to produce economic packages.

The changing Indian scenario, with implementation of various technologies and market promotion activities, has changed the scope for this industry exponentially.

The Indian soft drink market is worth Rs. 21,600 million a year with a growth of around 7%. The soft drinks segment is expected to grow to Rs. 1,05,000 million by the year 2005. The production of soft drinks has increased from 6230 million bottles in 1999-2000 to 6560 million bottles during the year 2001-2002. Table 1 gives the production of soft drinks. Tetrapack drinks market is currently growing at the rate of 10% with a total market share of 48%. The alcoholic beverages industry, covers Indian Made Foreign Liquors (IMFL), country liquor and beer. IMFL includes

Carbonated Beverages in PET Bottles

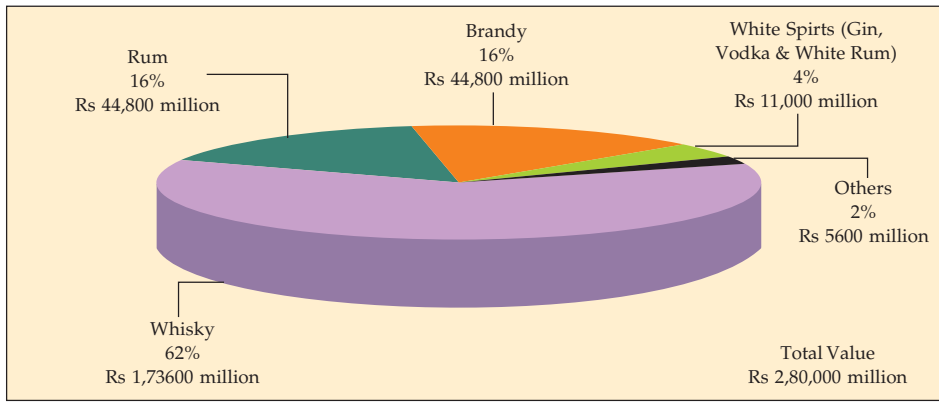
wine, whisky, gin, rum, brandy and other white spirits. IMFL industry in India is roughly valued at Rs. 28,000 crores, growing at a rate of 9-10% per annum in volume terms. The market size for IMFL categories in shown in Figure 1 and growth rate of IMFL categories is given in Figure 2. The Indian beer market estimated currently at Rs. 7,500 million a year has been growing at the rate of 15% per annum.

Table 1
Production of Soft Drinks

Year	Bottles(in million)
1997-1998	4920
1998-1999	5670
1999-2000	6230
2000-2001	6450
2001-2002	6600

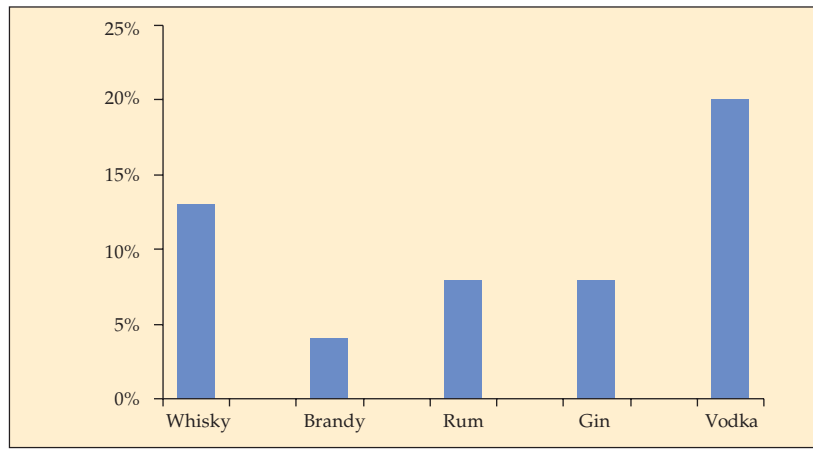
[Source: Ministry of Food Processing Industry – Annual Report (2001-02)]

Figure 1: Market size under IMFL Category (2000 – 2001)



[Source: Investment Research & Information Services Ltd. – Annual Report 2001]

Figure 2: Growth Rate Of IMFL Categories (2000 – 2001)

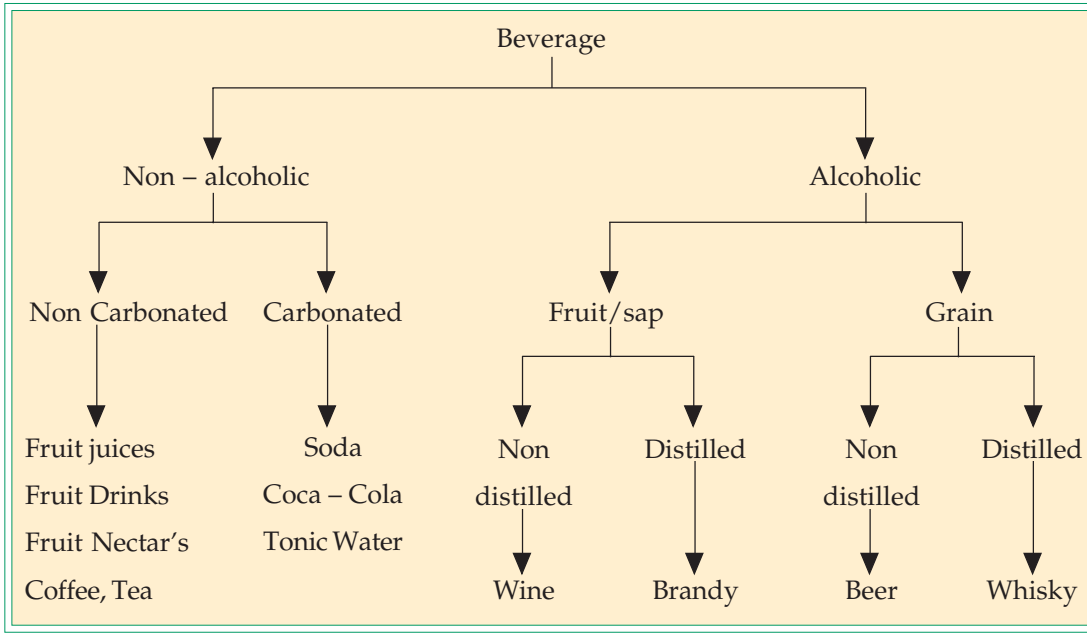


[Source: Investment Research & Information Services Ltd. – Annual Report 2001]

The term "beverage" is derived from French word "Beivre" which means a drink. General meaning of a drink includes a prepared drink.

According to the Fruit Products Order (FPO) 1955 Act, Fruit Beverage or Fruits Drink means a beverage or drink which is prepared from fruit juice and water or carbonated water and containing sugar, dextrose, invert sugar or liquid glucose. The minimum percentage of fruit juice in the final product shall not be less than 5%. Fruit syrup connotes sweetened fruit juice of not less than 25% of fruit juice.

Classification



The packaging requirements for all types of beverages are:

- Absolutely leak-proof and prevent contamination
- Protect the contents against chemical deterioration
- No pick up of external flavours
- Be hygienic and safe
- Retain carbonation in the case of carbonated beverages
- Economical, easy to use and dispose
- Good aesthetic appearance

Product Characteristics & Packaging Materials for Non-Alcoholic Beverages

Non-alcoholic beverages are further classified into non-carbonated and carbonated drinks.

Non-Carbonated Drinks

- **Fruit Beverages**

These include fruit juices, fruit drinks, and fruit nectars. They contain fruit juice, water, sugar, dextrose, invert sugar etc. The major deterioration that occurs in fruit beverages is loss of

nutrition, physico-chemical changes and microbial growth. The product characteristics to be considered in relation to packaging are:

- **Acidity:** All the fruit juices usually maintain an acidic character because they contain organic acids.
- **Enzymes:** Enzymes exist in all fruit juices. Sometimes they have to be destroyed and sometimes to be added.
- **Vitamin C (ascorbic acid):** The Vitamin C content of a fruit increases until just before ripening, and then decreases due to the action of an enzyme, ascorbic acid oxidase. When fruits are cooked, most of the ascorbic acid transfers from the tissue into the liquid or may be oxidized, oxidation occurring more easily in iron, copper or badly tinned vessels. Losses of Vitamin C also occur during storage. Storing at low temperature, and preventing contact with air and light reduces this. Addition of sulphite has a preserving effect on Vitamin C.
- **Colour and Flavour:** They are very important, and many fruit drinks contain certain legally permitted colourings. These are added to overcome the bleaching effect of the sulphite used as a preservative, and to provide an attractive appearance.

Spoilage of fruit juices is mainly due to yeast. Its growth depends upon the temperature. Spoilage of raw fruit juice at room temperature results in alcoholic fermentation, followed by the oxidation of alcohol and fruit acids by yeasts or moulds growing on the surface. Hence every living yeast cell must be removed or suppressed by pasteurization, filtration and/or preservatives.

Key parameters to be considered when selecting a packaging system are:

- Process
- Distribution, shelf-life requirements, legislation
- Product composition and quality as produced and at full shelf-life
- Product protection required during storage, distribution and retail sale
- Pack size, printing options, display etc.
- Packing system concept, automation options, ability to integrate with existing and/or future systems
- Consumer appeal, image of product and packing

The different packaging materials used are:

- **Glass Containers**: The use of glass bottles for the packaging of fruit beverages was widespread although the hot-fill/hold/cool process had to be applied with care to avoid breakage of the containers. Glass is still the preferred packaging medium for high quality fruit beverages. However, over recent years, an increasing proportion is being packed aseptically, into cartons.

  The improvements that have occurred in glass bottle packaging are:

  - Light weight
  - Surface coating to increase abrasion resistance
  - Use of wide mouth containers fitted with easy-open-caps.

- **Metal Containers:** Tinplate cans made of low carbon mild steel of 99.75% purity, coated with tin with easy open ends are used. These tinplate containers are either 3 piece or 2 piece containers. They are lacquered internally to prevent corrosion.

- **Plastic Containers:** Fruit juices contain organic substances, which are sensitive to bacterial contamination. Packaging of such products is done through hot filling, to achieve extended shelf-life, PET bottles are usually used for hot filling applications. Special features are added to the containers through design and manufacturing process. The package is heat-set in order to improve the temperature resistance of the containers. PET resins with a higher Tg (glass transition) temperature and/or a faster rate of crystallisation are used.

  Normally hot-filled PET bottles are designed about 1.5 times heavier than cold-filled bottles. Reinforcing ribs and grooves are also provided along the circumference and base of the bottle. After filling and capping operations, the liquid continues to cool, which results in formation of vacuum. The bottle wall can deform under the influence of vacuum, and this problem is overcome by providing vacuum panels in the container side wall. Generally, lower levels of PET co-polymer are preferred and intrinsic viscosities of about 80 are acceptable.

  Flexible plastic packages offer economic savings over conventional glass and metal containers but they are permeable to oxygen. Therefore, it is critical to select a flexible package that minimizes the permeability to oxygen. Flexible laminated pouches like metallised polyester/polyester/ polyethylene are used for hot fill packaging method without retorting for acidic fruit juices. These are used either as flat pouches or stand-up pouches. However, the shelf-life of the product in these pouches is limited.

- **Aseptic Packages:** Ready to serve fruit beverages and fruit pulps / concentrates, packed in aseptic packages provide excellent protection for fruit juices / pulps. These aseptic packages are made by combining thermoplastic with paperboard and aluminium foil. Their multi-layered construction enables the carton to protect the contents from various factors responsible for spoilage. The aluminium foil layer is a strong barrier for O_2 and light. The inner plastic layer made of polyethylene makes it possible to seal through the liquid. The outer paper layer provides stiffness making it possible for the cartons in a brick shape, thus, enabling maximum utilisation of available storage and transportation space. Excellent graphics are possible leading to good display and shelf appeal and also providing information regarding the product. The aseptic process makes the product bacteria-free before being packaged.

  To provide convenient access to the contents, beverage cartons offer a variety of opening devices. A familiar opening feature of the pack is the drinking straw, which

Fruit Drinks in Aseptic Packs

is attached to the package. Some recent trends are pull-tab opening, which can be readily detached from a pre-punched hole without compromising the package integrity. Also, custom designed caps and closures can be incorporated on beverage cartons for easier pouring and for enhancing the brand image.

Also, the beverage cartons are now available in new prisma shape, which is comfortable to hold, and the unique shape offers maximum display effectiveness and high space efficiency.

These packs are shelf-stable at room temperature and the shelf-life and nutrient composition of the fruit juice is influenced by the barrier properties of the tetrapak.

- **Bag-in-Box System:** It consists of a collapsible bag within a rigid container, a filling machine to introduce the liquid product into the bag and a dispenser to draw the product out.

  Bag: The outer container can be a box, a crate or a drum. The bag actually consists of two bags. An inner bag contains the liquid and an outer bag provides the barrier properties. Both are heat-sealed at the edges. The tubular spout fitted to the bag aids in filling and dispensing of the product. As little as 3 litres or as much as 1000 litres, can be packed.

  The bag is the "life" of the system. The bag itself consists of three components:

  i. **An inner layer**
  ii. **An outer layer**
  iii. **A spout**

  The function of the inner layer, the one in contact with the material being packed, is to provide the bag with seal integrity. The seals are to be strong enough to withstand constant mechanical and chemical "pressure" for at least twice the expected shelf-life of the product. Generally, the inner layer is not designed for barrier unless the product needs extra barrier, which the outer layer cannot provide. **Plastic films manufactured from high performance polyethylene, with excellent sealing and puncture properties are usually used as inner layer materials.**

  The function of the outer layer is to provide the bag with barrier commensurate with the expectation of the shelf-life of the product. In this respect, bag in box scores over other packaging forms, because unlike other packaging materials like jars and cans, the barrier property and hence the cost of this packaging form can be varied. The shelf-life expectations and storage condition play an important part in determining what the barrier requirements of the outer layer needs to be. The standard outside layer is a metallised film laminate, which under standard conditions has an OTR of 1cc/m^2 / 24hrs.

  The spout and cap assembly are made of injection moulded plastics. The spout is provided with a flange, which is welded to the bag's inner layer during bag's

manufacture. The spout and cap have two functions. They are used to fill the product in the bag and are also used to dispense the product from the pack. Several spout types are available ranging from a simple bung like configuration to ones, which can only be opened on the filling machine. The caps come with various tamper evident features as well.

Rigid Containers: The purpose of this container, is to hold the bag during storage, transportation and use. As is evident, the bag being made from flexible films, is incapable of being stored and transported by itself. Hence, each bag is individually stored into rigid outer container post filling. For packs of capacity below 50 litres, corrugated fibreboard cartons are generally used as the rigid containers. Beyond that plastics and metal drums are used. For very large bags, 1000 litres, + polygonal (6-8 faces) corrugated fibreboard containers made from 7 to 9 ply are used, though there are other alternatives as well.

- **Coffee**

Coffee is made from the coffee beans, which is converted into a consumable beverage. Some of the major deterioration reactions in coffee are:

- Staling: This may be due to loss of flavour volatiles or due to chemical changes caused by moisture and oxygen absorption
- Evolution of CO_2, which is emitted during the roasting process.
- Ingress of moisture in instant coffee results in caking. This usually happens when the moisture content reaches 7-8%. The initial moisture content of instant coffee is 2-4%.

Hence, while developing packaging system for coffee the following are to be considered:

- Moisture vapour ingress
- Oxygen permeability
- CO_2 and Volatile component egress
- Grease resistance

The packaging materials used are tinplate containers, composite containers, glass jars and flexible plastic pouches. The flexible laminates most widely used are 12µ PET / 2µ Al Foil / 70µ LDPE and MET PET / LDPE. Aluminium foil lined plastic pouches are most popular having 59% contribution in terms of volume.

- **Tea**

The unique taste and colour of tea is because of polyphenols (cate chins) and amino acids (theamine). The flavour is due to the essential oils present in fresh leaves and volatile components developed during the manufacturing process. The different types of tea are: Black tea (fermented), Oolong tea (semi-processed) and Green tea (non fermented).

Deterioration is caused by loss of volatile components, increase in undesirable "taints" arising from oxidation reaction from fatty acids. Deterioration in green tea is caused by reduction in ascorbic acid content, change in colour from bright green to olive green and change in odour.

The most common packaging material is paperboard carton with a liner or an overwrap of PP or regenerated cellulosic film. Other types are plastic jars, bottles, pouches, strips and envelopes. Plastic pouches have captured 12% of the tea market.

Carbonated Drinks

Carbonated drinks contain carbonated water, flavour, colour, sweeteners and preservatives. CO_2 gas from pure source is dissolved in water (amount varies with different types of beverages). A variety of ingredients like flavouring agents, colouring agents, preservatives, artificial sweeteners, antioxidants and foaming agents are then added.

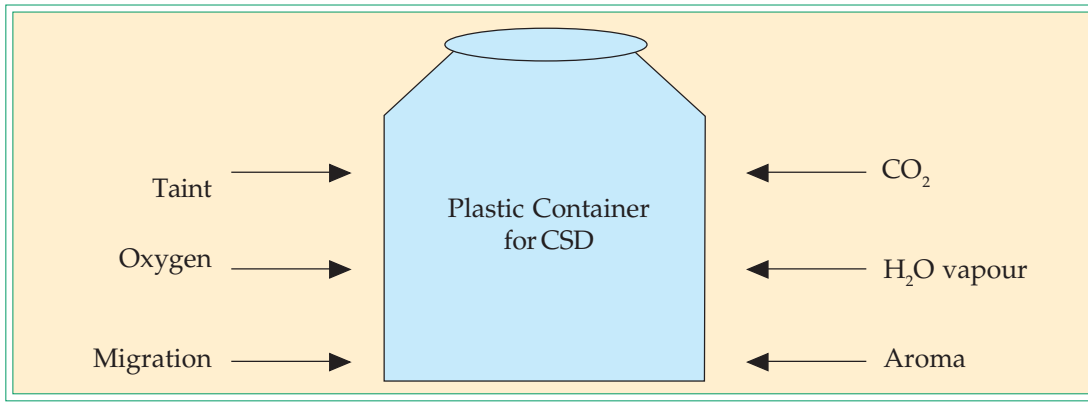
Two major deteriorative changes that occur in carbonated drinks are the loss of carbonation and rancidification of essential flavouring oils. The first is largely a function of the effectiveness of the package in providing a barrier to gas permeation, while the latter can be prevented by the use of high quality flavourings and antioxidants, and de-aerating the mix prior to carbonation. Oxidative rancidity is reduced by the effectiveness of the package in providing a barrier to gas permeation.

Hence, the carbonated drink package requires a container that will hold pressure and not contribute off flavours. For many years virtually all carbonated soft drinks were packaged in glass bottles sealed with crown cork. In recent years, non-returnable glass bottles are giving way to refillable bottles. These have a foam plastic protective label of paper/poly or an all plastic shrink sleeve, as a safety measure to prevent flying of glass fragments in case of breakage of these containers. The crown closure has been replaced with a roll-on aluminium screw cap with tamper proof facility.

Among the metal containers, the 3-piece tinplate containers have been used since long for the packaging of carbonated beverages. These are being replaced now by 2-piece aluminium cans. These cans retain the integrity of lacquer better than tin cans. Vinyl, epoxy and vinyl organosol coatings are used as lacquers for aluminium cans. Epoxy amine provides good adhesion, colour and flexibility to the can.

Among the plastic containers, PET bottles are the most preferred packaging material for packaging of soft drinks. The factors that influence the selection of a plastic package intended to contain CSD are indicated in Figure 3.

Figure 3: Factors to be Considered for CSD Packages



Soft drinks have a maximum permissible level of 20ppm for citrus flavoured beverages and 40ppm for cola drinks while the water loss is of the order of 1%. Also, the loss of CO_2 through the wall must be allowed for. While increasing thickness will decrease the rate of CO_2 permeation, the cost of the bottle, will also increase and so a compromise has to be made. Other problems to be considered in plastic containers are creep and elastic deformation. The polyethylene terephthalate (PET) bottle satisfies most of the requirements for packaging of carbonated soft drinks.

Improved blow moulding techniques and bi-axial stretching have made PET container to be pressurised due to its strength, dimensional stability and precision. Also, they have a glass like appearance, good transparency, lustre, chemical inertness and unbreakability.

Advantages of PET Containers

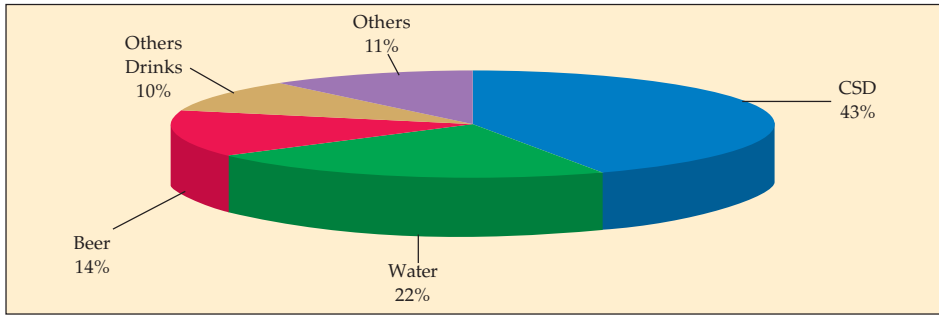
The advantages of PET container are:

- Superior packaging to product ratio: PET container being 63% and 47% more energy efficient than glass bottles and aluminium cans respectively.
- PET bottles are 32% more energy efficient than glass bottles during delivery of 1000 gallons of soft drinks.
- Glass bottles and Aluminium-cans generate 230% and 175% times more atmospheric emissions compared to PET.
- PET bottles contribute 68% and 18% less solid waste by weight compared to glass and aluminium containers.
- 100 kg of oil is required to produce 1000 1-litre PET bottles as against 230 kg for 1000 equivalent glass bottles.
- PET bottles help in fuel saving due to their lower weight.

The resins used in PET bottles to pack carbonated drinks are of a very special quality. The PET bottles have to be extremely strong to contain the internal pressure of CO_2 without distortion and expansion. This is obtained by using a resin, which has high intrinsic viscosity and lower co-polymer levels.

Currently, more than 90% of PET is consumed in food packaging with beverages/drinks forming nearly 80%. The breakup of world PET resin consumption by weight expressed as percentage share is shown in the Figure 4.

Figure 4: PET Resin Consumption



[Source: Beverage and Food World, September 2002]

Among other materials suitable to contain CSD, polyethylene naphthalate (PEN) meets several requirements such as physical, chemical and barrier properties. It has a barrier to CO_2, O_2, water vapour and UV light which is 4-5 times better than PET. Also, PEN is lighter in weight and has better shatter resistance. As pure PEN is expensive, it is blended with PET to form a co-polymer, still far too expensive to be used by bottle manufacturers.

Product Characteristics & Packaging Materials for Alcoholic Beverages

Alcoholic Beverages in PET Bottles

Alcoholic drinks originated through the action of yeast cells on sugar containing liquids. Alcoholic drinks are aromatic liquids with a specified alcohol content. Some kinds contain carbon dioxide, others a quantity of sugar. They are either fruit/sap based or grain based. They can either be non-distilled or distilled depending on the volume percentage of alcohol per litre. The border between the two kinds of drink is about 20%. The different types of alcoholic beverages are beer, wine, whiskey, brandy etc.

Non Distilled Alcoholic Beverages

- **Beer (Grain Based):** Beer is made from grains and has low alcoholic content around 5% by volume. Barley is the chief grain, but rice and corn are also used. The grains are brewed and fermented and then carbonated with CO_2 and flavoured with hops to give a bitter flavour.

  Owing to its low pH (about 4.0), microbial degradation is not usually a problem with beer, and the use of pasteurization and aseptic cold filtration excludes yeast. However, during storage beer can undergo irreversible changes leading to appearance of haze, development of off-flavours and increased colour. The oxidation reaction gives beer a "card-board-like" flavour. Flavour loss is also accelerated in the presence of light and certain metal ions. The fermentation process consumes oxygen. Also, brewing reduces the level of oxygen in beer to 40-50 ppb prior to packaging.

  During the packaging process, atmospheric oxygen enters the package and the level of oxygen contamination reaches 250-500 ppb, which corresponds to 0.1-0.2 ml of oxygen per 335 ml bottle or can. This results in a shelf-life of beer of 80 to 120 days. The oxygen consumption of beer varies with the composition of the beer, its age, presence of reducing agents, temperature etc.

  The traditional packaging media for beer is the glass bottle sealed with a crown closure. Recent development is the use of PET bottles for packaging of beer. Types of PET beer bottles used are non-tunnel pasterurised, one way tunnel pasterurised and returnable / re-fillable bottles.

Beer needs high performance in both CO_2 and O_2 barrier compared to PET used in carbonated soft drinks (CSD) applications. The level required depends on the type of beer, container size, distribution channels and environmental conditions (storage time, temperature and humidity levels). Improvements in the barrier can be obtained via colourants, creating multi-layer bottles and scavengers. Protection from U. V. light is obtained by adding colourants or U. V. additives, during the injection moulding stage. Because of the varied requirements for beer, the resins chosen must provide an adequate barrier, UV protection and clarity. Beer bottles need strength in order to maintain the CO_2 pressure over a wide range of temperatures. Intrinsic viscosities in the range of 0.8 to 0.84 are normally used. Since the PET bottles are lighter, a truck can carry 60% more of the beverage and 80% less packaging–a fuel saving of 40% and less air pollution.

- **Wine (Fruit/Sap based):** Wine is a beverage resulting from the fermentation by yeasts of the juice of grapes with appropriate processing and additions. The major deteriorative reaction in wines is caused by oxidation, the oxygen gradually changing the wine character, leading to development of browning and undesirable flavours.

The most common form of packaging used for wines is the glass bottle sealed with natural cork. Since wines are affected by sunlight, the bottles usually used are of coloured glass. Bottled wine is normally stored in the horizontal position so that the cork is kept moist, thereby providing a better barrier to the ingress of oxygen.

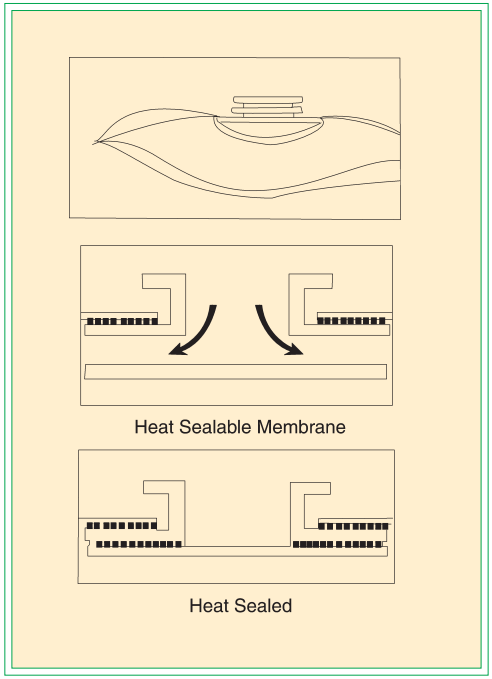
The most significant change in the packaging of wine resulted from the development of the bag-in-box package: a flexible, collapsible, fully sealed bag made from one or more plies of synthetic films, a closure and a tubular spout through which the contents are filled and dispensed, and a rigid outer box or container. The bag is generally constructed from co-extruded film of EVA-BA-EVOH-BA-EVA or LDPE-BA-EVOH-BA-LDPE. The features of the bag-in-box system of packaging have been explained earlier in the chapter.

Alcohol Beverages in PET Bottles

The physical strength of the bag is of prime importance and must remain intact throughout distribution and subsequent storage. Under normal circumstances, the bags are subjected to two forms of stress: hydraulic shock (normally caused by sudden acceleration/de-acceleration of the pack) and flex crack. By using polymers, which have high flex resistance and improving the adhesion between the films, the strength of the bag can be increased. One problem associated with the packaging of wine into bag-in-box system is the decrease in shelf-life as compared to that obtained using traditional glass bottles. This is due to permeation of oxygen through the valve material of the tap. By improving the barrier properties of the bag and the design of the tap the problem can be solved. A special heat-sealable membrane is partially attached to the gland during manufacture of the bag. After filling but prior to insertion of the tap, this membrane is fully sealed to the gland and the potential entry path is greatly reduced. As a result the bag is completely sealed and is

totally independent of the tap until the membrane is broached when the pack is just opened by the consumer. A cross section of the membrane and gland before and after filling is shown in Figure 5.

Figure 5: Bag-in-box before and after Filling



Wines are also available in PET bottles and in stand-up pouches of metallised polyester laminates.

Distilled Alcoholic Beverages

- **Brandy and Whisky:** These drinks are obtained by distillation of alcohol containing drinks. During distillation the aqueous part is separated from the alcohol. The distillates obtained are sold under several names like brandy, gin, whisky cognac, vodka, etc and have different alcohol percentage.

Because of their high alcohol percentages, these liquors are mostly packed in glass bottles so that they can be kept for an infinite time after opening. The bottles are sealed to prevent alcohol from evaporating and to protect the contents of the bottles from dirt and dust.

Conclusion

Tea, coffee, fruit juices, alcoholic drinks and carbonated soft drinks are the most popular beverages in the Indian society today. Sophisticated packaging media and techniques have enabled retention of the unique taste, colour and aroma of these beverages while in transportation and storage. The traditional returnable glass bottles have given way to newer plastic containers as packing solutions. In rigid applications, glass, metal and plastics are the major packaging material used. Flexible plastic packages offer economical savings over conventional glass and metal containers. Use of PET bottles for packing alcoholic beverages and carbonated soft drinks have revolutionized the packaging industry in India. The use of plastic packaging in the beverage market will witness high growth.

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