BEER IN PET PACKAGING

By Lilijana Peklar

Beer in PET bottles has been challenging the entire European beer-brewing industry as well as allied (co-dependent) industries. Until recently, this packaging used to exist more in theory than in practice; however, due to faster progress PET packaging has become more and more attractive for use with oxidation-sensitive beverages (different juices, wine, beer, etc.).

On extremely competitive markets where beers do not only battle other beer trademarks but also many other alcoholic beverages (i.e. beer blends, various alcopops, wine, etc.), the differentiation and recognition of packaging is also of great importance. Obviously, PET has great potential. Market competition became even stronger after Slovenia entered the EU, and beer in PET packaging on our market was only a question of time.

Pivovarna Laško, d.d. launched 0.38 l PET packaging in 2004 as the result of years-long research and testing of suitable materials. At the beginning of 2005, the initial PET packaging was followed by the introduction of 0.5 l and 1.0 l PET multilayer packaging due to low market interest for the 0.38 l capacity. In view of previous market activity, the Slovene market was found to be completely comparable to the traditional Western market, where this kind of packaging has gradually been making inroads – the share of beer in PET packaging is practically negligible at present, however.

Lilijana Peklar

Brief History, Business Strategy of the Company, Production Figures, Assortment

By Matej Oset, Head of the Technical Department

Pivovarna Laško, d.d. has taken the leading position in the Slovene beer-brewing industry, with more than one hundred seventy-five years of tradition, and there are three important time periods in its history to be pointed out. In 1825, Geyer, a seller of honey and sweetmeats, rearranged his Laško workshop into a brewery employing ten workers. Therefore, almost a century and a half later, the most profitable, respectable and promising economic activity of the town was established. In 1938 the Laško Brewery became a joint-stock company set up by Slovene innkeepers, thus reviving beer brewing after the factory had been closed down by a German competitor. Fifty employees were given jobs in those days. In 1995, the Laško Brewery would become a joint-stock company entered in the court register of Celje, and thus the Brewery, having the major share of the Slovene market, passed into the hands of 14,500 shareholders.

Pivovarna Laško, d.d. has constantly been keeping abreast of advanced world standards and has been directing its available capital to the most up-to-date technologies in order to make its beer quality competitive with the world's top brewers, based strongly on its traditional and proven recipes, kept as well-guarded secrets by the company.

Pivovarna Laško, d.d. devotes permanent investments to technology in order to meet the highest level of quality demanded by its customers, and provides employment for 340 workers. In 2005 Pivovarna Laško, d.d. sold 841,474 hectolitres of beer on the Slovene market and 240,234 hl on foreign markets. In 2005 the parent company, as well as the whole Laško Group, ran an extremely successfully business, dramatically surpassing the company's results in 2004 – history will record 2005 as one of the most significant to the enterprise.

In 2000, Pivovarna Laško, d.d. became a 94.55% owner of Jadranska Pivovara in Split and assumed 88.4% ownership in Radenska, d.d., in Radenci (which grew to 92,06% in 2006). The company had previously acquired a 51% ownership share in Vital d.o.o., Mestinje in 1999, which grew to 95.53% in 2006.

Without doubt, the year 2000 signifies one of the most important turning points in the history of the enterprise as the result of the capital interlock with Radenska, d.d., Radenci; Jadranska Pivovara, d.d., Split; and Vital, d.d., Mestinje. At the same time, the turn of the millennium also witnessed the launch of the enterprise's new business development strategy involving capital interlocking with the above companies.

In 2002 the enterprise managed to take over Pivovarna Union, d.d., Ljubljana with a 47.86% share of all company stock in a tender offer. However, Pivovarna Laško continued its capital investment by acquiring a 24.98% share in Delo, d.d., Ljubljana and thus became the leading owner of the company. In December 2004 Pivovarna Laško managed to acquire an additional 27,011 shares of the Union Ljubljana joint-stock company, which signified a 5.98% ownership. In this way, the Pivovarna Laško, d.d. joint-stock company became a 53.85% owner of all Union stock.

In February 2005 Pivovarna Laško, d.d. bought out the entire Interbrew ownership share, i.e. 186,400 shares of the Pivovarna Union, d.d., Ljubljana share issuer and thus became a 95.17% owner of that company. Now the share is 96,73%.

In 2006, the business strategy of the enterprise will focus on gaining new markets in the European Union as well as in Southeast Europe, where the marketing approach will be introduced to reinforce its efforts to offer premium quality products and trademarks using the LAŠKO PIVO crown to create the basis for uniform brand identity in all markets.

Pivovarna Laško Group, selling more than 5 million hectolitres of beverages, is becoming the most powerful beverage manufacturer in Southeast Europe. The brewery will continue its policy of strategic interlocking and globalisation to expand the economies of scale, purchasing power and capital and competitive advantages to aim at becoming the largest beverage manufacturer and supplier in Southeast Europe.

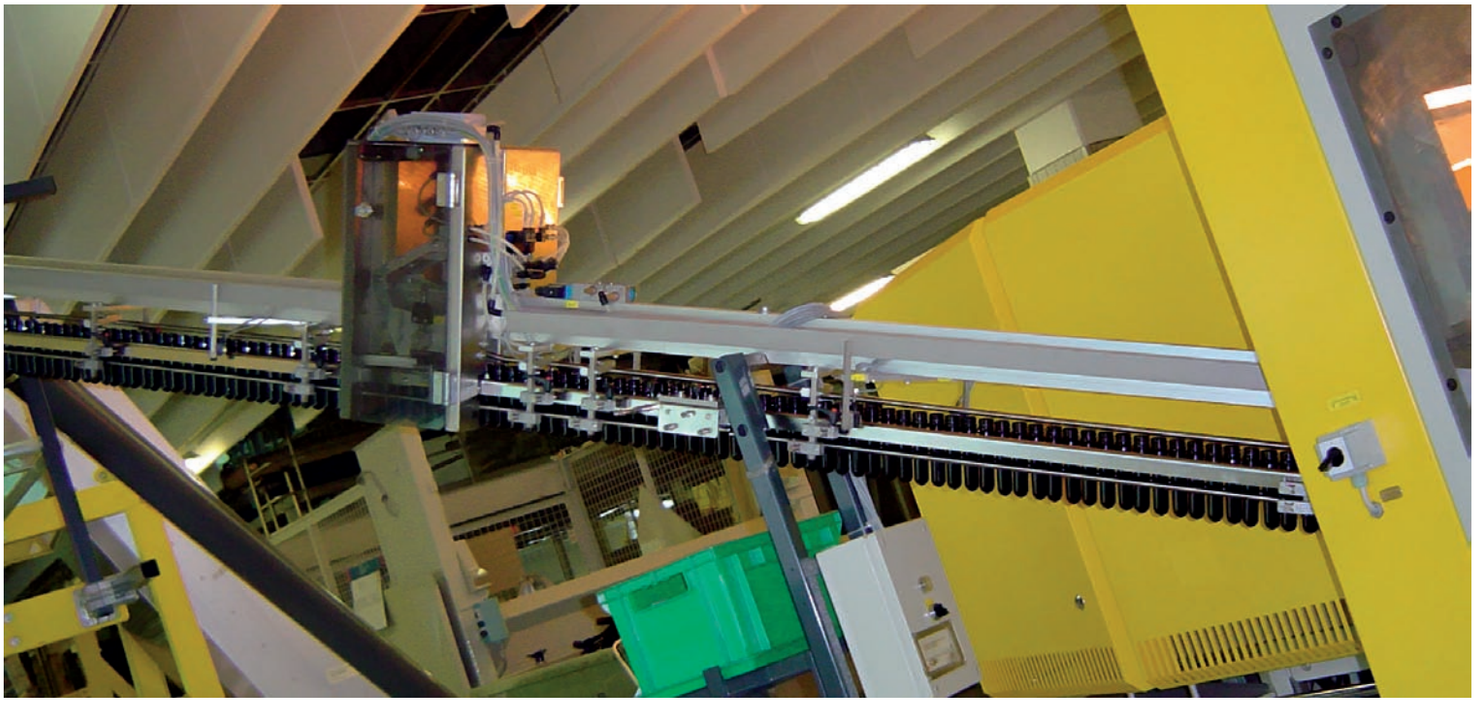
The production programme of Pivovarna Laško, d.d. involves beer products ranging from Gren light beer (1.7% vol), Laško Lahko light beer (2.7% vol), Zlatorog and Laško Club (4.9% vol) to Laško Temno dark beer (5.9% vol). Also included are special pale beer with the refreshing taste of tequila and lemon – Bandidos Tequila (5.1% vol), pale beer with Caipirinha aroma – Bandidos Ice (4.0% vol), a blend of pale beer and lemonade – Bandidos Light Lemon (2.4% vol) and spring water – Oda. In 2004, Pivovarna Laško, d.d. introduced a new variety of beer packaging – PET plastic bottles.

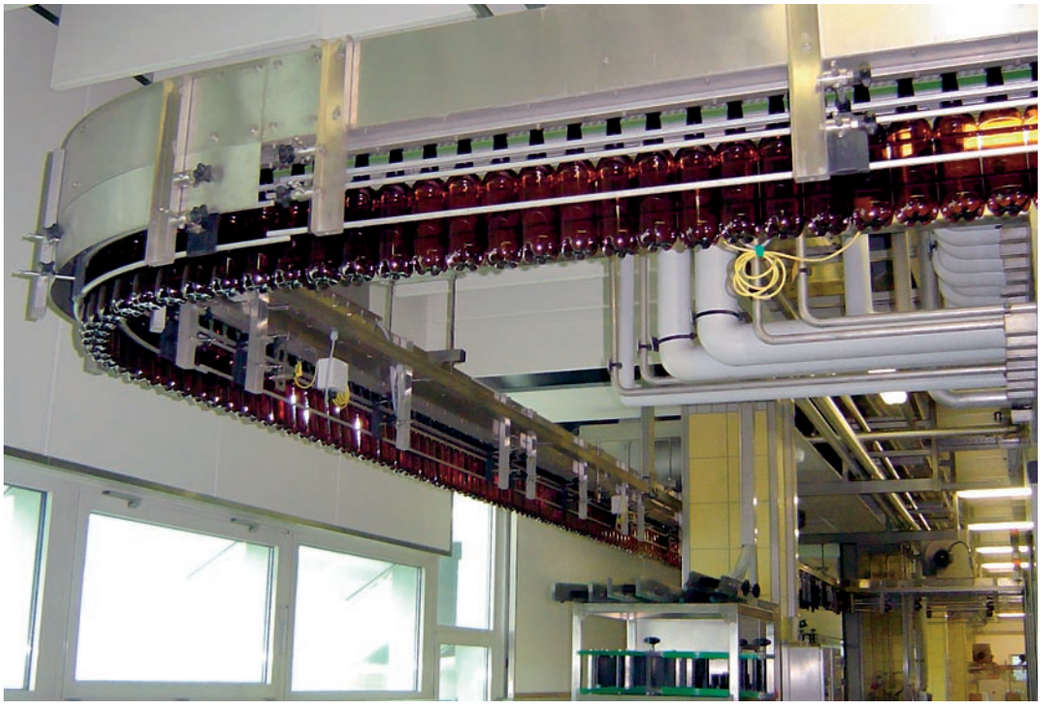
PET material

Polyethylene terephthalate (PET) is a very important polymer material used for packaging food products. Since the '70s when it was first introduced as a packaging material, its use has risen significantly. In fact, it is mostly involved in the beverage industry (more than 80% of all PET use) instead of traditional packaging previously dominated by glass and metal. It has also been replacing other plastic packaging materials, such as polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). The material itself became attractive in the field of non-returnable packaging mostly as the result of its properties and reasonable price.
PET is a linear, thermoplastic polyester produced by the esterification reaction of glycol and terephthalic acid. The combination of the aromatic component, which derives from terephthalic acid, and the aliphatic component of glycol determines the specific properties of the material. Copolymerization with other monomers produces resins of different degrees of crystallinity, including amorphous material. Polymer strength, durability, bonding power, gas permeability and thermal stability are consequences of crystal structure. However, the specific extension, ability of retracing to an elementary state, toughness, clarity and diffusion depend on amorphous areas in the polymer. In practice, the PET characteristics of specific extension depend on its molecular mass, tensile ratio, level of crystallisation, humidity, temperature and kind of copolymer and its structure.
Not only do properties as the outcome of polymerisation have a huge effect on PET material, but there are also various additives that are incorporated during the process of extrusion and moulding of a plastic resin or applied externally on the formed material. These substances are added in order to achieve suitable processing and the ultimate properties of the material (antioxidants, UV stabilizers, softeners, colorants, dyes, fillers, antistatics, etc.).

Advantages and disadvantages of PET packaging

Typical PET plastic bottles usually weigh only 24 to 40 g (0.5l), which represents only one-tenth of the weight of comparable glass packaging. They are also fracture or smash resistant (appropriate for picnic use, concerts, sports and other outdoor events where traditional glass packaging involves safety risks). With screw caps, the bottles can be reclosed and their transparency makes the content visible (a "clear" advantage over aluminium – beer cans); good flexibility of colour and a variety of PET bottle designs are also made possible. Furthermore, these bottles can be accurately manufactured and, like glass, the material is completely recyclable.
The biggest PET packaging disadvantage is its permeability to gases. In order to achieve the minimum expected shelf life of beer, i.e. six (6) months, it is of great significance to assure PET material resistance to oxygen uptake and loss of carbon dioxide. It is true that no material is 100% impermeable to gases. Carbon dioxide plays a characteristic role in beer – it is responsible for its fresh taste and affects the beer's stability and sharpness; its content in beer ranges from 3.5 to 5.5 g/l normally and it can be characterized as having good solubility, which it holds as the temperature rises, but the pressure in the packaging rises as well. The loss of carbon dioxide during storage depends on the packaging material. PET does allow a high degree of CO_2 permeability from the bottle as the consequence of partial pressure; oxygen penetration into the plastic bottle is quite possible. Oxygen is found to be approximately 40-times less soluble in beverages than carbon dioxide. It may enter the beverage during the process of filling and storage. For this reason, we have to make the right decision about the material which the bottles are made from; the bottling process itself is also very significant and should enable as little oxygen penetration during the process as possible – and even the appropriate material from which the bottle closures are made should be taken into account. Oxygen dissolved in beer responds in different ways according to different ingredients, which causes organoleptic modification, thus lessening the shelf life of beer drastically. During the process of bottling under pressure and use of CO_2 as





the supplanting gas, the oxygen value should not exceed 0.1 mg/l.
Beside the material of the plastic bottles and closures, and the system of bottling and storage, it is also the size of the plastic bottles that affects gas migration. The ratio between the volume and surface of bottles favours larger bottles – the permeability effect is lower. Oxygen migration should not exceed 1.0 mg/l over a period of six months; on the other hand, the loss of carbon dioxide is not expected to be higher than 15%.

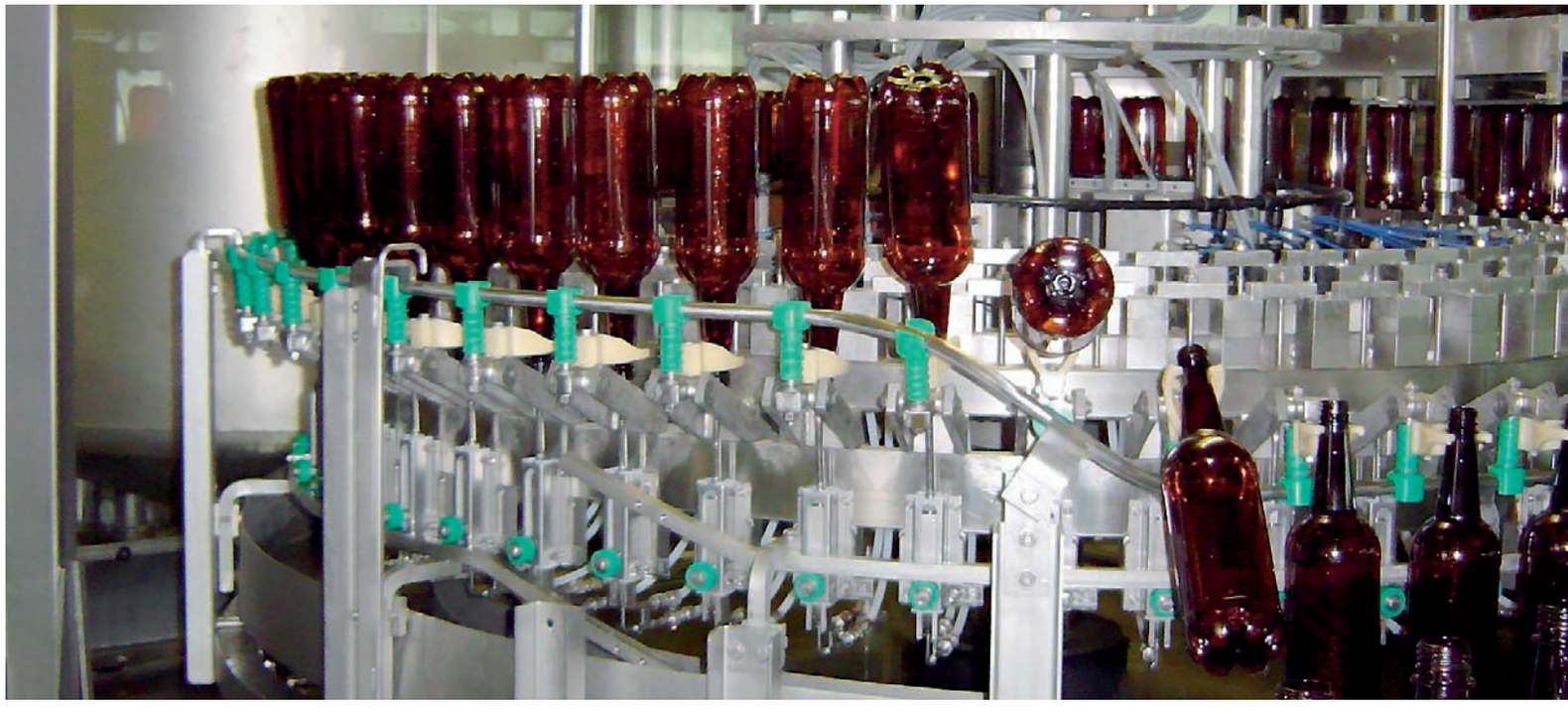
With reference to the above facts, we can claim that the development of new materials has been focused on the implementation of PET barrier characteristics lately because the standard PET plastic bottles without additives are only suitable for bottling less oxygen-sensitive beverages, such as water, lemonade and cola drinks. For oxygen-sensitive beverages, including beer, it is very important to reduce the permeability of the material, which can be achieved in several different ways, of which the following three methods are important: barrier masses, coating and multilayer technologies.

Method of barrier masses

This method is based on the principle of passive barriers that can retard gas permeability through the material. They can be used like monomaterial with added PET (blends) or can act like a special layer in multilayer plastic bottles. PEN has been considered the most effective monomaterial (polyethylene naphthalate) because of its more favourable barrier characteristics than pure PET (up to five times less oxygen and carbon dioxide permeability) – it is more durable when exposed to high temperatures, although it has not been commercially successful due to its high cost (up to three times more expensive). PET/PEN copolymers are more common in practice.

PET plastic bottles with barrier coatings (monolayer plastic bottles)

Coating methods can be divided into two categories: first, the methods which involve vacuum or plasma routes to deposit extremely thin films of organic (ethylene vinyl alcohol – EVOH, polyvinylidene chloride – PVDC, epoxy amines, polyamides – nylon) or inorganic material (amorphous carbon or glass silicon dioxide) as passive barriers on the inner or outer



surface of a blown plastic bottle; and second, methods which are based on the atomised spraying of liquid organic materials onto the external surfaces of the plastic bottle (this method has not been commercially accepted). In the beverage industry, the method of inner plasma coating involving inorganic materials has been most popular. Both carbon and silicon dioxide allow good barrier protection against oxygen and carbon dioxide, and since they are applied to the inner surface of plastic bottles, they do prevent the oxygen dissolved in the PET matrix from migrating into the beverages (beer) within the first several weeks of storage.

Multilayer technologies

In order to improve PET packaging permeability characteristics, the use of multilayer technology has already proved itself a perfect alternative. A particular material is used as an independent layer in a multilayer structure, i.e. a sandwich method where the inner layer is enclosed by additional layers of some other material (PET and other polymers) – up to seven-layer plastic bottles have already been introduced (three-layer plastic bottles have been used in beer bottling). These layers come together as manufacturing preforms for plastic bottles and play a role in protection against gas permeability. Such materials based on EVOH, PA and PEN were found to be good passive barriers, proving themselves to afford protection from the loss of carbon dioxide from beverages, but less effective against oxygen penetration. For this reason, different manufacturers developed the combination of inner chemically active and outer passive (physical) barriers. The function of the inner active barrier is to absorb oxygen that penetrates through the plastic bottle before it reaches the end product (e.g. beer) – together with the already present oxygen in the headspace of the plastic bottle and the oxygen which is in the end product itself, the total oxygen content is reduced. These materials are given the common name "oxygen scavenger". In fact, they all are polymers that are not stabilized against oxidation and that start to decompose when they are in contact with air. Therefore, it is very important to have a good passive barrier which allows as little oxygen as possible to enter the bottle, depending on time, temperature and relative humidity of the storage environment. Along with a rise in temperature, oxygen permeability rises too, thus the scavenger material is used up more rapidly. The combination of good passive protection and at least 1% active protection is the best solution.

Besides the previously mentioned problems with gas permeability through the material, another disadvantage of plastic bottles is their inability to be heated (pasteurisation difficulties) as the result of deformation caused by high temperature and thus physical instability. Preevacuation with CO_2 is not possible either, to the same degree as with glass packaging, which may lead to higher initial oxygen values. In comparison with glass, plastic bottles have lower solidity. For this reason, closing the plastic bottles causes problems as well.

Bottle closures

In addition to making the right decision about the material which plastic bottles are made from, the same importance holds true for closure material and type, since all components are a significant factor in oxygen intrusion and, consequently, self-life. At the moment, there are different possibilities being offered on the market, such as plastic (HDPE or LDPE) screw closers or aluminium ones, crown corks and so-called ring-pull closures, all having both good and bad aspects. The main advantage of the most commonly used plastic screw closures is the possibility of reclosing the bottle; however, the average one-piece screw cap is highly gas permeable. A two-piece cap has a separate insert or liner to improve the seal on the neck of the bottle. For oxygen-sensitive beverages (beer), the liner can also be made from a gas barrier material or an oxygen scavenger material (or both) to remove oxygen from the bottle headspace and improve the barrier performance of the cap. Similar characteristics also obtain with aluminium screw caps (they always require a liner); however aluminium caps may damage the plastic bottle when closing it.

Crown corks are the most widespread form of glass packaging closure, owing to good price and low gas permeability; however, they cannot be used to close plastic bottles since the high pressure involved in the capping head might damage the bottle. Reclosing is not possible either. On the other hand, ring-pull scavenger caps have been recognised as extremely attractive, as they require lower capping power than corks and no damage to plastic bottle necks have been reported. Unfortunately, they are not reclosable and may injure the user (cuts). Thus, it is more or less up dependent on consumer requirements which type of closure should be used and, of course, to our own packaging possibilities.

PET filling systems

Modern technology has made PET filling quite a simple procedure, with high bottling velocity and only a small group of employees required. At Pivovarna Laško, d.d. the filling capacity of the line is 12,000 plastic bottles per hour with only five line operators. The line capacity is more or less determined by the capacity of the stretch blow-moulding unit. From this step on, the plastic bottles are transported by air transport to the filling unit. In our company, a safer method of filling has been used, which involves rinsing the plastic beer bottles in a rinser unit. In order to avoid

undesired oxygen intrusion, the rinsing is carried out with degassed water.
Filling PET packaging can be performed in various ways: by fixed volume, fixed weight or a required level inside the plastic bottle. The first and last systems have come into use mostly, but both have their advantages and disadvantages. Volume filling enables precise filling and is more appropriate for plastic bottles of large diameter, in which 1 to 2 mm of level difference can mean higher losses. This system of filling has been well used in filling cans.
Since plastic bottles have not been physically stable enough to permit preevacuation with CO_2 and, consequently the reduction of oxygen in the plastic bottle, the method of rinsing with CO_2 under atmospheric conditions has become more common with beer filling in PET packaging. The classic system of level filling involving short tubes, which is used with glass packaging, enables low oxygen values including additional rinsing with carbon dioxide. In the case of double preevacuation of 0.5 l glass bottles, about 260 g CO_2/hl of beer is used, while in case of the average filling system involving short tubes and no preevacuation, as much as 3000 g CO_2/hl of bottled beer is used in filling 0.5 l plastic bottles. As the result of the large CO_2 consumption, it was necessary to develop new filling systems. One such system is level filling with long tubes and this has already been implemented at Pivovarna Laško, d.d. In fact, the system is based on filling from the bottom to the top of the plastic bottle without preevacuation. We are able to achieve extremely low values of charged oxygen (from 0.02 to 0.03 mg/l), and the use of rinsing CO_2 is lower than in the classic system (up to 700 g CO_2/hl of beer).

Testing procedures in Pivovarna Laško,d.d.

In our company, initial tests were carried out with various monolayer blend materials. Tests were performed by comparing these bottles with bottles made from 100% PET without any additives as the least inert packaging and glass packaging as the packaging with the lowest gas permeability. Ring-pull scavenger caps were use on the samples, except on the glass samples, where common crown corks were used. For all samples we used the same beer type and rank. The particular ratios between materials turned out to act as an extremely sufficient gas barrier, but some specific reactions between the layers (barriers) has occurred, which affected the final stage of beer sensority drastically. However, only an expert would be able to notice any modification of the characteristics of pale beer when the content of oxygen exceeds 1 mg/l.
When repeating the testing procedures we focused mainly on the plastic bottles. Taking into account all PET packaging and the beer characteristics listed, we decided on multilayer plastic bottles produced by a recognized manufacturer with an integrated active layer and equipped with plastic scavenger closures (active layer made of sodium sulphite) as the subject of our further testing. Filling conditions and beer characteristics were kept unmodified. With the use of these materials we managed to achieve more than a six-month shelf life. No significant organoleptic modifications of the beer were detected during this time.

Conclusion

A major step in PET packaging development has been taken lately in order to meet beverage company and consumer expectations. Both segments require as long a shelf-life as possible, in which the main role is played by the stability of the organoleptic properties of the beverages as the result of decision-making about the appropriate plastic bottles and closure material as well as the proper system of filling. Now it is the consumer's turn to decide on the suitability of beer in plastic bottles and, of course, both price and tradition will be important factors in this decision.

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