Chapter 7

PACKAGING ASPECTS OF BEVERAGES: CARBONATED AND NON-CARBONATED

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Introduction

According to the Fruit Products Order (FPO) 1955, fruit beverage or fruit drink means any beverage or drink which is purported to be 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 be not less than 5 percent. Fruit syrup connotes sweetened fruit juice of not less than 25 percent of fruit juice.

RTS fruit beverages should have minimum of not less than 10% of fruit juice and total soluble solids in the final product. Similar specifications have been cited for fruit crush, squash, cordial, unsweetened and sweetened juice, nectar and concentrate.

The Standards of Weights and Measures (Packaged Commodities) Rules 1977 specify (The Third Schedule) quantities in which aerated soft drinks and non-alcoholic beverages to be packed as: 100 ml, 150 ml, 200 ml, 250 ml, 300 ml, 330 ml (in cans only), 500 ml, 750 ml, 1 litre, 1.5 litres, 2 litres and thereafter in multiples of 1 litre upto 5 litres.

The requirements of packages intended to contain fruit beverages are:

i) Absolutely leak proof and prevent contamination.

ii) To protect the contents against chemical deterioration.

iii) No pickup of external flavours.

iv) Be hygienic and safe.

v) To retain carbonation in carbonated beverages.

vi) Economical, easy to use and disposable.

Processing Aspects

The traditional packaging procedure for fruit beverages involved heating the de-aerated juice to 90-95°C in heat-exchanger, filling the hot liquid directly into containers, sealing and inverting the cans, holding them for 10-20 minutes and subsequent cooling. This hot-fill-hold-cool process ensured the commercial sterility for the products. The use of glass container with suitable closures or acid-resistant (AR) lacquered tin plate cans was practiced.

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, in recent years, an increasing proportion is being packaged aseptically.

The improvements that have taken place in glass bottle packaging are:

i) Light weight.

ii) Surface coating to increase abrasion resistance.

iii) Use of wide mouth containers fitted with easy-open-end (EOE) caps.

Metal Containers

Tinplate cans which are made of low carbon mild steel of 99.75 purity strip, coated with tin either by dipping or electrolytical plating are suitable. Double reduced (DR) tinplate, with a second cold reduction treatment given, is widely used.

The three-piece cans have body and one end in steel-base and the other end fitted with an aluminium EOE, while two-piece cans have an integral body and bottom and top fitted with an EOE lid. The two-piece can has been claimed to be more economical due to savings in the use of metal, solder, etc., but its greatest technical advantages are the elimination of bottom double seam and the side seam and improved lacquering system.

Tin-free-steel (TFS) or ectrolytically chrome coated steel (ECCS) cans with adhesive bonded side seams also serve as beverage containers.

Fruit and vegetable juices packed and stored in aluminium cans with 21-26 inch of vacuum cause severe corrosion, hence lacquered cans should be used. The corrosion rate is dependent on the nature of organic acids present and the buffering capacity of the contents rather than the acidity. It has been shown that apple beverage stored for 22 months in aluminum can was comparable to other types of containers.

Easy-Open-Ends

The easy-open-ends used for beverage containers are made on one press from two sets of aluminium feed stock. The shell is made and scored in a normal press operation and a second strip of aluminium is later fed when the integral rivet is stamped in the centre of the end. The strip is stamped into a ring and is fitted over the rivet. The elongated scored area is removed when the ring is lifted and pulled back.

A non-detachable tab EOE is preferred since litter problem can be solved. Thus a number of types of 'environment friendly' ends have been developed.

Plastic Containers

Over the years, many types of plastic containers have been developed to package fruit beverages. The three types that have appeared are (i) Plastina-plastocan, (ii) Merolite and (iii) Rigello bottle.

Plastina

This type of container is made up of three components – (a) a two ply body material, (b) an outer container intended for use as a drinking cup and (c) an aluminium EOE. The Plastina can is represented by a major advance in processing in the development of co-extrusion system in which plies could be separated easily. This could reduce one of the major constraints in the use of laminates which could eliminate the inability to reprocess the scrap.

Merolite System

This container, developed in UK, consists of a film laminate based on oriented polyvinylidene chloride-coated polyethylene terephthalate (PET) made up of tubular packages. The container consisted of a lid opened by tearing off a strip of plastic covering a series of pouring holes.

The comparative efficiencies of different types of containers including plastic pouches in the retention of vitamin C in orange juice is shown in Table 7.1.

It has been shown that ascorbic acid (vitamin C) content in natural orange beverage packed in aluminum foil lined pouches was comparable to that packed in tinplate containers while metallized polyester/ polyethylene pouches indicated lesser retention, especially at higher temperatures (Table 7.2).

Table 7.1. Ascorbic acid retention in orange beverage

Package	% retention		
	1 m	2 m	3 m
Metal can	95	85	80
Glass bottle	93	80	78
Al-foil laminate pouch	93	78	75
PET-bottle	78	65	62
Standi pack (PA based)	65	52	50

Permeability to oxygen is the most critical factor in determining the shelf life of aseptically packed beverages. This explains why storage temperature plays an important role in maintaining the quality of products. Flexible packages offer economic savings over conventional glass and metal containers, but for the most part, are permeable to oxygen. Therefore, it critical to select a flexible package that minimizes the permeability to oxygen. Ascorbic acid loss in packs of various packaging materials with different transmission rates indicate the importance of selecting proper flexible package barrier (Table 7.3).

ASEPTIC PACKAGING

Functional Requirements of Aseptic Packages

1. High impermeability to water-vapour; zero for prolonged storage.
2. Very low permeability to gases especially oxygen since its interaction leads to chemical and biological deterioration.
3. Aroma barrier property to preserve odours and freedom from external taints.

Table 7.2. Ascorbic acid retention in laminate pouches

Package type	Ascorbic acid content value 32.58 mg %														
	40°C Days			27°C Days						4°C Days					
	14	30	50	14	30	50	65	80	90	14	30	50	65	80	90
Tin plate	25.0	22.7	22.2	26.0	25.0	26.0	25.0	23	22	27.2	26	26	26	24	23
PET/Foil/PE	25.0	18.5	15.8	22.1	21.8	15.8	71	43	30	25	24	24.2	24	19	18.6
MET/PET/PE	19.6	31	25	41	39	35	22.2	0	25	22	47	24.7	24.7	22.6	21.0

Table 7.3. Effect of oxygen transmission on vitamin retention		
Container material	**OTR ml O_2/m^2 24h. atm**	**Ascorbic acid retention, % 45 days/26°C**
PET/AL-FOIL/CPP	0	92
PET/PE/EVA/PVDC/EVA/PE	1	87
PE/EVA/PVDC/EVA/PE	4	37
BOPP/PVDC/PE	8	31

4. Compatibility with the product packed and also sterilizability with heat, chemicals or radiations.

5. Perfect package and closure integrity.

6. Capacity to form well on operating machinery.

7. Provide user convenience for unit and bulk packages.

8. Thermal stability for both low and high temperature.

9. Sufficiently robust to withstand rough treatment likely to occur during handling and transportation.

10. Meet all regulatory specifications.

Package Forms

Aseptically processed foods are packed in varieties of packaging materials and package forms. They comprise of flexible, semi-rigid and rigid containers. Aseptic packages can be divided into the following main types:

i. Flexible pouches and bags.

Fig. 7.1. Asepctically packaged fruit juices

ii. Carton form-fill-seal (FFS) systems similar to Tetra Pak and Tetra Brick principle.

iii. Thermoform-fill-seal systems fed from the reel stock.

iv. Bag-in-box systems.

v. Conventional containers made of glass, tin-plate, etc.

Hot-Fill-Hold Systems

These are generally used for acid or acidified foods and beverages. Typically the product is filled into a container at temperatures of 70-93°C, sealed and held at the fill temperature for about 10 minutes for achieving commercial sterility.

The package used for hot-filled process should be resistant to moisture and heat and withstand the vacuum resulting from the condensation of water-vapour in the headspace once the product is cooled. Conventional metal cans and glass containers have performed well in hot-fill hold applications.

New package forms which are used for juices, drinks and sauces are pouches made of composite films, as they should withstand the heat treatments from both sides of the pouch. Either flat type or stand-up type pouches are used. The material of construction generally is polyester/ polyethylene, metallized PET/Polyethylene or laminates of PET/Aluminium foil/PE, and some co-extruded film structures. Either HDPE or HD-LDPE combination or polypropylene can be used as the innermost layer to provide good thermal resistance and seal integrity.

Aseptic Packaging in Cartons

The three types of cartons used for packing liquid foodstuffs are the gable-top, the tetrahedron and the brick shape.

The gable-top type, which is mostly used for milk, is made by feeding of the blank from a magazine, and the lay-flat tube is then unfolded and made to enter a mandrel where the bottom is heated with hot air. The bottom is then folded in accordance with the score lines, and pressure is applied for finishing the bottom sealing. This rectangular shaped carton is removed from the mandrel on to a conveyer, filled with liquid and then top sealed. The top seal is performed with hot air and pressure.

The tetra hedral shaped pouches (Tetra Pak) are extensively being used for aseptically packed liquid foods. The tetrahedral shape requires less packaging material than other designs, as it offers the most favourable ratio of area to volume.

For this type of carton, the packaging material is supplied from a reel and passed up to a bending roller and shaped into a tube with longitudinal made at the ends of the carton giving the tetrahedral shape. The process is continuous and results in a chain of filled packages. As the seals are made under the liquid surface, the packages have no headspace. The transverse seals are produced by heat and pressure. First, the jaws compress the tube of material thus excluding liquid from the sealing surface. Secondly, induction heat is supplied, melting and fusing the plastic. Pressure is maintained while cooling the seal. The outer plastic cooling is then heated with a short pulse to ensure that when opening the jaws, they do not stick to the packaging material and possibly pull the seam apart.

The Brick-Pack System

Rectangular shaped (Tetra Brik) cartons were introduced around 1963 to facilitate distribution and have proved very popular. The production of tetra brick-type packages from roll-fed machines follows the same principles as for tetra standard; but the transverse seams are sealed parallel. The characteristic brick shape is formed after cutting off individual packages from the tube, by folding in the flaps and heat-sealing them.

Table 7.4. Oxygen permeation at scored areas

Sl. No.	Material	Oxygen transmission rate (cc/m^2.24 h) Flat area	Scored area
1.	PE/Paper-board/PE/foil/Ionomer/PE (Aseptic brick type package)	35-40	1500-1520
2.	PE/Paper-board/PE/Foil/Ionomer/PE (Hot pack purepack material)	30-35	2000
3.	Heat-seal lacquer coated polyester (75 μm)	20-22	20-40
4.	Polyester (25 μm)	70-80	70-100

Brick-style cartons are currently widely used for the packaging of high and low acid drink products. These are essentially constructed of PE/Paper/PE/aluminium foil/PE with slight differences among manufacturers. Especially for aseptic juice applications, the innermost layer is PE-Ionomer co-extruded web as this eliminates PE delamination from the foil. A pH value of 4.5 is the critical bench mark of product acidity, determining the utilization of PE/Ionomer layers for products below 4.5 pH.

The outermost polyethylene layer provides water vapour barrier property while the paper-board provides stiffness, ease of formation on automatic machines and printability. Aluminium foil of thickness 0.009 to 0.01 mm affords gas and water-vapour barrier properties, odour proofness and light protection. The innermost web of ionomer (Surlyn) is claimed to offer 5-10 times more heat-seal (hot tack) strength than ordinary PE, eliminate seal failures and leakers and resist cracking at score lines. The relative amounts of constituents in the material will be approximately 71% paper, 22% plastics and the remaining 7% aluminium. However, it has been shown that oxygen transmission rate at the scored area would be 40-50 times higher than the flat area.

To eliminate the risk of contamination from the base carton, all edges are protected. Further, as permeation can occur through raw cut edges of a carton, especially for long life product, the interior raw edges are eliminated to make the product as close to being hermetically sealed as possible.

In the common fin-seal, i.e. polyethylene to polyethylene layer seal is effected. An extra strip of plastic overlapping the internal side of the longitudinal seal (as in Tetra brick) effectively closes the edges. The other type is the so-called 'skiving' technique, where the inner end of the carton is reduced to one-half of the original thickness, folded in and sealed to the outer end.

Bag-in-Box Systems

The bag-in-box package utilizes a high-barrier multiplayer bag contained in a shipping container of corrugated fibre-board or wooden box or metal drum. The capacity of the bag ranges from about 5 litres for institutional use to 250 litres (60 gallons) for the industrial market. Even 1,135 litres (300 gallon) containers are available.

Smaller bags (5 and 10 l) are generally made of PE/metallized polyester or polyamide/PE having four-sides seals of width 5-10 mm. Inclusion of a single web of inner loose liner of LLDPE often provides added physical strength.

The outermost polyester or polyamide layer provides good tensile strength, abrasion resistance and protection to inner foil web. Aluminium foil of gauges ranging from 0.009 to 0.04 mm are used as a barrier against water-vapour, gases and volatiles.

The high-barrier structures containing foil and metallized plastics are susceptible for flexure fracture during transportation and handling. The extent of the damage due to two-crack can be assessed by gelbo flexing the packaging material for specific numbers of cycles and determining the barrier properties. Metallized films, especially sandwiched between two thermoplastic webs show less effect than foils. The effect of flexing on the barrier properties of some laminates are given in the Table 7.5.

In the bag design concept, one of the important factors is that of spout. The bag in normal use has a welded filament which contains a rigid plastic spout; it is fitted with a screw cap or pressed fit cap and sometimes with spigots for easy dispensing. There are different forms of construction of the spouts with ability to maintain aseptic condition.

Other Aseptic Systems

Several packaging systems are available for packaging foods into formed plastic cups. Most of these systems use FFS-variety where cups are thermoformed on the packaging machine from roll stock material. The construction of the cup material is either polystyrene modifications or high barrier plastic forms comprising of PVDC or EVOH resins.

Composite cans have also been used for aseptic packaging, especially for acid foods.

STERILIZATION OF PACKAGING MATERIALS

The surface of the packaging material must be completely free of microorganisms before filling of the food product. Different methods are used for achieving sterility – physical processes, chemical sterilants and radiation.

Table 7.5. Effect of flexing on the barrier properties

Sl. No.	Substrate	WVTR, $g/m^2.d$ Flat	WVTR, $g/m^2.d$ Flexed (50 - times)	OTR, $cc/m^2.d.atm$ Flat	OTR, $cc/m^2.d.atm$ Flexed (50 - times)	OTR, $cc/m^2.d.atm$ Flexed (100 - times)
1.	Paper/PE/Foil/PE	0.093	4.542	0.326	6014	-
2.	Paper/Metallized/OPP	1.736	2.170	52.08	306.9	-
3.	Paper/PE/Metallized/ PET	0.449	1.488	1.411	-	4.34

PHYSICAL PROCESSES

Super Heated Steam System

Metal containers can withstand the high temperatures involved in this method. Glass containers are also sterilized by steam, but processing times are longer than with cans because common glass bottles cannot tolerate the high temperatures. For plastic laminates, other methods of sterilization must be utilized because they cannot withstand high temperatures. The advantage of super-heated steam is that it can achieve high temperatures at atmospheric pressures. However, it has been shown that microorganisms are more resistant to superheated steam than saturated steam.

Dry Hot Air System

Hot air sterilization has advantages and disadvantages similar to super-heated steam. This has been used for a laminate of the type paper/foil/PP. Because the temperature of the air must be low enough to prevent material destruction, this system is limited to the packaging of high acid foods.

PACKAGING OF CARBONATED SOFT DRINKS

The two major deteriorative changes that occur in a carbonated soft drink (CSD) are the loss of carbonation and rancidification of essential flavouring oils. The hydrolytic rancidity could be reduced to a large extent by the use of high quality raw materials and anti-oxidants, and de-aerating the mix prior to carbonation. Oxidative rancidity could be mitigated by the effectiveness of the package in providing a barrier to gas permeation.

Conventional Containers

For many years virtually all carbonated soft drinks were packaged in glass bottles sealed with crown cork. This closure has a short skirt with 21 flutes which are crimped into locking position on the bottle head. The flutes are angled at 15° in order to maintain an efficient seal.

In recent years, non-returnable glass bottles are giving way to refillable bottles. These have a foam plastic protective label or a paper/polyolefin or an all-plastic shrink sleeve, in part as a safety measure to prevent flying glass fragments in the case of breakage of these containers, the crown closure has been replaced with a roll-on aluminium screw-cup with tamper-proof facility.

Among the metal containers, the 3-piece tinplate containers have been used since long for the packaging of carbonated beverages. The highly corrosive nature of the contents demands complete protection of the cans by the use of lacquers. For 3-piece cans, this involves spraying of lacquer after soldering or welding of side seams.

Although tinplate and TFS cans are still being used to pack carbonated beverages, 2-piece aluminium cans predominate the market. In this, integrity of can lacquer is well retained. Container weight and design have been subject of much developmental work with the weight of modern can with end down to 18 grams.

It has been reported that cola and lemon based CSD containing 5-10 ppm aluminium showed no sufficient flavour deterioration after 6 months at 23°C. It has been found that corrosion action can be reduced considerably by incorporating Mn and Mg in aluminium alloys. Thin walled alumi-

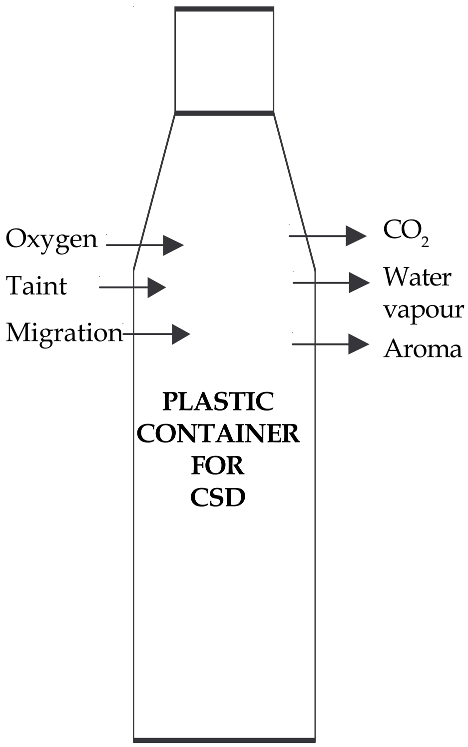

Fig. 7.2. Factors to be considered for use of plastic containers for CSD.

nium can resists high internal pressure of CSD.

Among the lacquers, vinyl, epoxy and vinyl organosol coatings have been found to be compatible with CSD. Epoxy amine has been found to provide good adhesion, colour, flexibility and freedom from tainting to the product.

Plastic Containers

The factors that influence the selection of a plastic package intended to contain CSD are indicated in the Figure 7.2. Although beer is more sensitive to oxygen interaction, soft drinks have a maximum permissible level of 20 ppm for citrus flavoured beverages and 40 ppm for cola drinks while the water loss is of the order of 1 percent. Also, the loss of CO_2 through the wall must not be allowed. While increasing thickness will decrease the rate of CO_2 permeation, the cost therefore, of the bottle will also increase and a compromise has to be arrived at.

Polyethylene Terephthalate Bottles

The polyester, polyethylene terephthalate (PET) bottles for carbonated beverages satisfies most of the requirements. 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, luster, chemical inertness and unbreakability.

The Advantages of PET Containers

- Superior packaging to product ratio, PET container being 63% and 47% more energy efficient than glass bottles and aluminium cans, respectively.

Fig. 7.3. PET bottles for carbonated soft drinks

- PET bottles are 32% more energy efficient than glass bottles during delivery of 1,000 gallons of soft drinks.
- Glass bottles and Al-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 1,000 one litre capacity PET bottles as against 230 kg for 1,000 equivalent glass bottles.
- PET bottles help in fuel saving due to their lesser weight.

Currently, more than 90% of PET is consumed in food packaging with beverages/drinks forming nearly 80%.

Among other plastic materials suitable to contain CSD, polyethylene naphthanate (PEN) meets several requirements such as physical, chemical and barrier properties. But it is much more expensive than PET. It is of importance to note, that diversification of plastics will make recycling more difficult and hence materials should be specified and multilayer structures avoided wherever possible.

Secondary Packaging

Secondary packaging for beverage packs may consist of corrugated fibre-board boxes, shrink wrapping and reusable plastic crates. In addition to all the technical and commercial consideration, the issues to be addressed comprise recycling the used packages and the directive to use the minimum amount of packaging possible.

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