SELECTING THE IDEAL PACKAGING FOR FRUIT BASED BEVERAGES*

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INTRODUCTION

What is the ideal packaging for juices and fruit based drinks? This question was put on the table at the IFW 2007 in Cologne. There is no single answer as the optimum solution will, for every case, depend on several factors, such as:

- Who the consumer is and where he/she will drink the beverage
- The distribution system
- The sensitivity of the product

Based on a presentation at IFW 2007 in Cologne, this article, gives 'a packaging view' of the international juice market and a comparison of the most common package types for fruit juice beverages.

INTERNATIONAL JUICE MARKETS

North America and Europe are the two largest juice markets. While recent years have seen a decline in North American consumption of 100 % juices, the European market shows a steady increase and sales volumes in both regions are now at some 11 billion liters per year. There are, however, large differences in the distribution systems in the two regions. In the USA and Canada almost half of all juices go through the cold chain, championed by orange juice in cartons. In Europe, on the other hand, the lion share, or more than 85 % of packaged juices, is distributed at ambient. Juice based drinks move almost entirely without refrigeration.

A closer look at the packaging mix for fruit juices, figure 1, reveals that in North America cartons command a similar market share as plastic bottles, about 40 % each. In Europe, aseptic cartons dominate with glass in second place. The data from Canadean for 2005 show that PET bottles accounted for a mere 4 %, although with high growth rates and consumer acceptance, they are quickly taking shares from glass bottles as well as cartons. The gains of PET packaging are particularly striking in Germany, where, from 2005 to 2006, non-returnable PET bottles took a 20 % jump and now represent more than half of the total alcohol-free beverages and waters market (GfK, Germany).

Further disparities between European and US juice beverage industry include their preferred filling methods for PET containers. When PET bottles were introduced in North America to replace glass containers for juice drinks, converting hot-fill glass installations to the new material was the obvious step. At the time, aseptic systems for PET were not yet well established. With bottle manufacturing

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FIG. 1: PACKAGING MIX FOR FRUIT JUICES IN NORTH AMERICA AND EUROPE, 2005

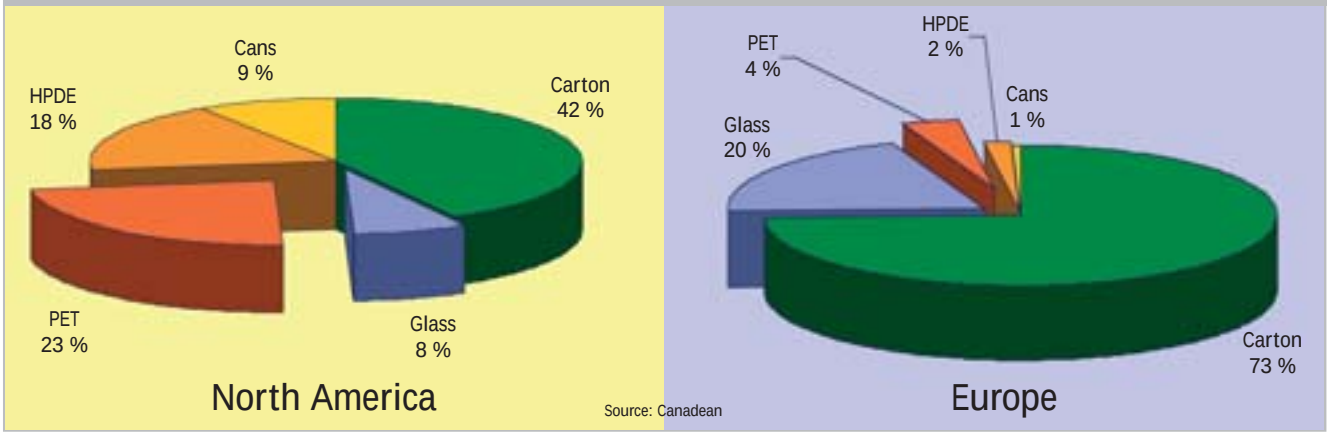


Fig. 2: Tetra Aseptic Gemina in 'gable top' shape

Technological advancements have as well enabled weight reduction and additional freedom in the design of hot-fill PET containers. Instead of the traditional rectangular vacuum panels, the necessary areas for bottle contraction now form an integral part of the bottle, such as a built-in grip. The new technologies provide the opportunity for global brands to maintain similar container appearance despite different filling processes, thereby strengthening their brand identity.

facilities put in place, the majority of US bottling companies for shelf stable juice drinks have remained loyal to hot-filling.

Their European counterparts, who made the shift to PET several years later, have, by and large, opted for aseptic filling, despite the fact that it entails considerably higher investments and more complex operation than the hot-fill process. The higher capital outlay is partly compensated for by the lower costs for the containers themselves – filling aseptically at ambient temperature allows for a lighter bottle and heat-setting is not required. Furthermore, this process offers larger freedom in bottle shape, which has permitted European juice manufacturers to replicate glass bottle designs in PET and successfully expand well established products into new consumer categories. Many juice brands are available in PET as well as glass bottles for different market segments.

HOW DO THESE PACKAGING TYPES COMPARE?

This review looks at package performance primarily in terms of protecting product quality. Realistic shelf life and recyclability of the packages are also taken into consideration. For shelf stable fruit beverages the packaging must in all cases prevent microbiological contamination.

The most important package properties in regards to maintaining quality of the product are:

- Gas barrier
- Light barrier
- Aroma barrier

Most fruit based beverages are sensitive to oxidation, which results in losses of vitamins and unfavourable changes in taste and colour. The rate of oxidation, and thus quality degradation, is not only determined by the gas barrier properties of the container itself, but by the total oxygen exposure. This includes:

- Permeation through spout or closure
- Oxygen in head space
- Permeability of container walls

- Oxygen desorbed from the container
- Oxygen dissolving into the beverage during filling process

Package evaluations should be made under realistic conditions that mimic conditions for commercial filling, storage and transport. Samples stored in a climate controlled laboratory do not necessarily result in a fair comparison – high humidity has a negative effect on certain barriers and transport movements can lead to cracks or micro holes.

GLASS BOTTLES

Glass bottles provide excellent protection thanks to perfect gas and aroma barriers. Insufficient tightness around the metal closure is a potential source of oxygen ingress, but can be minimised by various liner solutions. Visible light and part of the ultraviolet light spectra penetrate through clear glass, as well as PET, and may affect photosensitive compounds, such as certain vitamins. Addition of UV absorbers to the glass will protect the bottle content against ultraviolet rays.

Shelf life is usually 12 months, or more, for fruit beverages in glass. They are commonly hot-filled, not withstanding a number of installations for cold aseptic filling. Oxygen should be minimised to limit oxidation at the high filling temperatures.

Lastly, glass recycling systems are in place in most markets. Refillable bottles, which are returned to the juice plant for washing and filling, have given way to one-way PET in retail but are still preferred in the hotel and restaurant trade.

CARTONS

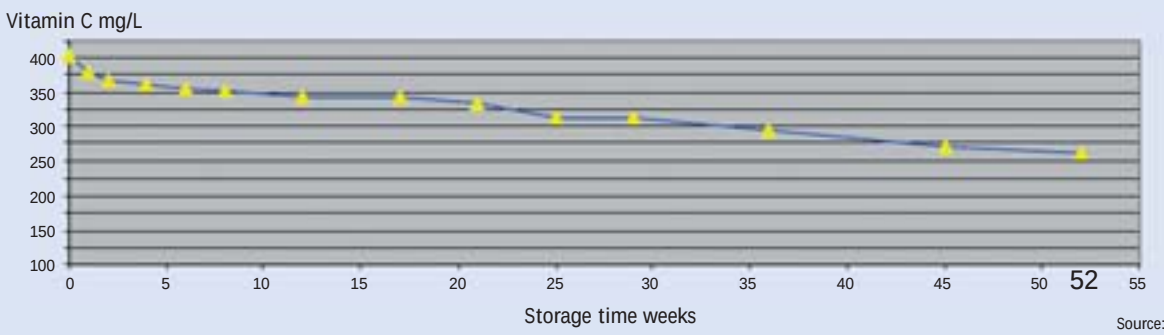
The laminated cardboard carton, aka the “drink-box”, is currently the most common package for fruit beverages. Although features like openings and package shape matter dearly to consumers, differences in filling system and packaging material have a greater influence on product quality. Most shelf stable fruit beverages in cartons are filled aseptically at ambient temperature. This segment is dominated by three companies, Tetra Pak, in the leading position, followed by SIG Combibloc and, in third place, Norwegian based Elopak.

The carton packages are formed and sterilised, using hot hydrogen peroxide, within the filling machine, before being filled and sealed. In the Tetra Pak system, where laminated cardboard is fed on a roll at one end of the filling equipment, product is not in contact with air during filling. Head space is created, when needed, by injecting nitrogen gas into the product before filling.

In the packaging systems from SIG Combibloc and Elopak prefabricated blanks are formed into cartons in the filling machine, followed by sterilisation and filling. Optional purging with nitrogen minimises oxygen exposure of the product in the filler.

The laminated packaging material comprises a barrier layer, commonly a thin aluminium film. It provides a very high gas barrier but oxygen may permeate at ‘leaks’ at the seals or through micro holes, formed when the material is folded. The plastic spouts, if used, are applied onto the outside, in order not to compromise the microbiological integrity of the package, and do not impact the overall gas barrier.

FIG. 3: STORAGE TESTS WITH ORANGE JUICE



Source: SIG Combibloc

The aluminium film is also an effective barrier against light ingress and aroma permeation. Nonetheless, the internal polyethylene layer may absorb oily aroma, like citrus oils, from the product.

The evolution of vitamin C content in orange juice is a frequently used method to assess package performance and predict product shelf life. The degradation of vitamin C in orange juice is directly related to oxygen ingress, after vitamin losses caused by anaerobic reactions have been subtracted. In fig 3 vitamin C levels have been measured over a year. Taking into account that 40-50 % of vitamin C losses are 'anaerobic' in this case, the test results confirm a very high oxygen barrier of the package.

Cartons typically permit shelf life of 12 months for juice beverages in the 1 litre format, while shelf life in single serve packages is somewhat lower.

Recycling of cartons vary greatly between countries, from 10 to 90 %, depending on the collection and recycling systems in place.

PET BOTTLES

To consumers, PET bottles offer several advantages compared to glass: they are light weight, unbreakable, and have an attractive, glossy appearance.

For producers of juices and drinks the picture is more complex. PET, polyethylene terephthalate, provides a good aroma barrier and a relatively high oxygen barrier. Nevertheless, it is not sufficient to protect quality of oxygen sensitive beverages, both in terms of maintaining sensorial properties and nutritional content, during extended storage. Furthermore, visual changes, such as browning or fading colours, become more apparent in thin wall PET bottles than in glass bottles.

Attracted by the immense potential of the beer market, the PET industry has developed a range of technologies to improve gas barriers for PET containers. Continued developments aim to refine the existing systems and to find more cost-effective solutions.

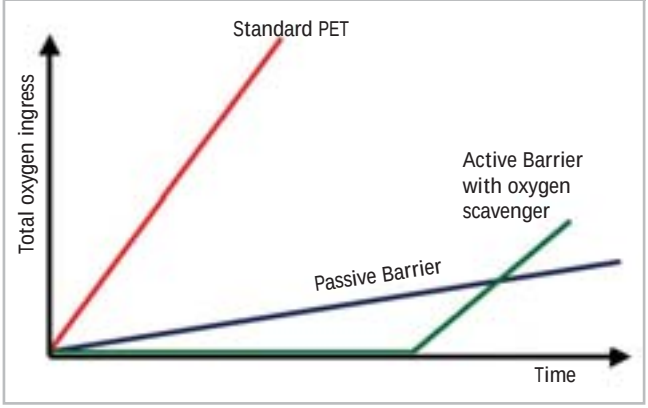
Barrier material in preforms is applied either as a direct blend with PET (mono-layer) or as one, or more, separate layers between PET (multi-layer). Mono-layer barrier preforms have the advantage of being manufactured on standard equipment while multi-layer solutions require more complex injection moulding systems. There is a risk of haziness in the mono-layer bottles, however, especially at high barrier concentrations.

The barrier materials are of two different types, often used in combination:

- Active barriers
  These are oxygen scavengers that react with oxygen migration through the bottle wall. They offer a very effective barriere – until the scavenger is depleted.
- Passive barrier materials
  These reduce oxygen permeation rate through bottle wall during the entire shelf life. Polyamides and EVOH are commonly used for these passive barriers.

Technologies for adding extra barrier to blown bottles are primarily plasma coating, which entails the deposit of a

FIG. 4: PROTECTION IN PET BOTTLES WITH DIFFERENT BARRIERS



very thin barrier layer on the interior bottle surface, or spray coating of a barrier material onto the exterior. Both methods provide passive barrier.

The oxygen protection over time for different barrier solutions is explained schematically in figure 4. Most of the current barrier technologies have certain flexibility in barrier protection. Thus, barrier levels can be adapted to meet actual requirements, by adjusting thickness of bottle coating or amount of barrier material in preforms. Careful evaluations of the fruit beverage will help in selecting appropriate materials and avoid unnecessary expenses. Barrier requirements will also depend on container size – the product suffers relatively higher oxygen ingress in small bottles than in large containers. Similarly, the impact of head space increases with smaller sizes.

When evaluating total package performance, the closure needs to be taken into account. Plastic closures of polyethylene, or polypropylene, provide a relatively poor gas barrier. To reduce oxygen ingress, closures with oxygen scavenger or additional passive barrier can be used.

Recycling systems for PET bottles are established in many countries. The compatibility with the recycling stream is assessed individually for each barrier solution by means of a standard testing protocol. Coatings have been approved for recycling into new PET bottles. Polyamide and EVOH, on the other hand, impair the quality of recycled PET, making it unsuitable for new bottles. Hence, blends of these materials should be recycled into other PET uses, such as fibres or strapping.

OTHER PLASTIC BOTTLES

There are several alternative polymer materials to PET for bottles, such as bio-plastics, clarified polypropylene, PEN and polycarbonates. Their attractiveness depends on many factors, including consumer preferences and economics. Currently available bio-plastic materials have inferior gas and aroma barrier properties compared to PET. Additional barrier would be required to provide adequate protection for fruit beverages; such systems are under development.

CONCLUSION

As shown in this review, there is an increasing choice of packaging formats for fruit based beverages, with their respective pro's and con's. In order to make the appropriate packaging selection, juice producers need not only a thorough knowledge of their own beverages but a comprehensive understanding of the packaging systems associated with the different container types – considerations which go beyond the scope of the current review.

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