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Effects of PET packaging on the quality of an orange juice made from concentrate

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ABSTRACT

An orange juice made from concentrate was conditioned in three different PET (PolyEthylene Terephtalate) and glass packagings. Influence of storage conditions (length of storage, light, oxygen) on vitamin C content, browning index, and colour were measured. Results show that permeability to oxygen of PET packagings is the major factor detrimentally affecting the above parameters.

Key words: orange juice made from concentrate, quality, PET packaging, oxygen permeability, vitamin C, browning.

INTRODUCTION

Orange juice is the most important fruit juice in the world of which 90% is made from frozen concentrate. The food and drink industry is currently looking for suitable raw materials and packaging to improve quality and shelf life of the products. Plastic packaging is increasingly used for economic reasons and the most widely used is PET (polyethylene terephtalate). However, it is known that PET has oxygen permeability and can absorb some flavour compounds from the food matrix (1). Furthermore, shelf life is also reduced by degradation of the juice through Maillard reactions on vitamin C that occur whatever the considered packaging and are believed to be responsible of non-enzymatic browning (2).

Developments of new PET technologies as multilayer PET tend to decrease the permeability to oxygen of the material in order to maintain quality of the juice. One aim of this study was to investigate to which extent quality of the juice and permeability to oxygen of the plastic material are linked.

Quality of orange juice depends drastically of the vitamin C content; so it is important to find the best storage conditions to maintain quality. It is well established for instance that negative temperatures allow a slower degradation of vitamin C (2). The effect of light on vitamin C losses has been investigated contradictory. Ahmed *et al.* (3) show that these losses increase with light exposure whereas no influence was found by Solomon *et al.* (4).

In the present study, the effects of length of storage, light exposure and permeability to oxygen of different plastic packagings were investigated on vitamin C content, browning index, and colour in orange juice made by concentrate.

MATERIALS AND METHODS

Packaging materials
Three different PET packagings were used: standard monolayer (PET 1), multilayer (PET 2), and plasma-treated (internal carbon coating) (PET 3). Plastic bottles (0.33 L) were closed after filling with aluminium lids. Glass bottles (0.5 L) were also used as reference conditioning; they were closed after filling with aluminium lids. The headspace volumes were of 20 mL for plastic bottles and 30 mL for glass bottles, respectively.

Preparation of orange juice made from concentrate
An orange juice was prepared by initially mixing an orange juice concentrate from Brazil (60°Brix) with an orange juice oil fraction before diluting with water to 11.5 °Brix. It was then supplemented with an orange juice aqueous essence before homogenisation and degassing with nitrogen. The reconstituted juice was then flash-pasteurized for 20 sec at 92°C then aseptically bottled in different packaging materials.

Storage
Bottles were stored at room temperature (20°C), either under artificial light (NS for normal storage), or in the dark (DS for storage in the dark), or immersed under water under artificial light (WS for storage under water).

Oxygen permeability
Permeabilities of the different PET packagings were measured by an OX-TRAN® 2/20 system (Mocon, USA) at zero time. Plastic bottle was stuck on a support then swept by nitrogen during 16 hours, then during 30 min oxygen entering into the bottle was transferred to a coulometric detector and converted into an oxygen flow (UA = cm^3 / 24 h / bottle).

Vitamin C analysis
Vitamin C contents were measured using 2,6-dichloroindophenol titrimetric method (5). Each analysis was performed in triplicate on 3 different bottles from the same batch.

Browning index
Browning was measured at 420 nm on centrifuged (2000 g, 15 min), filtered (0.45 μm, Millipore, USA), then 2 × diluted (distilled water) reconstituted orange juice (2). Each measure was performed in triplicate on 3 different bottles from the same batch.

Colour
L*, a*, and b* values were measured with an X-Rite 3200 colorimeter. Each measure was performed in triplicate on 3 different bottles from the same batch.

RESULTS AND DISCUSSION

Oxygen permeability of the different plastic materials
The permeability to oxygen of (PET 1), (PET 2) and (PET 3) were 0.0318, 0.0029 and 0.0028 UA, respectively. (PET 1) was 10 × more permeable to oxygen than (PET 2) and (PET 3), which were almost equal.

Evolution of vitamin C contents during shelf life
At zero time, juice had an usual vitamin C content of 383 mg/L (Table 1). After 2 and 3 months of normal storage (NS) in (PET 1), vitamin C decreased by ~39% and ~43%, respectively (Table 1 and Figure 1). Under same storage conditions, losses observed in (PET 2) and (PET 3) were lower and similar (~29%) whatever storage duration. The glass bottles were found to be most efficient in protecting vitamin C since only ~18% and ~24% were lost after 2 and 3 months of normal storage.
These data show that losses in vitamin C were partly related to oxygen permeabilities of the different packagings : (PET 1), having the highest permeability, showed the highest losses while (PET 2) and

(PET 3) which have similar permeabilities exhibited similar losses for vitamin C. Losses observed in glass bottles were attributed to oxygen present in the bottle headspace and in the reconstituted juice.

Table 1. Vitamin C (mg/L +/- 10 mg/L) contents of the initial juice (zero time) and storage-aged samples under normal storage (NS), storage in the dark (DS), and storage under water and artificial light (WS) (n=3).

packaging material	zero time	2 months (NS)	3 months (NS)	2 months (WS)	3 months (DS)
glass	383	314	290	-	304
(PET 1)	383	235	220	250	224
(PET 2)	383	272	270	282	259
(PET 3)	383	276	271	302	264

After 2 months of storage under water (WS), losses were of ~35, ~26 and ~21% for (PET 1), (PET 2) and (PET 3), respectively. When compared with 2 months of normal storage, losses measured in juices stored under water were by 3-8% lower. Thus limitation of oxygen diffusion by immersing the bottles would have had a limited positive effect. Storage in the dark for 3 months had not positive effect when compared with 3 months of normal storage, losses being almost identical.

These results show that use of plastic packaging with good oxygen barrier properties had impact against vitamin C losses.

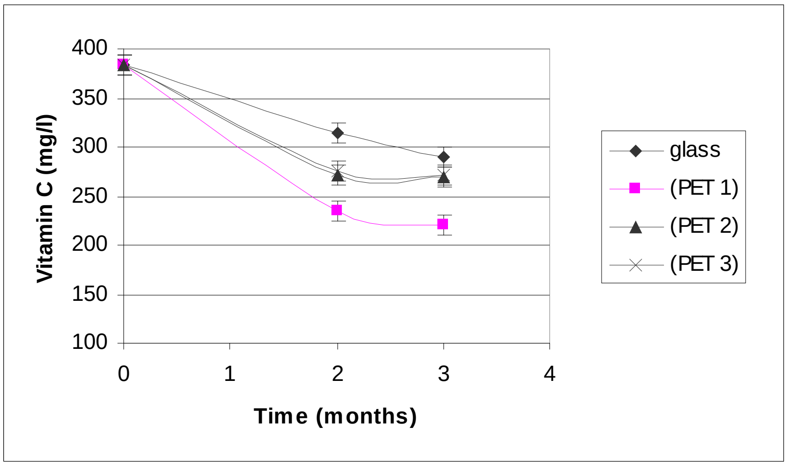

Figure 1. Evolution of vitamin C content in orange juice made from concentrate

Browning index

At zero time, absorbance at 420 nm was 0.33 (Table 2). After 2 months of normal storage, the browning index of all juices increased (Table 2 and Figure 2); for bottles stored for the same time under water, the increases were the same as under normal storage conditions. After 3 months, one can notice a decrease of the browning indexes, the ordering of packagings being the same as in the case of vitamin C losses: glass conditioning being the most favourable while (PET 1) being the most detrimental. This lowering of the browning indexes after 3 months following an increase after 2 months remains difficult to explain.

The same ordering was observed for juices stored in the dark however a non-browning was observed in glass bottles.

Table 2. Absorbance at 420 nm (+/- 0.05) of the initial juice (zero time) and storage-aged samples in normal storage (NS), storage in the dark (DS), and storage under water and artificial light (WS) (n=3).

packaging material	zero time	2 months (NS)	3 months (NS)	2 months (WS)	3 months (DS)
glass	0.33	0.43	0.35	-	0.33
(PET 1)	0.33	0.48	0.43	0.49	0.41
(PET 2)	0.33	0.49	0.38	0.47	0.37
(PET 3)	0.33	0.46	0.38	0.44	0.35

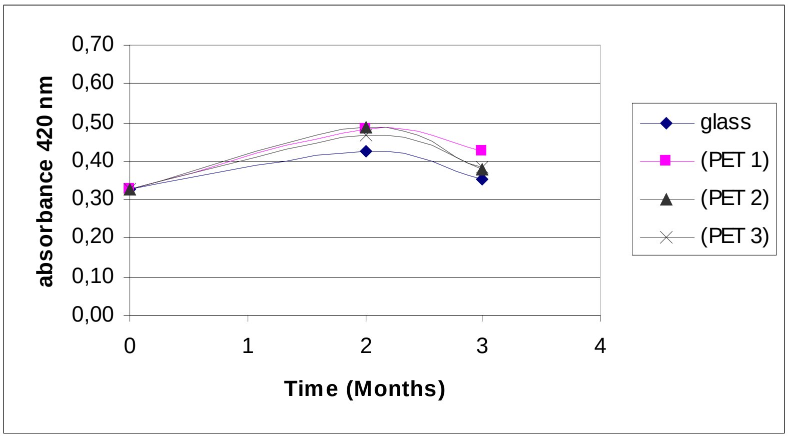

Figure 2. Evolution of the browning index in orange juice made from concentrate

Colour

Figures 3 and 4 show the evolutions of L*, a* and b* values of our juice samples. L*, an indicator of lightness, showed no significant changes during 3 months of normal storage. Lee and Nagy (6) also showed no variations in the L* value during storage of a grapefruit juice for 5 months at 20 °C.

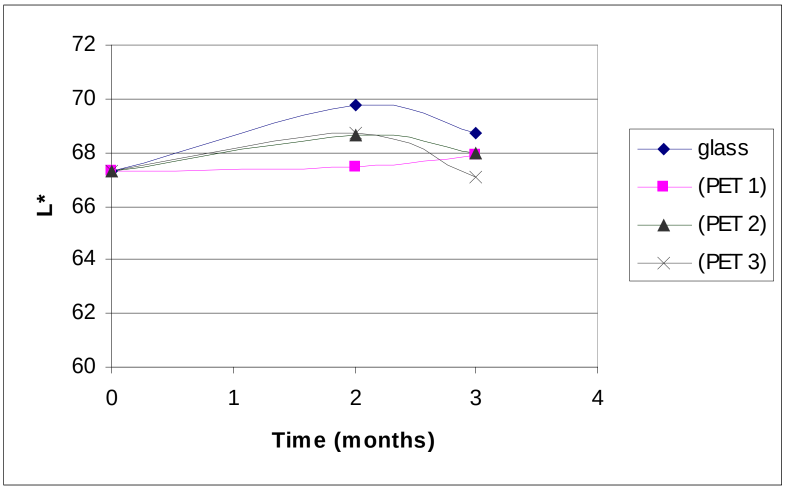

Figure 3 : Evolution of L* value in orange juice made from concentrate during normal storage (NS)

The more characteristic evolutions are, whatever the packaging, an a* increase and a b* decrease. Positive Δa^* indicates that the juice is redder than green and negative Δb^* indicates that the juice is bluer than yellow. These results are in agreement with the formation of brown pigments and the loss of the yellowness of the initial juice.

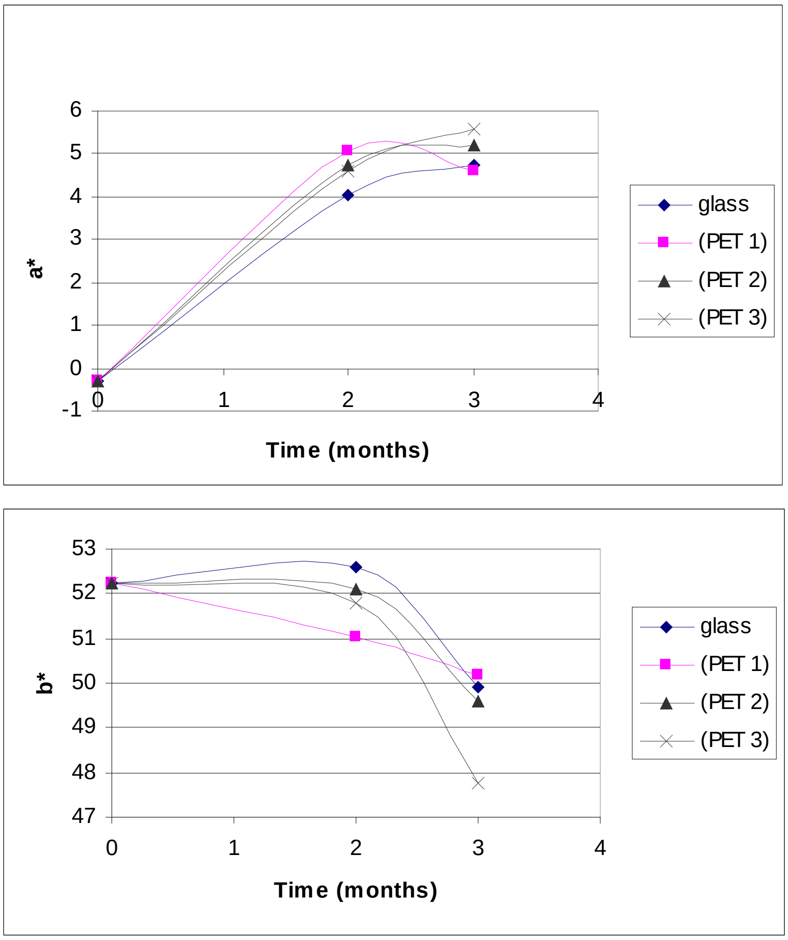

Figure 4. Evolutions of a* and b* values of orange juice made from concentrate

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CONCLUSION

In comparison with standard PET, multilayer or internal carbon coating PETs with good oxygen barrier properties show better vitamin C contents after 3 months of storage. Flavour compounds, as well as vitamin C, play a major role on quality of orange juice. Future studies will investigate the influence of plastic packaging on the preservation of organoleptic quality during shelf life.

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