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PACKAGING REDUCTION TO IMPROVE THE SUSTAINABILITY OF CARBONATED SOFT DRINKS

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ABSTRACT

The popularity of carbonated soft drinks is mainly due to the refreshing taste which, in turn, depends on their flavour and on the carbon dioxide content. The shelf life of carbonated soft drinks is primarily correlated with the retention of carbon dioxide inside the PET bottle, hence with its barrier properties, however, other quality parameters, such as the volatiles content, should be taken into account and monitored in order to guarantee the consumers with the highest quality at every stage of the product commercial life. Considering the high incidence of packaging material on the final product, both in terms of cost and of environmental impact, the reduction of the bottle thickness could play a significant role in the overall improvement of the sustainability in the industry of soft drinks. Sibat Tomarchio s.r.l. is committed with the improvement of sustainability of productions and has decided to evaluate lighter preforms for bottling two of its core-products: Aranciata, containing 12% juice from Sicilian oranges, and Verdello, with 17% juice from Sicilian lemons. Tests on the CO_2 retention performances are performed at every change (design, volume, material, etc.) occurring in the bottle, however this parameter has been considered as the only representative of the overall quality loss of carbonated soft drinks, while the aroma composition has not received sufficient attention. The research aimed at assessing alternative preforms to the one actually in use. One standard preform (clear, 34 g) was compared with two alternative ones (clear, 32 g and coloured, 32 g). During 6 months the samples were subjected to CO2 retention test, analysis of aroma profiles by HS-SPME-GC, and sensory analysis. Results demonstrate that it is possible to improve the sustainability of carbonated soft drinks by selecting lighter preforms, through shelf life studies based on the main quality parameters, supported by sensory analysis.

Keywords: PET, carbonation, aroma, shelf life, packaging reduction

1. INTRODUCTION

PET bottles are characterized by some permeability to CO_2, which affects the shelf life of the packaged carbonated soft drinks. Indeed, the bottle material performances, with special regards for barrier to CO_2, play a major role in the shelf-life extension. In order to guarantee the consumers with the original characteristics and quality of PET-packaged beverages, companies select appropriate preforms through the verification of the bottle CO_2 retention performances (CORIOLANI *et al.*, 2006; LICCIARDELLO *et al.*, 2011). This determination is what companies usually do routinely and each time they consider alternative preforms. Together with the CO_2 concentration in the beverage, the aroma composition is an important quality attribute that should be taken into account in order to guarantee the highest global quality during storage. The aim of the study was to evaluate the possibility to reduce the preform weight for 1.5-litre PET bottles without compromising the shelf life standards. Since packaging is the main hotspot for most environmental impacts in the carbonated soft drinks sector (AMIENYO *et al.*, 2013; MANFREDI and VIGNALI, 2015), the reduction of PET weight would represent a significative improvement for the sustainability of such production.

2. MATERIALS AND METHODS

A comparative shelf life test was carried out during 6 months for two products, namely Aranciata (orange-based soft drink) and Verdello (lemon-based soft drink). Each product was bottled using three different preforms: a 34-gram clear preform, considered as control, a 32-gram coloured preform and a 32-gram uncoloured one. All PET preforms were supplied by Plasco s.p.a. (Anagni, FR, Italy) and formed into 1.5-litre bottles following a consolidated industrial process. Bottle forming and filling was carried out at Sibat Tomarchio s.r.l (Acireale, CT, Italy). The gas level at bottling was 6.7 g/l for Aranciata and 6.5 g/l for Verdello, and gas measurements were carried out at definite time intervals using an aphrometer (Alca Impianti s.r.l., Bolgare, BG, Italy) on three replicate bottles for each product and preform. Volatiles profiles by HS-SPME-GC-MS, using a CAR/PDMS fibre, and sensory parameters were determined on two replicate bottles for each product and preform.

3. RESULTS AND DISCUSSIONS

The CO_2 level (Fig. 1) revealed a constant decrease during storage time, this change being independent from the packaging type. Since the CO_2 level is regarded as the main quality parameter in carbonated beverages, it can be inferred that different preforms guaranteed the same shelf life standards, irrespective of weight. Two typical chromatograms, one for each of the two soft drinks object of the study, are reported (Figs. 2 and 3). Concerning the orange-based beverage, the volatile composition is characterized by the presence of limonene, which alone represents around 70% of the total compounds, followed by β-ocimene, terpinolene, α-terpineol, neryl acetate, geranyl acetate, β-caryophyllene, α-bergamotene and bisabolene. Minor amounts of aldehydes, esters, terpenes and sesquiterpenes also contribute to the formation of the overall aroma. Concerning the lemon-based beverage, limonene, g-terpinene and decanal prevail, followed by terpinolene, linalool, myrcene and minor amounts of other volatiles. Overall, the volatile composition of the two soft drinks did not change significantly during storage time.

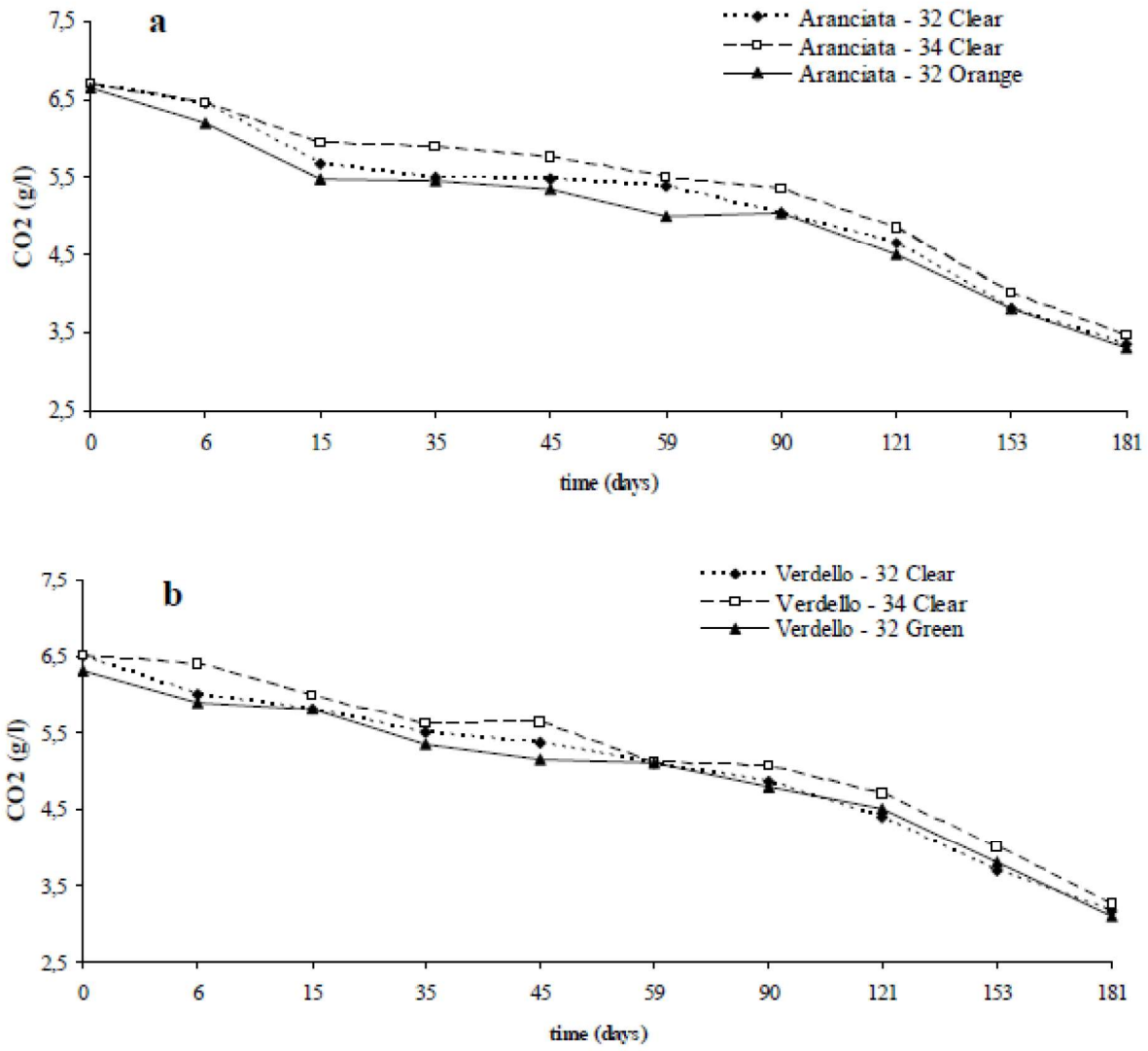

Figure 1: Variation of the CO_2 concentration in orange (a) and lemon-based (b) soft-drinks, as affected by preform and storage time.

Moreover, the volatile profiles among the three packaging types did not show significant differences for neither of the two beverages.

Sensory analysis demonstrated that the descriptors subjected to variation were those related with the CO_2 content: amount of bubbles and fizzy for the orange-based product, fizzy and off-flavour for the lemon-based one. Indeed, a reduction in the CO_2 level was registered, as expected, and this change was perceived by the judges.

Results for the CO_2 level, supported by data on the aroma composition and by sensory evaluation, demonstrate that it is possible to reduce the PET bottle weight by 2 grams without compromising the bottle performances. Being that packaging is among the most relevant environmental burdens for carbonated soft drinks (AMIENYO *et al.*, 2013; MANFREDI and VIGNALI, 2015), it can be concluded that the adoption of a lighter bottle

allows to reduce the environmental impact of packaging on the finished product, still guaranteeing the shelf life standards of the produce.

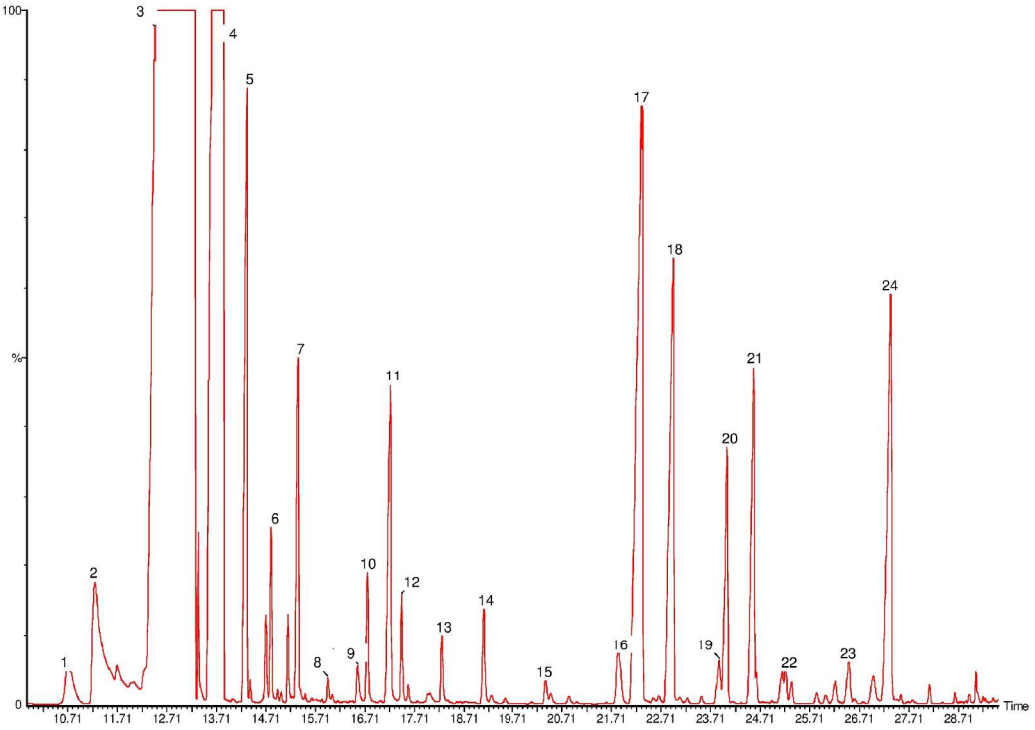

Figure 2: Typical chromatogram for an orange-based carbonated soft drink. 1: β-pinene; 2: myrcene; 3: limonene; 4: β-ocimene; 5: terpinolene; 6: nonanal; 7: methyl octanoate (internal std); 8: β-terpineol; 9: verbenol; 10: terpinen-4-ol; 11: α-terpineol; 12: decanal; 13: neral; 14: geranial; 15: undecanal; 16: citronellyl acetate; 17: neryl acetate; 18: geranyl acetate; 19: dodecanal; 20: β-caryophyllene; 21: α-bergamotene; 22: trans-β-farnesene; 23: valencene; 24: bisabolene.

Table 1: Mean scores of the significant sensory attributes for the orange-based beverage. Values marked with different letters in the same row are significantly different ($p \leq 0.05$) according to the LSD multiple comparison test.

		Days of storage					
Attributes	**Samples**	**1**	**7**	**15**	**30**	**90**	**180**
Amount of bubbles	32 Green	7.0^{b}	4.3^{a}	5.4^{ab}	4.5^{a}	5.1^{a}	4.7^{a}
Fizzy		5.5^{b}	2.9^{a}	3.8^{a}	2.5^{a}	3.2^{a}	2.3^{a}
Amount of bubbles	32 Clear	7.0^{b}	4.6^{a}	5.1^{a}	4.9^{a}	5.6^{ab}	4.5^{a}
Fizzy		5.5^{b}	4.0^{ab}	3.6^{a}	3.0^{a}	2.5^{a}	2.5^{a}
Amount of bubbles	Control	7.0^{b}	4.3^{a}	5.5^{ab}	5.0^{a}	5.9^{ab}	5.0^{a}
Fizzy		5.5^{b}	3.2^{a}	3.5^{a}	2.5^{a}	2.4^{a}	3.1^{a}

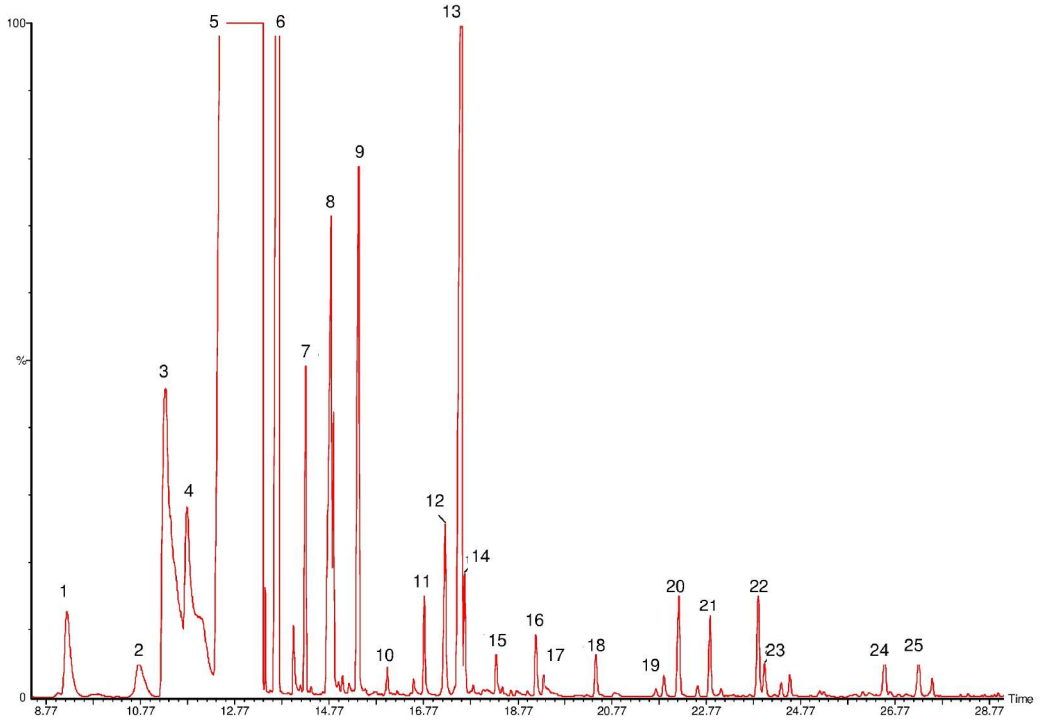

Figure 3: Typical chromatogram for a lemon-based carbonated soft drink. 1: phellandrene; 2: β-Pinene; 3: myrcene; 4: octanal; 5: limonene; 6: γ-terpinene; 7: terpinolene; 8: linalool; 9: methyl octanoate (internal std); 10: β-terpineol; 11: terpinen-4-ol; 12: *α*-terpineol; 13: decanal; 14: octyl acetate; 15: neral; 16: geranial; 17: peryllaldehyde; 18: undecanal; 19: citronellyl acetate; 20: neryl acetate; 21: geranyl acetate; 22: dodecanal; 23: β-caryophyllene; 24: valencene; 24: bisabolene.

Table 2: Mean scores of the significant sensory attributes for the lemon-based beverage. Values marked with different letters in the same row are significantly different ($p \leq 0.05$) according to the LSD multiple comparison test.

		Days of storage					
Attributes	**Samples**	**1**	**7**	**15**	**30**	**90**	**180**
Fizzy	32 Green	5.8^{c}	4.0^{ab}	5.1^{bc}	3.6^{ab}	4.0^{ab}	2.5^{a}
Off-flavour		3.4^{bc}	2.8^{abc}	1.7^{a}	2.2^{ab}	1.4^{a}	4.0^{c}
Fizzy	32 Clear	5.8^{c}	4.2^{b}	4.3^{bc}	3.5^{ab}	3.8^{b}	2.2^{a}
Off-flavour		3.4^{b}	2.7^{ab}	1.7^{a}	2.0^{ab}	2.3^{ab}	3.5^{b}
Fizzy	Control	5.8^{b}	4.4^{ab}	4.5^{ab}	3.5^{a}	3.8^{a}	3.0^{a}
Off-flavour		3.4^{b}	2.5^{ab}	1.9^{a}	2.1^{ab}	1.9^{a}	3.2^{ab}

4. CONCLUSIONS

A comparative shelf life test on two carbonated beverages performed with different preforms demonstrated that the PET bottle weight can be reduced by 2 grams without affecting the shelf life standards of the produce, neither in terms of CO_2 retention, nor volatile composition. Studies aimed at assessing alternative bottles are crucial for the improvement of sustainability of carbonated beverages, since packaging represents the main factor affecting environmental impact in this specific industrial sector.

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