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EFFECT OF PACKAGING MATERIALS ON QUALITY OF ORANGE JUICE

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ABSTRACT

Refrigerated orange juice was packed in four different refills, three of them made of cardboards with different composition and the fourth from polyethylene terephthalate transparent. The four refills were stored at 4 °c for 75 days, during the storage of juice, changes in the headspace gas composition, vitamin C, and color. In addition , the sensory evaluation of arbitrators for both color, flavor and unwanted odors. Experimental data indicated that the deterioration of orange juices (ascorbic acid degradation and darkening of color) was triggered by the rise in oxygen in the headspace of the storage refills. The type of refill played a predominant role in determining the juice quality, with carton refills with an inner layer of aluminum foil providing the juices with the best quality throughout their storage.

INTRODUCTION

Consumers purchase a product based mainly on their perception of the product quality and the relationship price / quality (Thai and Shewfelt, 1991).

One the other hand, fruit juices and beverages must be handled carefully during processing and storage to control nutrient losses and color changes. Ascorbic acid (AA) is an important nutritional component of many juice products, and the label AA content per-serving must be valid throughout the produce shelf life (Will *et al*., 2000) Numerous complex factors, including the protection provided by the container, affect AA loss in foods, and the kinetics of the degradation appears to be dependent on the specific processing system (Shakpo and Arawande, 2011). AA degradation is also associated with nonenzymatic browning (Lee and Nagy, 1996).

For these reasons, selection of the packaging materials is one of the basics of the food industry because of their influences on the quality of foods during storage. The permeation through them and the degradation of color and nutrients by oxygen transmission through packages have been an increasing area of research (Sharma and Dinesh, 2010).

The interiors of preformed board cartons are composed of differnt barrier materials depending on the nature of the food to be packed. For example, aluminum cartons are used for fruit juices while those coated with polyethylene are primarily for products such as milk (Lee and Nagy, 1996). Increasingly, ready - to - serve beverages are packaged in different kinds of packing materials such as polyethylene terephthalate (PET), polyethylene napthalate (PEN) and cardboards. Exposure to light and/or oxygen content (headspace and/or dissolved) may be a degradative factors for some beverages packaged in transparent cartons (Sahbaz and Somer, 1993 ; Main *et al*., 2001 ; Hillier *et al*., 2012) , but no information is available on the effects of carton materials on mandarin juice .

Due to the importance of vitamin C for humans and its sensitivity with respect to light, high temperatures, and oxygen ascorbic acid retention is often regarded as a significant marker of overall nutrient recovery (Jung *et al*., 1995). To preserve the ascorbic acid content, it is possible to act on food processing (by means of mild technologies) and packaging. The use of high barrier containers could be effective against oxidative degradation of ascorbic acid and be able to slow down browning phenomena (Kebeda *et al*., 1998).

The main objective of this study was to compare the color properties, AA degradation and changes of gas composition in the headspace of refrigerated orange juice stored in four different refills. In addition, the sensory evaluation of the number of arbitrators for both color , flavor and unwanted odors in the juices. Results from this study will allow to make recommendations on which refill is the best for refrigerating orange juices.

MATERIALS AND METHODS

Orange (Baladi variety of season, 2012*)* were all grown under in identical conditions of soil, irrigation and illumination in citrus processing plant at Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

The fruits were collected in winter (January 2012*)* and these cultivars were selected based on their maturity (All experiments were done at the laboratories of the Food Technology Research Institute).

The juice was obtained using a Premium Juice Extractor (FMC corporation , vero Beach, FL 2004). A total of 20.000 L of juice was prepared, thus, four different batches of 5.000 L was prepared for each treatment (packaging materials). All analyses were carried out in each one of the four different batches belonging to each treatment (packaging material).

The juices were processed under aseptic packaging and thermal treatment of pasteurization (86 °c / 20 s). These juices were packaged in four different refills consists of ; -1- Tetra pak; outside polyethylene layer 13.5% + cardboard 27% + aluminum foil for Inner layer 59.5% (I) -2- Elopak ; outside polyethylene layer 7% + cardboard 38.5% + aluminum foil for inner layer 54.5% (II) -3- Combibloc container ; outside polyethylene layer 4.5% + cardboard 76% + Ethylene vinyl alcohol copolymers 19.5% (III) -4- PET bottle , polyethylene terephthalate (IV) . The first three containers are nontransparent plastic refills and the last is transparent plastic refills, and all of them were stored under refrigeration (4 °c) conditions. The juice samples were analyzed on days 0, 15, 30, 45, 60 and 75 (end of storage period).

Ascorbic acid determination :

Ascorbic acid determination was performed according to the 2.6 – dichloroindophenol titrimetric method *(*AOAC, 1990*)*.

Colour measurment :

Optical density measurement (color intensity) of the four packaged juices was determined at 474 nm wave length (as B - cartone) using UV spectrophotometer (Becman DU- 600). The total carotenoids yield and degradation index (DI) during storage were determined by the

spectrophotometric differential method of *(*Bower and Baxter, 2000*)*. Color measurement were carried out every 15 days.

Headspace Oxygen Content :

Oxygen production was measured in the juice containers by extracting 1 ml of the headspace using a gas syringe , and oxygen was quantified using a shimadzu model 14A gas chromatograph (Kyoto , Japan) equipped with a thermal conductivity detector and a stainless steel column . The column temperature was 55°c, and the injector and detector temperatures were 110 °c. Results were expressed as percentage of oxygen in the headspace atmosphere (Berlinet *et al*., 2003 *)*.

Sensory Evaluation :

Sensory evaluation (hedonic tests) was used to determine the color and flavor acceptability of the orange juices. Twenty consumers were recruited with a small advertisement in Giza, All of them between 18 and 40 years of age.

Orange juice samples sorted under refrigeration in different refills were given to consumers for sensory evaluation at 0,15,30,45,60 and 75 days of the intensities of different organoleptic attributes : color , fresh orange flavor (impressions perceived via the chemical senses from a juice in the mouth) and off–flavors (impressions of nontypical or expected aromatics from a juice in the mouth) . Assessors were trained to rinse their mouths with water and wait at least for 2 min between samples.

The consumers participated in a ranking test in which the samples of orange juice should be stored out according to their preference for their color and flavor (the subjects) were instructed to assign rank 1 to the sample with a more intense orange color, fresh orange flavor and off – flavors, and 4 to the sample with a less intense orange color, fresh orange flavor and off – flavors. This test was run in triplicate (Meilgaard *et al*., 1999).

All data were subjected to analysis of variance and the Tukey least significant difference multicomparison test to determine significant differences among orange juice samples as affected by packaging materials (Genard and Bruchou 1992*)*. Significance of differences was represent as $P \leq 0.001$. Finally, ranking data were analyzed by a Friedman test (Meilgaard *et al.*, 1999).

RESULTS AND DISCUSSION

Vitamin C

The initial vitamin C concentration for refrigerated orange juices (day 0) was 375 mg/L. The type of refills significantly affected the changes of vitamin C concentration with time (Table 1and Fig 1). At the end of the storage period of orange juices, the juice with the highest vitamin C concentration was (I) 206 mg/L, followed by juice (II) 180 mg/L, juice (III) 70 mg/L, and finally, juice (IV) 59 mg/L. These experimental results proved that the refill type was important for nutritional values as degradation rate of vitamin C.

The experts committee of the European Association of Citrus Juice producers (AIJN) establishes a minimum level of vitamin C concentration (100 mg/L) on orange and mandarin juices that must be maintained throughout the shelf life of these products *(*AIJN, 2005*)* . This minimum content was not reached by juices (I) and (II) after a storage period of 75 days, while it was reached on day 60 and 45 by juices (III) and (IV), respectively. Therefore, the shelf life of the juices was reduced from more than 75 days on juices (I) and (II) and to approximately 60 and 45 days for juices (III) and (IV), respectively.

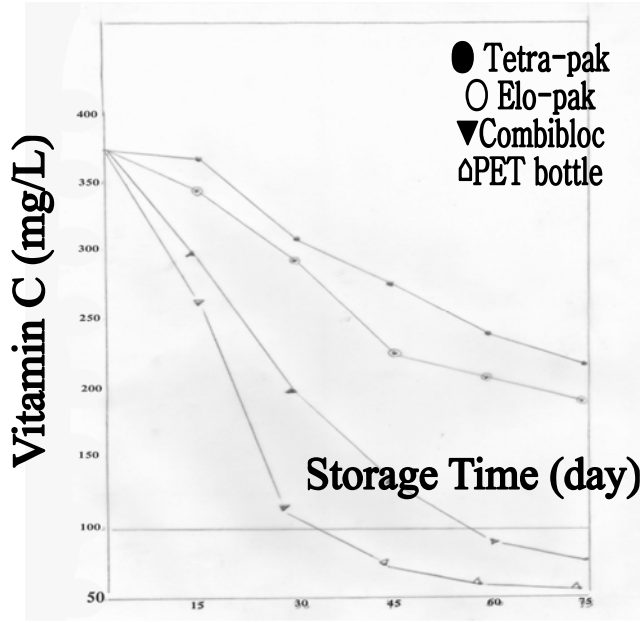

Fig (1)changes of V.C concentration with time in orange juices packed in different refills

The main explanation for the high reductions in the vitamin C content in juices (III) and (IV) is that higher oxygen contents were present in these juices as compared with juices (I) and (II). Ascorbic acid stability is greatly influenced by temperature, oxygen and metal ion-content. (Fennema, 1996 ; Polydera *et al*., 2003*)*.

Table (1): Effect of packaging material on the vitamin C retention of orange juice (mg/1000 ml).

Ascorbic acid (mg / 1000 ml)							
Storage periods / Refills	0 days	15 days	30 days	45 days	60 days	75 days	Ascorbic acid retention(%)
Tetra pak	375	370	325	275	230	206	45%
Elopak	375	340	285	219	203	180	52%
Combibloc	375	300	198	130	91	70	81%
PET bottle	375	264	118	82	65	59	84%

Ascorbic acid in the presence of oxygen and metallic ions will degrade to dehydroascorbic acid (Fennema, 1996*)*. Thus, precautions should be used to minimize ascorbic acid degradation, for instance, removal of as much oxygen as possible from equipment and refill is needed to improve shelf life of ascorbic acid addition as a nutrient.

Headspace Oxygen Content :

Packaging material plays an important role in the quality of foods (Plestenjak *et al.,* 2001*).* The oxygen content in the headspace of the refills was measured throughout the storage period of the orange juices, and experimental results are summarized in Table (2) and Fig (2).

Table (2): Changes of oxygen concentration with time in orange juices filled in different refills.

Oxygen (%)						
Storage period / Refills	0 days	15 days	30 days	45 days	60 days	75 days
Tetra pak(I)	0	0.5	0.70	1.0	3.5	4
Elopak (II)	0	0.5	0.75	1.5	6.0	7.5
Combibloc (III)	0	1.0	3.0	9.0	14.0	18.0
PET bottle (IV)	0	4.0	7.0	15.0	22.0	23.0

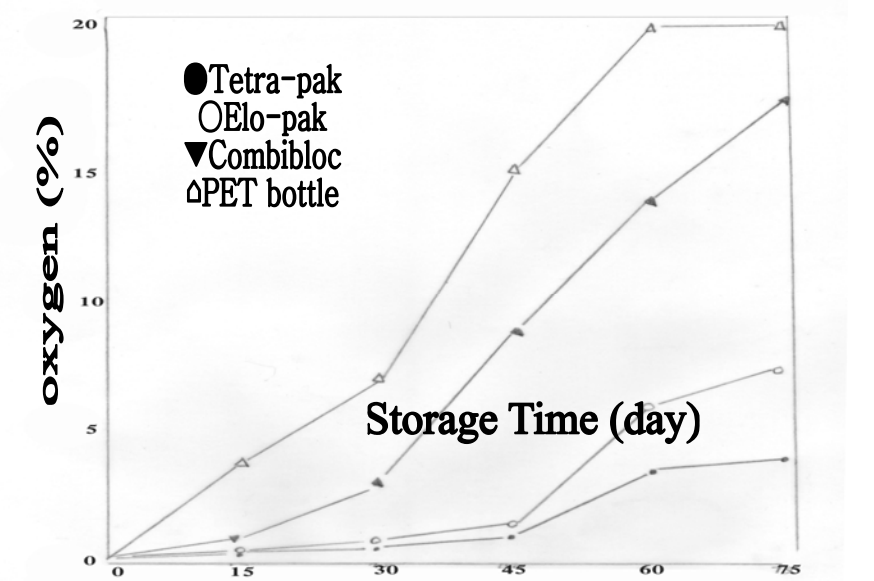

Fig (2)change of oxygen concentration with time in orange juices packed in different refills

The initial oxygen content was zero because during the packaging of the juices, the headspace gasses were displaced using liquid nitrogen (FMC, 2004). Juices (III) and (IV) packed in "carton (III)" and PET , respectively, presented higher oxygen concentrations than refrigerated orange juices (I)

and (II) packed in "cartons" . These experimental results provided a real proof that somehow carton (III) and PET bottle were partially permeable to oxygen; according to our experience, micropores could be present in some of the junctions of the juice (III) package. According to Berlinet *et al.* (2003), it is known that PET has oxygen permeability and can absorb some flavor compounds from the food matrix (Ducruet *et al*., 2001). According to our experimental results, cartons (I) and (II) could be considered as high oxygen barriers, while carton (III) and PET bottle should be considered as intermediate or low oxygen. barriers. In our opinion, the main entrance of air into refill (III) and (IV) must be located in the joints of their upper part.

Color stability

Results in Table (3) showed that the color stability of orange juices was affected during storage by the type of refills, it can be concluded that refrigerated orange juice (I) packed in carton provided the juice with the highest carotenoids and thus providing a high intensity of orange color. The experimental results proved that carton composition was an important quality control parameter in determining the degradation of the initial orange color of the refrigerated orange juices. It seems evident that "carton (I)" provided better experimental results than "carton (II) and (III)" and PET bottle. Regarding the packaged and stored juices, juices (I), (II) and (III), packed in carton, showed a better behavior than juice (IV) paced in PET bottle (Perez-Lopez and Carbonell –Barrachina, 2006).

Once this point is reached, the next question is clear: 1s this instrumentally detected change of orange juice color due to refills type and composition, detected by the regular consumer of citrus juices? (Melendez - Martinez *et al*., 2003).

Sensory analysis :

In each session (there was one session for each sampling there was one session for [0,15,30,45,60 and 75 days]) , consumers were asked to arrange the four orange juices (from four different refills) according to their liking of the sample color , fresh orange flavor and intensity of unwanted odors. Experimental results are summarized in Table (4).

Table (3): Color coordinate changes with time orange juices filled in different carton composition and PET bottles and stored at 4 °c.

Storage periods / Refills	Treatments			
	Tetra pak	Elopak	Combibloc	PET bottle
0	0.47	0.47	0.47	0.47
15	0.43	0.42	0.40	0.38
30	0.40	0.38	0.36	0.24
45	0.38	0.36	0.34	0.21
60	0.34	0.33	0.31	0.17
75	0.30	0.29	0.28	0.12
Reduction (%)	36%	38%	40%	74%

The first sensory attribute to present significant differences among the studied juices was color, after only 15 days , juice (IV) (PET bottle) presented a less intense color than the other refills of the juices . After 30 days both juices (I) and (II) presented a more intense orange color then (III) and (IV)

juices; no significant differences were found between these last two samples (Meilgaard *et al*.,1999).

Fresh orange flavor started to disappear after 30 days of refrigerated storage in juice (IV). After 45 days , both juices (I) and (II) presented significantly higher intensities of fresh orange flavor than juices (III) and (IV) ; this statement was true until the of this study (Genard and Bruchou, 1992).

Table (4): Statistical analysis of the ranking data of color , fresh orange flavor and unwanted odors after 0,15,30,45,60 and 75 days of storage at (4°c) .

Time (day)	refills	Rank sum		
		color	Fresh orange	Unwanted odors
0	I	45	47	49
	II	50	47	48
	III	50	50	47
	IV	51	53	52
	statistics	0.66 N.S	0.54 NS	0.42 NS
15	I	37b	50	50
	II	41b	46	53
	III	54ab	51	49
	IV	65a	50	45
	statistics	15.2 *	0.42 N.S	1.26 N.S
30	I	33b	44b	56
	II	38b	39b	52
	III	62a	50ab	45
	IV	67a	63a	43
	statistics	27.8 *	9.7 *	3.30 N.S
45	I	32b	31b	60a
	II	46ab	36b	58a
	III	57a	58b	42b
	IV	63a	71a	36b
	statistics	18.0 *	31.7 *	12.6 *
60	I	26b	24b	66a
	II	40b	36b	63a
	III	62a	62a	32b
	IV	68a	74a	38b
	statistics	34.2 *	47.6 *	33.5 *
75	I	23c	22b	74a
	II	38c	36b	64a
	III	57b	62a	37b
	IV	78a	76a	21c
	statistics	51.1 *	53.9 *	53.3 *

(20 Assessors ; 4 samples ; T (5% ; 3df) ; LSD rank = 16.0)
Values followed by the same later in column are not* significant differences at p < 0.05.
N.S., not significant differences. L.S.D., Least Significant Differences.
(I)-1- Tetra pak; outside polyethylene layer 13.5% + cardboard 27% + aluminum foil for Inner layer 59.5%, (II) -2- Elopak ; outside polyethylene layer 7% + cardboard 38.5% + Aluminum foil for Inner
layer 54.5% , (III) -3- Combibloc container ; outside polyethylene layer 4.5% + cardboard 76% + Ethylene vinyl alcohol copolymers 19.5%, (IV) -4- PET bottle , polyethylene terephthalate

Finally, 45 days of refrigerated storage was needed in order to find off-flavor (negative aromas) in orange juices (III) and (IV). After 75 days, juices IV presented a significantly higher intensity of unwanted odors than any other juice.

CONCLUSIONS

Orange juice was filled in four different packaging materials, and its quality was studied during 75 days of storage at (4 °c). Experimental results of aluminum foil provided better results than cartons with an inner layer of ethylene vinyl alcohol copolymers and transparent PET bottles. This high quality of orange juice was based on a high vitamin C content (related with lower oxygen content in the headspace of the containers), intense orange color, fresh orange flavor and absence of negative off-flavor.

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تأثير مادة العبوة على جودة عصير البرتقال

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تم دراسة تعبأة عصير البرتقال فى ٣ أنواع من عبوات كرتونية مختلفة التركيب بالاضافة الى عبوة شفافة تتركب من polyethylene terephthalate transparent وتم تخزين هذه العبوات على درجة ٤ °م لمدة ٧٥ يوم وخلال فترة التخزين حدث تغير فى تركيب الغاز فى الفراغ القمى بالعبوات المختلفة وكذلك كمية فيتامين ج ودرجة اللون بالعصير – وتم عمل تقييم حسى بعدد من المحكمين للون والنكهة ، والروائح الغير مرغوبة unwanted odors.

اظهرت النتائج حدوث تدهور فى محتوى فيتامين ج ، دكانة اللون فى عصير البرتقال وكان ذلك مرتبط إرتباط وثيق بزيادة كمية الأكسجين فى الفراغ القمى headspace للعبوات المختلفة – كما أثبتت النتائج أن نوع العبوة له دور مؤثرو واضح فى حفظ جودة العصير أثناء التخزين خاصةاً فى العبوات الكرتونية ذات الطبقة الداخلية من الألومينوم فويل.

قام بتحكيم البحث

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