ASEPTIC PACKAGING SYSTEM

Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the containers so that reinfection is prevented. This results in a product, which is shelf-stable at ambient conditions. The term "aseptic" is derived from the Greek word "septicos" which means the absence of putrefactive micro-organisms.

Milk in Aseptic Pack

In practice, generally there are two specific fields of application of aseptic packaging technology:

- Packaging of pre-sterilised and sterile products. Examples are milk and dairy products, puddings, desserts, fruit and vegetable juices, soups, sauces, and products with particulates.
- Packaging of non-sterile product to avoid infection by micro-organisms. Examples of this application include fermented dairy products like yoghurt.

Aseptic packaging technology is fundamentally different from that of conventional food processing by canning. In canning, the process begins with treating the food prior to filling. Initial operations inactivate enzymes so that these will not degrade the product during processing. The package is cleaned, and the product is introduced into the package, usually hot. Generally, air that can cause oxidative damage is removed from the interior. The package is hermetically sealed and then subjected to heating. The package must be able to withstand heat up to about 100°C for high acid products and up to 127°C for low acid products, which must receive added heat to destroy heat-resistant microbial spores. Packages containing low-acid (above pH 4.5) food must withstand pressure as well.

Although conventional canning renders food products commercially sterile, the nutritional contents and the organoleptic properties of the food generally suffer in the processing. Moreover, tinplate containers are heavy in weight, prone to rusting and are of high cost.

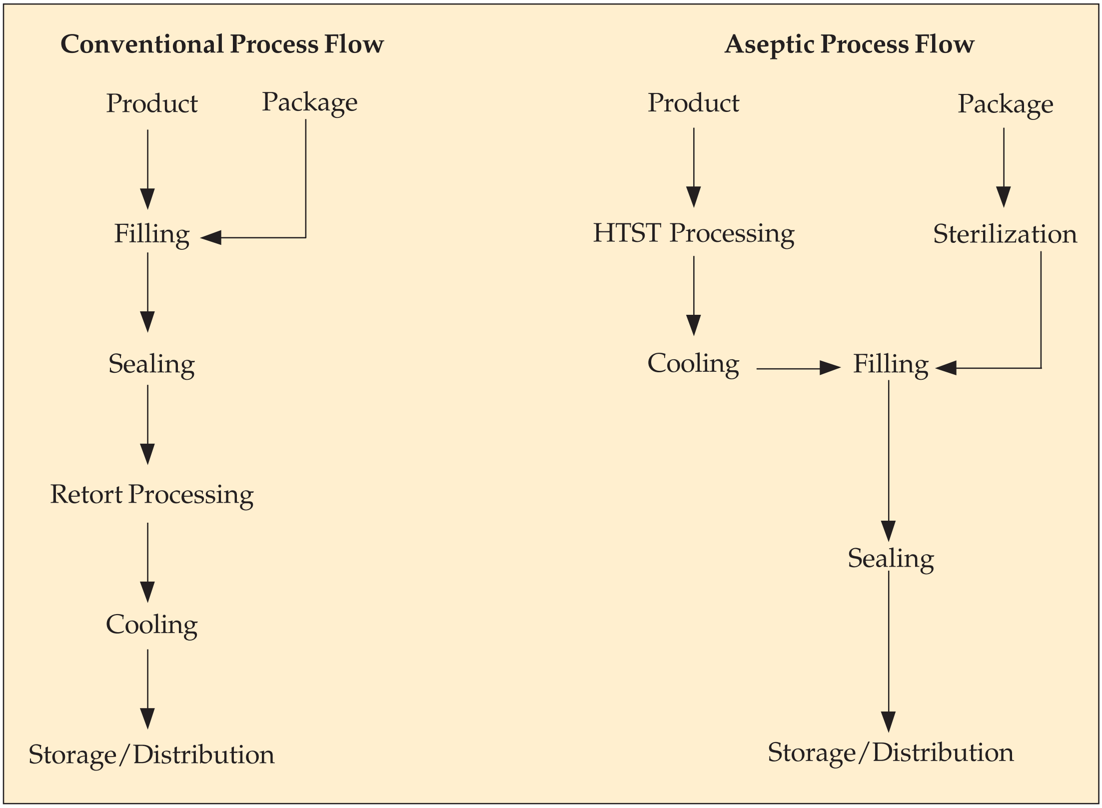
Figure 1 is a simple illustration comparing the basic difference between conventional canning and aseptic packaging processes for the production of shelf-stable food products.

Advantages of Aseptic Packaging Technology

The three main advantages of using aseptic packaging technology are:

- Packaging materials, which are unsuitable for in-package sterilisation can be used. Therefore, light weight materials consuming less space offering convenient features

Figure 1: Conventional Canning v/s Aseptic Packaging



and with low cost such as paper and flexible and semi-rigid plastic materials can be used gainfully.

- Sterilisation process of high-temperature-short time (HTST) for aseptic packaging is thermally efficient and generally gives rise to products of high quality and nutritive value compared to those processed at lower temperatures for longer time.
- Extension of shelf-life of products at normal temperatures by packing them aseptically.

Besides the features mentioned above, additional advantages are that the HTST process utilises less energy, as part of the process-heat is recovered through the heat exchangers and the aseptic process is a modern continuous flow process needing fewer operators.

Aseptic Processing – Methodology

Aseptic processing comprises the following:

- Sterilisation of the products before filling
- Sterilisation of packaging materials or containers and closures before filling
- Sterilisation of aseptic installations before operation (UHT unit, lines for products, sterile air and gases, filler and relevant machine zones)

- Maintaining sterility in this total system during operation; sterilization of all media entering the system, like air, gases, sterile water
- Production of hermetic packages

Sterilization of Products

In aseptic processing, the design to achieve commercial stability is based on the well-founded principles of thermal bacteriology and integrated effect of time/temperature treatment on spores of micro-organisms.

Pre-sterilization of a product usually consists of heating the product to the desired UHT temperature, maintaining this temperature for a given period in order to achieve the desired degree of sterility, with subsequent cooling, usually to ambient temperature and sometimes to an elevated temperature to achieve right viscosity for filling. Heating and cooling should be performed as rapidly as possible to achieve the best quality, depending upon the nature of the product. A fast heat exchange rate is desired for cost reasons.

Various heat transfer methods are used, but essentially the systems can be divided into direct and indirect heat exchange methods.

Table 1 summarizes the characteristics of the heat exchange systems used for aseptic processing of liquids.

TABLE 1
Characteristics of the Heat Exchange Systems Used for Aseptic Processing of Liquids

Equipment Type	Product Quality	Aroma Retention	Energy Saving	Capital Cost	Space	Pulp Capability	Fouling Length of Run	Turndown*
Steam Injection/ Infusion	Excellent	No	Poor	High	Fair	Fair-Good	Excellent	Fair
Plate Heat Exchanger	Good	Yes	Excellent	Low	Excellent	Limited	Limited	Good
Tubular:								
• Small Tubes	Medium	Yes	Fair	Medium	Good	Good	Limited	Good
• Large Tubes	Poor	Yes	Fair	Low	Fair	Good	Good	Good
Swept Surface	Good	Yes	Very Poor	Very High	High	Fair-Good	Good	Good

(* Turndown is the capability of the system to process at different rates to accommodate different number of fillers or different package sizes.)

[Source : Dinnage (1983)]

Some of the latest methods of sterilisation of products include:

- Microwaves
- Electrical resistance heating
- High voltage discharge
- Ultra high pressure

Sterilisation of Aseptic Packaging Materials and Equipment

- **Sterilisation Agents:** Heat, chemicals and radiation have been used, alone or in combination, for sterilization of aseptic equipment and packaging materials. Practical considerations and regulatory requirements have limited the number of sterilants, which are used for aseptic systems.

  - Heat

  Initially, heat was used as the sterilant for aseptic systems as a natural extension of thermal processing. Product supply lines and fillers are commonly sterilized by 'moist' heat in the form of hot water or saturated steam under pressure. 'Dry' heat, in the form of superheated steam or hot air, may also be used to sterilize equipment. However, due to the relatively high dry heat resistance of bacterial endospores, the time-temperature requirements for dry heat sterilization are considerably higher than those for moist heat sterilization.

  Since, relatively large masses of metal are often present in aseptic filling and packaging systems, high temperatures and relatively long holding periods are necessary to assure that appropriate sterilization has occurred. Systems employing moist heat are frequently sterilized at temperatures ranging from 121°C to 129°C, while 176°C to 232°C is used for sterilization by dry heat. In addition, sterilization of air by incineration usually is conducted at temperatures ranging from 260°C to 315°C.

  - Chemicals

  Hydrogen peroxide is the overwhelming choice for use as a chemical sterilant. Other chemicals which have been used as sterilants, primarily for use in systems for acid food, include various acids, ethanol, ethylene oxide and peracetic acid.

  Hydrogen peroxide is not an efficient sporicide when used at room temperature. However, the sporicidal activity increases substantially with increasing temperatures. Therefore, most aseptic packaging systems use hydrogen peroxide (at concentrations of 30 to 35%) as a sterilant for packaging materials followed by hot air (60°C to 125°C) to dissipate residual hydrogen peroxide.

  - Radiation

  Gamma-radiation has been used for decades to decontaminate packaging materials for use in aseptic systems for packing acid and acidified food. Due to the penetrating powers of gamma-radiation, packages are treated in bulk at commercial irradiators. A dose of approximately 1.5 Megaradians (Mrad) is commonly used to decontaminate containers for acid and acidified food. Recently, processes for low acid food aseptic filling and packaging systems are also being accepted. Doses required to sterilize containers for use with low acid food are considerably higher than those required for acid and acidified food.

  Other types of radiation are not widely used in aseptic systems. Ultraviolet (UV-C) light has been used to decontaminate food contact surfaces. The low penetration and problems associated with 'shadowing', limit the use of UV-C for aseptic systems packaging of low acid food. While equipment size, speed and costs have precluded use of electron beam irradiators until now; it is only a matter of time before such a system is developed.

Filling

- Once the product has been brought to the sterilisation temperature, it flows into a holding tube. The tube provides the required residence time at the sterilisation temperature. The process is designed to ensure that the fastest moving particle through the holding tube will receive a time/temperature process sufficient for sterilisation. Since there is some loss of temperature as product passes through the holding tube, the product temperature must be sufficiently high on entering, so that even with some temperature drop, it will still at least be at the prescribed minimum temperature at the exit of the holding tube. No external heating of the holding tube should take place.
- A **deaerator** is used to remove air, as most products, which are aseptically processed, must be deaerated prior to packaging. The air is removed to prevent undesirable oxidative reactions, which occur as the product temperature is increased during the process. The deaerator generally consists of a vessel in which the product is exposed to a vacuum on a continuous flow.
- The sterilised product is accumulated in an aseptic surge tank prior to packaging. The valve system that connects the surge tank between the end of the cooling section and the packaging system, allows the processor to carry out the processing and packaging functions more or less independently. The product is pumped into the surge tank and is removed by maintaining a positive pressure in the tank with sterile air or other sterile gas. The positive pressure must be monitored and controlled to protect the tank from contamination.

Tetra Brik Aseptic

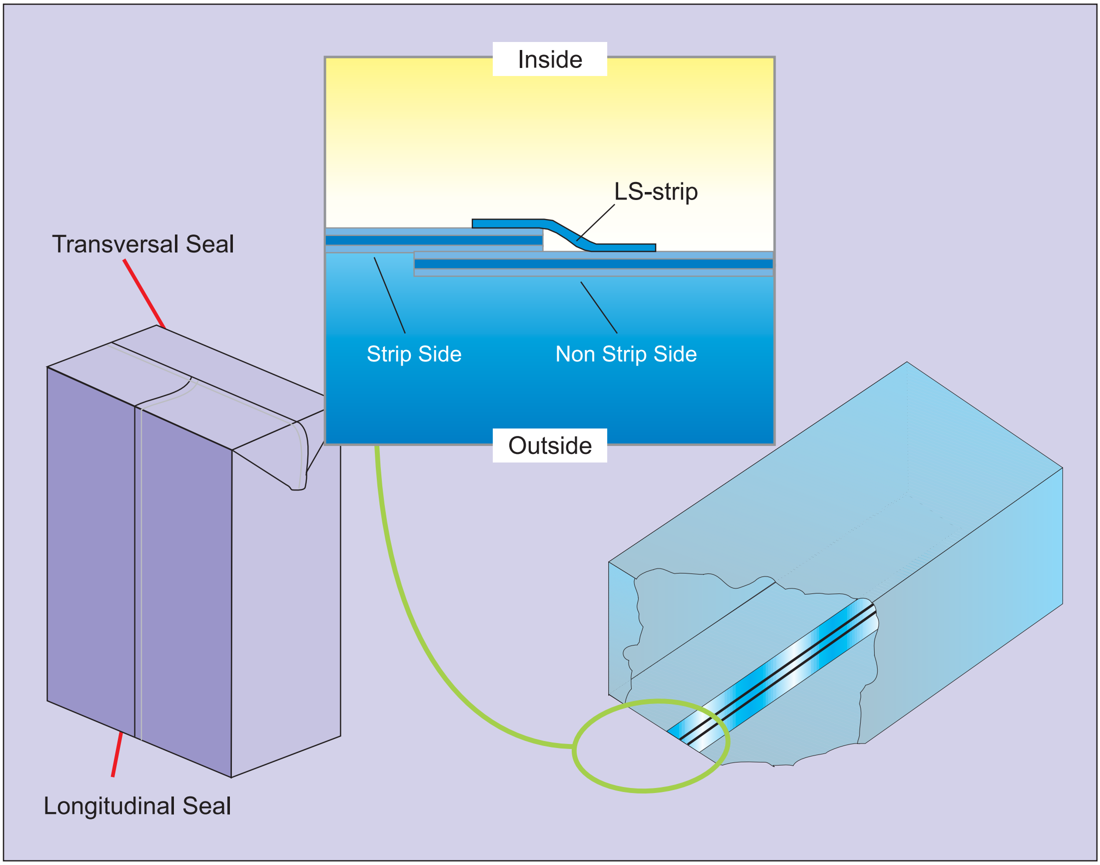
Tetra Brik Aseptic with Spin Cap

Tetra Rex

Seals and Closures

Any aseptic system must be capable of closing and/or sealing the package hermetically to maintain sterility during handling and distribution. The integrity of the closure and seal is therefore of paramount importance. The integrity of the heat-seals used in most aseptic

Figure 2: Sealings



systems is principally influenced by the efficiency of the sealing system used and by contamination of the heat seal area by the product. To avoid recontamination, the production units, which are tight are required. Two systems are manufactured in the Tetrapak system- the longitudinal and the transverse seam.

In the longitudnal system, a flat web of packaging material is used, supplied in reels. This flat material web is formed into a tube, which is sealed longitudinally resulting in a cylinder shaped structure. The strength of this longitudinal seam is determined partly by an "overlap seal" and partly by a plastic longitudinal strip. This strip is first sealed to one edge of the packaging material web and–once the packaging material tube has been formed – sealed to the inner surface of the packaging material. Both these operations, the strip application and the actual longitudinal sealing are done by using sterile, hot air and pressure (Figure 2).

Transversal sealing is done below the level of the product in the packaging material tube. By constantly moving sealing and pressure jaws, pressure is applied from the outside of the packaging material tube squeezing the product from the sealing area. An electrical impulse is passed through the sealing jaw and heat is transferred from the outside to the inside plastic layer of the packaging material. The polyethylene layer is heated, melted and pressed together between a pair of jaws. While pressure is maintained, the melted plastic layer cools down and a bonding is effectuated between the two opposite packaging material surfaces: they are sealed transversally.

Maintenance and preventive maintenance is needed to ensure satisfactory seam quality as well as to prevent damage of the packaging material in general, which may interfere with the tightness of the container. Thus, units are produced which are sufficiently tight to prevent re-infection of the product.

Types of Aseptic Packs

Consumer Packages

A great variety of packages may be aseptically filled now as listed.

- **Carton Boxes:** Some of the existing aseptic carton boxes may now be filled with particulates, also aseptically.
- **Bags and Pouches:** Pillow pouches are usually used for packaging of milk; three-sided sealed pouch, however, is suitable also for aseptic packaging of particulates up to particle sizes of 12µ and bag sizes from 1-5 litres. For standing pouches a Japanese machine uses closed pouches from a reel with sterile interior surfaces, the exterior of which is sterilized in a hydrogen peroxide bath when the web with pouches enters the aseptic cabinet. The bags are then cut from the web, filled and sealed.
- **Cups and Trays:** These are either used pre-made or formed, filled and sealed in thermoform/fill/seal machines. Both types of machines exist for filling particulates and also in packs suitable for microwave heating. Usually polypropylene-based multilayer materials with EVOH barrier are applied for this purpose.
- **Bottles and Jars:** Glass bottles may be aseptically filled with food containing small particles, for instance for baby food. Jars may be filled with larger particles - 12mm cube size or larger - if one dimension is smaller. In a recent development, returnable bottles are filled aseptically, which up to now were applied only for UHT – treated milk.

Fruits, Juices in Tetra Pack with and without Spin Cap

  Basically, the same products can be filled into plastic bottles and jars as into glass containers. Closing is usually done by heat-sealing aluminium lids. For this reason, much attention has to be paid to avoid contamination of heat-sealing rims.

- **Metal Cans:** As mentioned earlier, only the Dole system is able to apply to cans from steel and aluminium for aseptic filling. The existing slit filler, however, limits applications to liquids with very small particles, such as rice.

- **Plastic Cans:** An aseptic machine for filling and closing of two-piece plastic cans, 'gourmet cans', was recently developed. Cans and lids with easy opening feature consist of PP/EVOH/PP. They are sterilized with hydrogen peroxide, UV radiation and heat-sealed inductively. The can is presently offered for liquids only – for example coffee.
- **Composite Cans:** These may, at present, not be filled with particulate food, but only with fruit juice with long fibers.

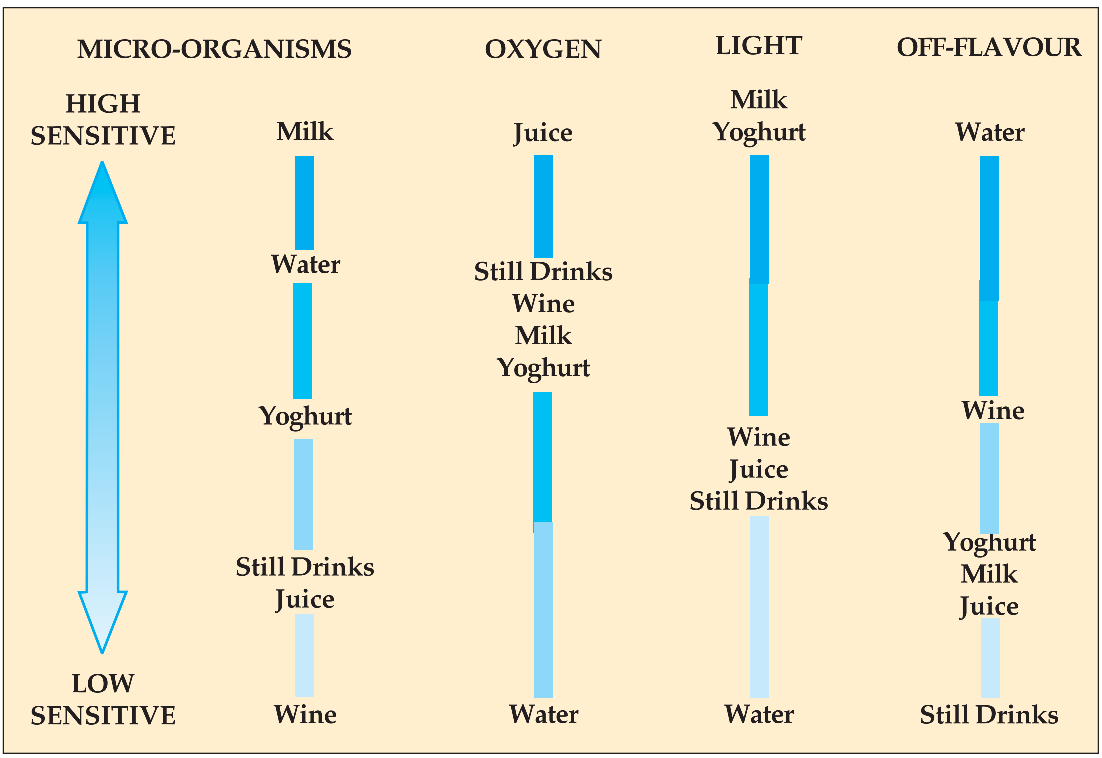
Aseptic Packaging Materials

Packaging materials must meet following factors :

- The packaging material must be compatible with the product intended to be packed and must comply with applicable material migration requirements.
- Physical integrity of the package is necessary to assume containment of the product and maintenance of sterility.
- The package material must be able to withstand sterilization and be compatible with the methods of sterilization.
- The package must protect the product from oxygen, also package must retain the aroma of the product.

Figure 3 gives the different sensitivities of aseptically packed products

Figure 3: Different Sensitivities



Special Need of Plastics in Aseptic Packaging

Packaging for aseptics was particularly demanding of the long shelf-life, high seal integrity and consumer appeal. However, because plastic material is so important to aseptic packaging, it is useful to discuss some special properties demanded of plastics by aseptic process itself. They are as follows:

- Chemical resistance and wettability
- Thermal stability
- Low levels of contaminating microorganisms; and
- Resistance to ionizing radiations

Package Structure and Composition

Aseptic package has not only to protect the product but also to maintain the quality of the product. Hence the structure as well as composition of aseptic packaging are more complex and vary depending on product application, package size and package type. Factors such as seal strength and integrity, package shape, stiffness and durability, as well as barrier properties determine the choice and/or combination of materials required. Generally to achieve all required properties, aseptic packages incorporate more than one material in the structure that is assembled by lamination or co-extrusion process. Examples of some materials commonly used in aseptic packaging are given in Table 2.

Market Data on Packaging of Fruit Juices and Milk in Tetra Pak Packages in India

This data is as compared to other packaging systems, based on 2002 data. As per the data available from Tetra pak India, the trends are as follows:

- **White Milk:** Total production of milk in India was 84 billion litres in 2002. A significant portion (1/3rd) is retained at the farm level itself, and the balance is termed market milk (roughly 55 billion litres). Of this, only 35 billion litres is liquid white milk, the balance going into milk products and by-products. 27% of this liquid market milk is packed, the balance is sold loose. Almost all packed milk comes pasterurized in plastic pouches-this segment is estimated to be between 11 and 12 billion litres. Almost 58% is sold through the 500ml size, and 38% in 1000ml. Milk from vending machines, available only in certain cities, amounts to some 1.4% or 0.4 billion litres.

  The balance packed milk is predominantly in Tetra Pak packages, amounting to some 70 million litres, although there is one player offering white milk and flavoured milk in aseptic plastic pouches in Delhi. Of the Tetra Pak share, some 50 million litres comes in Tetra Brik Aseptic (TBA) packages, 6 million litres in the tetrahedron-shaped Tetra Classic

Figure 4: Tetra Pak Share

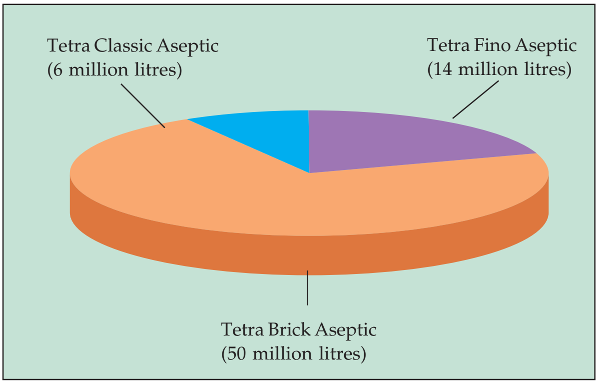


TABLE 2

Functional Attributes of Some Aseptic Packaging Materials

Material	Barrier Property			Seal Quality & Adhesion	Durability		
	Oxygen	Moisture	Light		Stiffness	Tear	Puncture
Paperboard			✓		✓		
Aluminum Foil	✓	✓	✓				
Metallized Film	✓		✓				
Ethylene Acrylic Acid				✓			✓
Low-density Polyethylene		✓		✓			
Linear low-density Polyethylene		✓		✓		✓	✓
Nylon						✓	✓
Polypropylene		✓		✓		✓	
Polystyrene					✓		
Polyvinylidine Chloride	✓	✓					
Ethylene Vinyl Alcohol	✓						

[Source: Aseptic Packaging by Frank A. Paine]

Aseptic (TCA) packages and the balance 14 million litres in the pouch-shaped Tetra Fino Aseptic (TFA) carton-based packaging system (Figure 4).

Apart from white milk, the other liquid dairy products like cream, lassi and buttermilk, flavoured milk etc. are available either in (sterilized) glass bottles, or ordinary plastic pouches, or in Tetra Pak packages.

The pasteurized milk in plastic pouches reaches the consumer mainly through the highly stable and very efficient home delivery channel; a very small proportion is stocked at milk parlours and provision stores to meet the emergency needs of shoppers. Milk production is increasing at the rate of 4.5% per annum. While pasteurized milk in plastic pouches will continue to grow (conversions from loose milk), white milk substitutes like milk powders will actually lose market shares. The UHT milk segment-packed in Tetra Pak packages-is currently growing at 28-30% per annum.

- **Juices and Nectars:** The packed juices and nectars market in India is around 33.90 million litres. Of this, 61% or 20.8 million litres is in long-life cartons (predominantly Tetra Pak packages), and 9.5% or 3.5 million litres is (largely) imported juices and nectars (such as the Australian Berri etc.) in PET bottles. This is likely to increase to 51 million litres by 2007. The organized, packed juice market is still at a nascent stage, but reported to be growing at over 30% per annum. The two main players in the packed juice market are Dabur's Real and Pepsico's Tropicana. The branded juice market is reported to be worth Rs. 120 crores. There is some amount of juice and nectars available in cans, but this segment is rapidly on the decline. The unorganized loose market, which includes the roadside stalls and juice bars is estimated to be around 172 million litres in 2002.

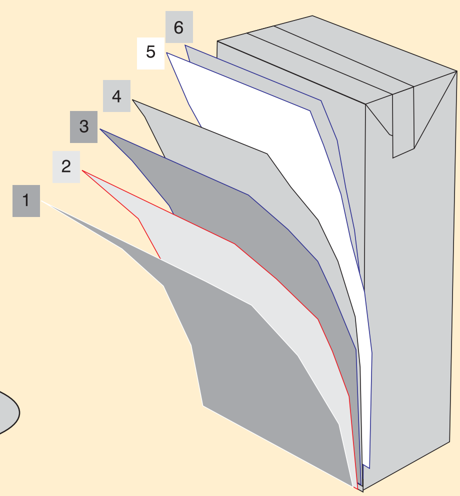
- **Juice Drinks:** The packed juice drinks market in India is around 152 million litres. Popular brands of juice drinks-predominantly mango-are Frooti, Maaza, Slice and Mangola from the three major players: Parle Agro, Coca Cola and Pepsico. While juice drinks in glass bottles account for 82.8 million litres, the balance (nearly 43%) is in Tetra Pak packages. The packaged juice drink segment is still only 6% of the total juice drinks market, estimated at 2400 million litres. The market is seen to be mature, with the brands enjoying good visibility and recall, and growing at less than 10% per annum.

Composition of Tetra Pak Aseptic Cartons

Tetra Pak aseptic cartons are made of three basic materials that together result in a very efficient, safe and light-weight package. Each material provides a specific function (Figure 5).

Figure 5: Composition of Tetrapak Aseptic Carton

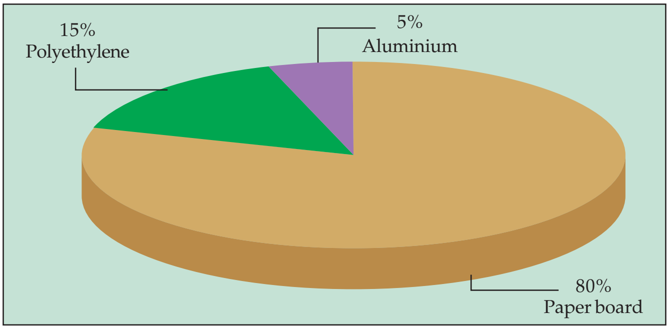
1. Polyethylene: Protects against moisture
2. Paper: For stability & strength
3. Polyethylene: Adhesion
4. Aluminium: Oxygen, flavour & light
5. Polyethylene: Adhesion
6. Polyethylene: Seals in the liquid



6 Layers Providing Total Protection

- Paper (80%): to provide strength and stiffness
- Polyethylene (15%): to make packages liquid tight and to provide a barrier to micro-organisms
- Aluminium foil (5%): to keep out air, light, and off-flavours - all the things that can cause food to deteriorate (Figure 6)

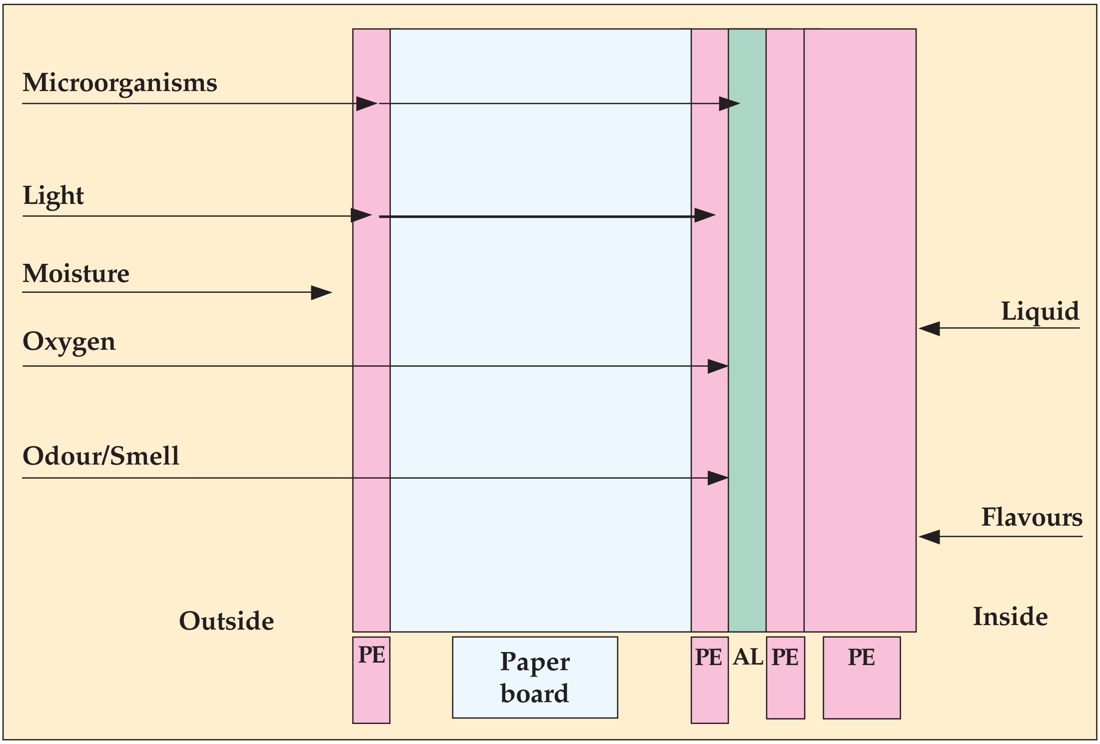
Figure 6: How is an Aseptic Carton Made



Combining each of these three materials has enabled Tetra Pak to produce a packaging material with optimal properties and excellent performance characteristics (Figure 7).

- Higher degree of safety, hygiene and nutrient retention in food
- Preserving taste and freshness
- Can be kept for months with no need for refrigeration or preservatives
- Efficient (a filled package weight is 97% product and only 3% packaging material), using a minimum quantity of materials necessary to achieve a given function
- A good example of resource efficiency is its light-weight (among the lightest packages available)

Figure 7: Properties of Aseptic Packaging Material



Type of Package Forms available in India

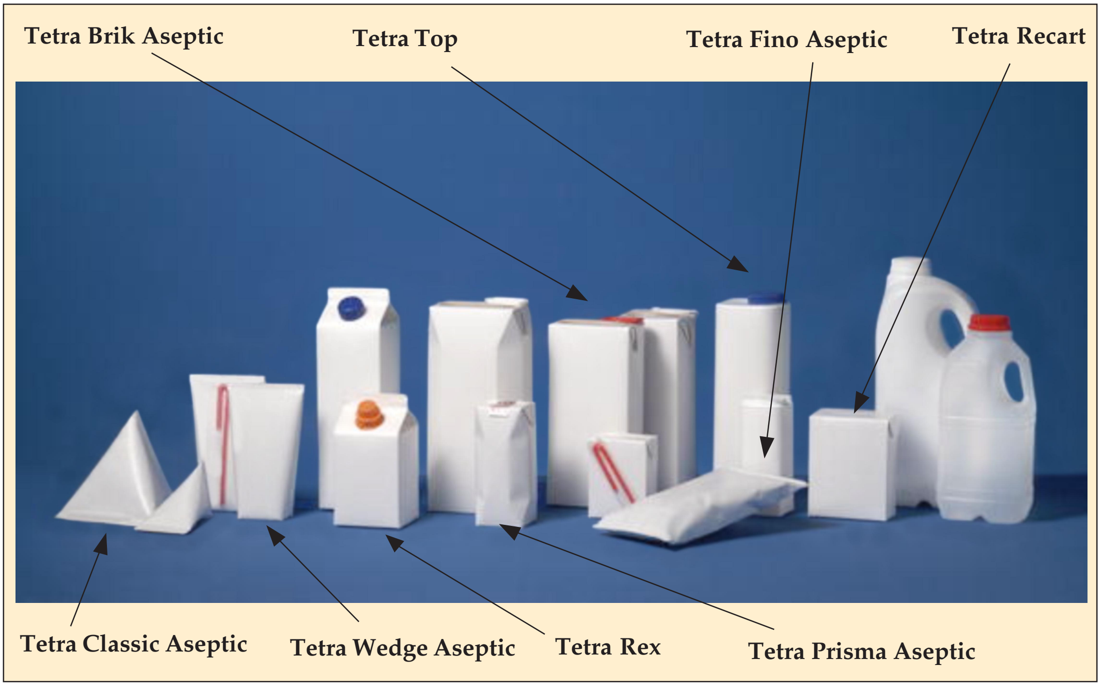
In India, Tetra Pak offers the following packaging systems currently:

TBA: Tetra Brik Aseptic

TCA: Tetra Classic Aseptic

TFA: Tetra Fino Aseptic

TWA: Tetra Wedge Aseptic



Types of Tetra Packs

These packages come in various sizes and shape configurations, and those currently available in India are in keeping with current legislative standards. The packages also have a variety of openings and closures appropriate to product and consumer needs.

Bulk Aseptic Packaging

'Aseptic Bag-In-Box' system caters to packaging of 'High' as well as 'Low' acid products and products containing particles for filling range from 25 litres up to 1140 litres. Typical packaging applications are:

- Fruit Juices, concentrates, purees
- Tomato Products
- Milk and Cream
- Coconut Products
- Jam

- **Working Principles of Bulk Filling Machine:** The packages are manufactured from a variety of laminates to match the product and required shelf-life. The packages are provided with patented spouts designed for aseptic filling. The inside of the package is sterilized before delivery; the packages are supplied flat preventing the entry of air or gas.

  They are available in volumes from catering size up to sizes intended for shipping of product from manufacturer/grower to processor/packer/distributor. All packages are intended to be supported, when filled, by an outer container, for instance a drum or heavy-duty box.

- **Advantages of Bulk Aseptic Packaging:** It offers the following advantages:
  - Safety
  - Reliability
  - Extended Shelf-life
  - Product quality

  - **Safety due to:**
    - Steam sterilization of spout, and sterilization effect can be controlled and recorded.
    - No chemical sprays used to sterilize the chamber.
    - Spout is tamperproof.
    - Safer sterilization and easier to monitor.
    - No risk of adding chemicals to the product.
    - No risk of laminate material relating with chemicals

  - **Reliability, because:**
    - The filling machine is uncomplicated as there is no sterile chamber.
    - Filling is controlled by weight. This ensures accuracy as no adjustments for specific gravity need to be made.
    - Customer will have one partner with worldwide service organizations and long experience in processing and packaging technology.

  - **Extended Shelf-life due to:**
    - High oxygen barrier of the laminate. Laminate is less susceptible to flex cracking.
    - Secure spout with limited possibility of oxygen permeation. Spout is made of HDPE, which has three times less oxygen transmission rate compared to LDPE.
    - There is no head space in the bag.

  - **Product quality because:**
    - Chemical browning is minimised due to high oxygen barrier properties of pouch material.

Bulk Aseptic Bags

A bulk aseptic bag is a multi-layer structure consisting of an outer barrier laminate and an inner bag in contact with the product. All bags are pre-sterilized using gamma irradiation and supplied flat. The level of gamma irradiation is specifically selected to facilitate packaging of high as well as low acid products.

The bag has three distinctive features as below:

- Highly Secure Spout
- Outer Bag Barrier
- Inner Bag Barrier
- **Types and Sizes of Bulk Aseptic Bags:** Depending upon the choice of barrier material employed, the bags are classified as:
  - Super Barrier
  - Medium Barrier

  Metallised Polyester is the conventional barrier for aseptic bags and is used in medium barrier bags.

  Aluminium foil as barrier material is used if the products are extremely sensitive to oxidation and loss of aroma and is used in super barrier bags.

  The bags are available in sizes of 25 litres, 200 litres and 1140 litres. The 1140 litres bag is also available with separate emptying spout.

Conclusion

The aseptic packaging is very well accepted in food service applications worldwide as a safe and high-quality packaging option. Aseptic processing sterilizes food products by destroying the harmful bacteria and pathogenic micro-organisms through a tightly controlled thermal process and combines the sterile product with the sterile packaging material in a sterile environment, the end result is a shelf-stable product requiring no refrigeration.

The use of plastics in the aseptic packaging significantly increases the non-refrigerated shelf-life and availability of many perishable products. Today, this is readily being used in the innermost contact layers of the package, thereby protecting the quality of food.

References

1. Aseptic Processing and Packaging of Particulate Food, Edited by Edward M.A. Willhoft
2. Aseptic Packaging of Food, Edited by H. Reuter
3. Tetrapak Company Magazine No. 76
4. Handbook of Canning and Aseptic Packaging, Edited by Ranganna
5. The Wiley Encyclopedia of Packaging Technology
6. Modern Food Packaging, IIP Publication, Aseptic Packaging by Dr. Bern Hard Von Bookelmann, A. B. Tetra Pak, Lund, Sweden
7. Aseptic Packaging, Modern Processing, Packaging and Distribution Systems for Food by Frank A. Paine
8. Websites
   - www.tetrapak.com
   - www.sgi.com
   - www.hassia.de
   - www.packexpo.com
   - www.serac-group.com
   - www.brevettiangela.com
   - www.boschpackaging.com
   - www.indiadairy.com