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Quality and shelf life of pomegranate juice aseptically packed in different packaging materials

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ABSTRACT

Refrigerated pomegranate juice was packed in four different containers; Polyethylene, polyethylene terephtha late bottle, aluminum foil and ethylene vinyl alcohol copolymers and was stored at 4º for eight weeks . During the storage of these juices, changes in the headspace gas composition, vitamin C, and color stability were evaluated. In addition, a consumer panel evaluated the sensory color, fresh pomegranate flavor and presence of off-flavors in the juices. Experimental data indicated that the deterioration of pomegranate juices (ascorbic acid degradation and darkening of color) was triggered by the rise in oxygen in the headspace of the storage containers. The type of container played a predominant role in determining the juice quality. The type of carton container with an inner layer of aluminum foil gave the best results throughout their storage in respect, the quality of the juice.

Key words: Pomegranate juice; packaging; Oxygen; Ascorbic acid; shelf life

Introduction

Pomegranate fruits (Punicagranatum L.) are cultivated in large areas in the newly reclaimed lands and it is one of the important and commercial horticultural fruits which is generally very well adapted to the Mediterranean climate (Biala, 1981) . The last few years have seen a tremendous increase in treading of pomegranate fruits. Perhaps the aspect that has contributed most to the increased demand for pomegranate is its reputed health promoting effects.

Total area of pomegranate fruit grows in Egypt reached about 10175 feddan in 2010 and the annual production is approximately 51150 tons (Anonymous, 2010). The fruit has a red color and medium size, weighing on average. between 175 – 290 gm. Pomegranate fruits are consumed fresh or processed as juice, Jellies and surup for industrial production (Natural juices and/or canned beverages). Besides, it is considered as an excellent source for nutrients and characterized flavor, it is also a good source of the brilliant naturally color called anthocyanins (Botrus *et al.*, 1984).

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

On 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 product shelf life (Will *et al* ., 2000) . Numerous complex factors, including the protection provided by the container, affect AA loss and pigment degradation in juices, and the kinetices 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).

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 Singh, 2013; Siegmud*et al*., 2012; Zerdin*et al*., 2003)

Because of its excellent mechanical properties, its clearness, UV resistance and good oxygen barrier properties, PET (polyethylene terephthalate) is increasingly used in food packaging . Liquid foods such as oil are some of the products for which PET has been proposed as a packaging material (Moyssiadi*et al*., 2004). As for fruit juices bottling, PET is being actually used even though limited research work has been published on the matter (Muratore*et al*., 2005).

Increasingly, ready – to – serve beverages are packaged in different kinds of packing materials such as polyethylene terephtha late/polyethylene napthalate (PET/PEN) and cardboards. Exposure to light may be adegra dative factor for some beverages packaged in transparent cartons (Babak*et al*., 2011)

The interiors of preformed board cartons are composed of different 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)

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Among the factors affecting vitamin C loss in packed fruit juices, temperature, dissolved oxygen and oxygen barrier provided by the container material should be considered (Maria *et al*., 2007).The presence of oxygen is one of the main factors responsible for fruit juices deterioration . The adverse effects of dissolved oxygen on fruit juice quality have been investigated by many researchers and include degradation of ascorbic acid, increasing browning and growth of aerobic bacteria and moulds (Eiroa*et al*., 1999; Kennedy *et al*., 1992) Traditional methods for juice packaging aim to reduce the exposure of the juice to oxygen through the use of high barrier materials such glass with or without nitrogen flushing (Zerdin *et al*., 2003) or improving gas barrier by blending with aromatic polyamides (Hu *et al*., 2005). The use of oxygen scavengers with an appropriate packaging material can further reduce the presence of dissolved oxygen in the juice or present initially in the headspace. This technique has been investigated for the packaging of solid foods (Martinez *et al* ., 2006)

Although materials with a low permeability to oxygen as glass have been proposed by many author as the best to preserve nutritive and sensory quality of liquid foods, (Hu *et al*., 2005) the cost of these packaging materials is relatively high. The use of lower priced materials, with a higher permeability to oxygen , in conjunction with techniques aimed at reducing the presence of oxygen inside the package, appears as an attractive alternative for oxygen sensitive liquid product as pomegranate juice, but no information is available on the effects of carbon materials and with polyethylene or aluminum foil on pomegranate juice.

To preserve the ascorbic acid content, the attractive color and pleasant flavor and refreshing taste, it is possible to act on food processing (by means of mild technologies) and packaging, consequelntly, this investigation was directed at evaluating the effects of packaging materials during cold storage condition on color and vitamin C retention of pomegranate juice.

The main objective of this study was to compare the color retention , AA degradation and changes of gas composition in the head-space of refrigerated pomegranate juice stored in four different packaging material containers. In addition, a consumer panel evaluated the sensory color, fresh pomegranate flavor and presence of off- flavors in the juices, to know on which container is the best for refrigerating pomegranate juice.

Material And Methods

Fruit Materials:

Pomegranates (Punicagranatum L.) cultivars Ganesh Manfalouty were all grown under identical conditions of soil, irrigation and illuminationin Horticultural Research Institute Farm, (Assiut Governorate, Egypt).

The fruits were collected in Autumn (mid-October 2013). The fruits were selected based on their diameter, 94.0 ± 0.2 mm, and maturity index. The main reason for selecting the fruits that it is one of the most industrially processed pomegranates cultivars for juice production.

Four types of containers were used in this study. The main materials used in the manufacture of the containers ; 1- polyethylene terephthalate (PET bottles) 2- Outside polyethylene layer 13.5% + cardboard 27% + 59.5% aluminum foil (Tetra Pak) 3- Outside polyethylene layer 4.5% + cardboard 76% + 19.5% ethylene vinyl alcohol copolymers (LDPT) 4- Polyethylene 100% (PE) . All container samples were obtained from El-Shark company (6 October city).

Sample preparation:

The juice was obtained using Premium Juice Extractor ; FMC corporation, Vero Beach, FL (FMC, 2004) . The fruits were peeled and the arils were separated from the tissues, and washed in 2% chlorine (cl_2) for 2 minutes; A total of 60 liters of juice was prepared in 12 different batches of 5 liters each (4 treatments × 3 replicates),

The juices were processed under aseptic packaging and thermal treatment of pasteurization (86 ˚C /20s). These juices were packaged and stored under refrigeration (4 ˚c) conditions. The juice samples were analyzed on 0, 2, 4, 6 and 8 weeks (end of storage time) Pomegranate juice (1) was stored in bottles made of PET and juices 2, 3 and 4 were stored in containers made of aluminum foil, Ethylene vinyl alcohol copolymers and polyethylene only, respectively.

Ascorbic acid determination :

Ascorbic acid determination was performed according to the 2, 6- dichloroindophenoltitrimetic method (AOAC, 2000). This determination is based on redox reactions. Ascorbic acid reduces the 2, 6-dichloroindophenol, oxidizing itself of dehydroascorbicacid . As a consequence, this method allows the determination of the reduced form of the ascorbic acid .

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 Shimadzy model 14 A 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 the mean ± standard error of 5 determinations for each of the replicates used, and were expressed as percentage of oxygen in the headspace atmosphere.

Color Measurement:

Optical density measurement (colour intensity) of the variously treated pomegranate juices were determined at 510 nm wave length using a UV spectrophotometer model BC 200. Total anthocyanin (Tacy) content and degradation index (DI) during storage were determined by the spectrophotometric differential method of fuleki and francis (1968) .

Sensory Evaluation:

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

Pomegranates juice samples stored under refrigeration in different containers were given to consumers for sensory evaluation at 0, 2, 4, 6, and 8 weeks of the intensities of different organoleptic attributes : color, fresh pomegranates flavor (impressions perceived via the chemical senses from a juice in the mouth and off-flavors (impressionsof 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 pomegranates juice should be sorted 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 red color, fresh pomegranates flavor and without any off-flavors and 4 to the sample with a less intense red color, less fresh pomegranates flavor and more 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 pomegranates juice samples as affected by packaging materials (Genard and Bruchou, 1992). Significance of differences was represented as $P \leq 0.001$. Finally, ranking data were analyzed by a Friedman test (Iso8587 : 1988).

Results and Discussion

Vitamin C:

The initial vitamin C concentration for refrigerated pomegranate juice (Day zero) was 12.68 mg/100 ml. The type of container significantly affected the changes of vitamin C concentration with time (Table 1, Fig 1) . At the end of the storage of the refrigerated pomegranate juices, the juice with the highest vitamic c concentration was A (9.38 mg/100 ml) followed by juice B (7.61 mg/100 ml), juice C (6.59 mg/ 100 ml), and finally, juice D (4.94 mg/100 ml). These experimental results proved that the container type was important for nutritional values as degradation rate of vitamin C. Vitamin c lossing was reached about 48 and 61% in juice C and D respectively after 8 weeks of cold storage, therefore, the shelf life of these juices was reduced than the other juices A and B (AIJN 2005)

The main explanation for the high reductions in the vitamin C content in juices C and D is that higher oxygen contents were present in these juices as compared with juices A and B . Ascorbic acid stability is greatly influenced by temperature, oxygen and metal ion content (fennema1996 ;Polydera *et al*., 2003). 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 container , 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 containers was measured throughout the storage of the pomegranate juices, and experimental results are summarized in Table 2 and Fig 2.

The initial oxygen content was zero because during the packaging of the juices, the headspacegasses were displaced using liquid nitrogen (Kimball 2002; FMC 2004) . Juices II and I packed in PE and PET respectively, presented higher oxygen concentrations than refrigerated juices IV and III packed in carton with aluminum foil and in carton with polyethylene and ethylene vinyl alcohol copolymers respectively. These experimental results provided a real proof that somehow PE and PET bottle were partially permeable to oxygen; micropores could be present in some of the junctions of the juice II 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, Tetra-Pak IV and LDPT III containers could be considered as high oxygen barriers, while PET bottle I and PE II should be considered as intermediate or low oxygen barriers . The cause, it may be entrance of air into the containers from the jointsof their upper part during its sealing .

Color Stability:

Results in Table (3) showed that the color stability of pomegranate juices was affected during storage by the type of containers, it can be concluded that regrigerated pomegranate juice packed in carton (Tetra- Pak and LDPT) provided the juice with the highest anthocyanin pigments and thus providing a high intensity of the red color .The experimental results proved that carton composition was an important quality control parameter in determining the degradation of the initial red color of the refrigerated pomegranate juices . It seems evident that LDPT container provided better experimental results which has 75.5% carton than Tetra-Pak container which has 27% .carton only, and the two types provided better experimental results and showed a better behavior than PT and PET bottle which haven't carton . After 8 weeks of storage at refrigerator the percent reduction of total anthocyanine not exceed 19 and 22% in LDPT and Tetra-Pak containers respectively but it reached 30 and 33% in PE and PET bottle respectively. At the same time , the pigment retention (%) at 5˚C reached 80 and 77% in LDPT and Tetra-Pak containers respectively but it not exceed 68 and 66% in PE and PET bottle respectively.

Once this point is reached that the change of pomegranate color due to container type and composition beside the temperature of storage .

Table 1: Effect of packaging materials on the vitamin c retention of pomegranate juices during storage at 4˚C.

Types of package	Ascorbic Acid (mg/100ml)									Ascorbic acid retention
	Storage per weeks									
	0	1	2	3	4	5	6	7	8	%
Tetra-Pak(A)	12.68	12.28	11.87	11.48	11.06	10.70	10.30	9.77	9.38	74
LDPT (B)	12.68	12.06	11.42	10.77	10.40	9.53	8.90	8.18	7.61	60
PT (C)	12.68	11.94	11.18	10.43	9.71	8.95	8.08	7.26	6.59	52
PET (D)	12.68	11.72	10.75	9.78	8.80	7.81	8.85	7.86	4.94	39

Table 2: changes of oxygen concentration with time in pomegranate juices packed in different containers

Types of package	Oxygen (%)								
	Storage per weeks								
	0	1	2	3	4	5	6	7	8
PET (I)	0	5.50	8.30	11.20	14.00	16.90	19.70	22.50	25.40
PT (II)	0	1.75	4.00	5.80	7.00	11.20	15.00	18.70	22.00
LDPT (III)	0	1.00	3.50	5.70	8.40	10.90	13.40	14.00	16.60
Tetra-pak (IV)	0	0.50	1.60	2.70	3.80	4.00	5.20	6.30	7.50

Table 3: Effect of packaging materials on the color stability of pomegranate juices during storage at 4˚C.

Type of package	Tetra-Pak			PET			PE			LDPT		
Period of storage per week	Tacy	PR%	DI	Tacy	PR%	DI	Tacy	PR%	DI	Tacy	PR%	DI
1	14.38	99.17	1.48	14.31	98.69	1.47	14.30	98.62	1.47	14.36	99.03	1.48
2	14.21	98.00	1.46	14.07	97.03	1.45	14.05	96.90	1.47	14.16	97.66	1.46
3	13.96	96.28	1.44	13.77	94.97	1.42	13.75	94.83	1.42	13.93	96.07	1.43
4	13.61	93.86	1.40	13.39	92.34	1.38	13.37	92.21	1.38	13.64	94.07	1.40
5	13.14	90.62	1.35	12.92	89.10	1.33	12.90	88.97	1.33	13.28	91.59	1.37
6	12.57	86.69	1.29	12.32	84.97	1.27	12.32	84.97	1.27	12.84	88.55	1.32
7	11.88	81.93	1.22	11.55	79.66	1.19	11.72	80.83	1.21	12.29	84.76	1.27
8	11.16	96.97	1.15	9.57	66.00	1.09	9.99	68.89	1.08	11.60	80.00	1.19
Reduction (%)	22%			33%			30%			19%		

Tacy: Total Anthocyanine mg/100ml, (Initial Tacy = 14.50)
PR% : Pigment retention % at 4˚C.
DI: Degradation index.

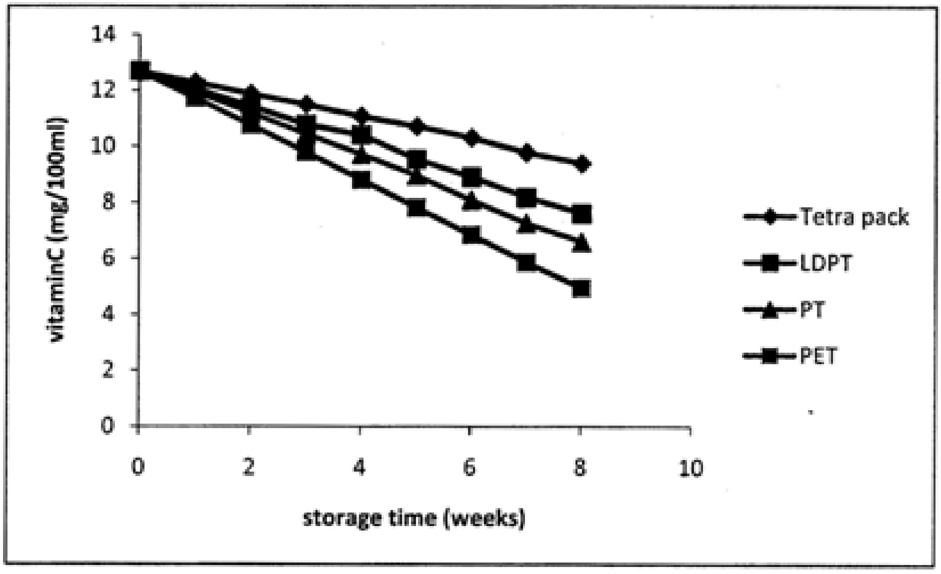

Fig. 1: change of V.C concentration with time in pomegranate juices packed in different containers.

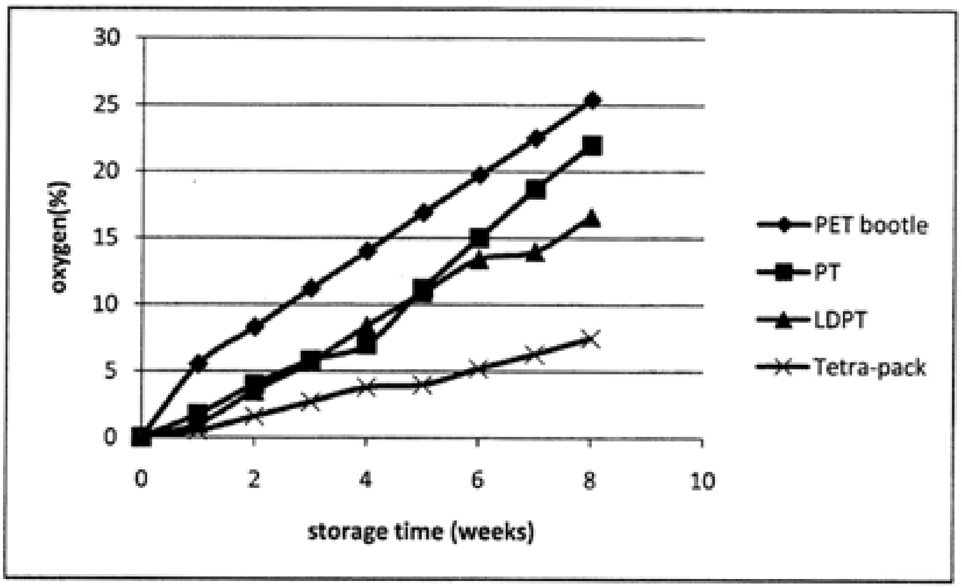

Fig. 2: change of oxygen concentration with time in pomegranate juices packed in different containers.

Sensory Analysis:

In each session (there was one session for each sampling week (0, 2, 4, 6 and 8 weeks), consumers were asked to arrange the four pomegranate juices (from four different containers) according to their liking of the sample color, fresh pomegranate flavor and intensity of off- flavors. Experimental results are summarized in Table 4.

The first sensory attribute to present significant differences among the studied juices was color ($P < 0.05$), after only 2 weeks, juice VI (PET bottle) presented a less intense color than the rest of the juices. After 4 weeks, both juices I and II presented a more intense red color than III and IV Juices , no significant differences were found between these last two samples.

Fresh pomegranate flavor started to disappear after 4 weeks of refrigerated storage in juice IV . After 6 weeks, both juices I and II presented significantly higher intensities of fresh pomegranate flavor than juices III and IV; this statement was true until the end of 8 weeks of storage.

Finally, 6 weeks of refrigerated storage was needed in order to find off-flavors (negative aromas) in pomegranate juices III and IV.After 8 weeks, juice IV presented a significantly higher intensity of off-flavors than any other juice.

Once again, these affective data proved that the container nature played an important role in determining the quality of the refrigerated pomegranate juices, and that transparent PET bottle provided the worst experimental results in this sensory study.

Table 4: Statistical analysis of the ranking data of color, fresh pomegranate flavor and off-flavors after 0, 2, 4, 6 and 8 weeks of storage at 4˚C

Time (weeks)	Container	Rank sum		
		Color	Fresh pomegranate flavor	Off- Flavors
0	I	44 **	49	51
	II	51	49	50
	III	51	52	49
	IV	53	55	55
	Statistics	0.66*** N.S	0.54 N.S	0.42 N.S
2	I	36 b ↔	52	52
	II	41 b	48	55
	III	55 ab	53	51
	IV	67 a	52	47
	Statistics	15.2*	0.42 N.S	1.26 N.S
4	I	31 b	46 b	58
	II	37 b	41 b	54
	III	62 a	52 ab	47
	IV	69 a	66 a	46
	Statistics	27.2*	9.7 * N.S	3.30 N.S
6	I	30 b	33 b	62 a
	II	46 ab	38 b	60 a
	III	58 a	60 a	44 b
	IV	65 a	74 a	39 b
	Statistics	18.0 *	31.7 * N.S	12.6 * N.S
8	I	25 b	26 b	68 a
	II	41 b	38 b	65 a
	III	63 a	64 a	34 b
	IV	69 a	77 a	33 b
	Statistics	34.2 *	47.6 * N.S	33.5 * N.S

N.S : Not Significantly different.
L.S.D : Least Significant difference.
** : Significant differences at P < 0.05* *** : Rank sum .*
**** : Experimental "t" value .*
↔ : Value followed by the same letter, within the same column, are not significantly different (P < 0.05), LSD test.
I : Tetra Pak II : LDPE III : PT IV : PET bottle.

Conclusions:

Pomegranate juice was packed in four different packaging materials, and its quality was studied during 8 weeks of storage at 4˚C, Experimental results proved that cartons consisting of polyethylene, cardboard and an inner layer 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 pomegranate juice was based on ahigh vitamin C content (related with lower oxygen content, in the headspace of the containers), intense red color, fresh pomegranate flavor and absence of off-flavors.

References

A.OA.C ., 2000. Official Methods of Analysis Association of Official Agricultural Chemists 15th Ed, Washington, Dc, USA.

AIJN (EUROPEAN FRUIT JUICE ASSOCIATION), 2005. AIJN code of practice for evaluation of fruit and vegetable juices. (accessed December 18, 2005).

Anonymous, 2012. Annual report , Economic Research Institute, Agric. Res Center. Egypt .

Babak, G., A. Hadi and A.E. Ali, 2011. Degradation of L. ascorbic acid mechanism of non – enzymic browning reaction-Industrial Crops and Products., (33): 229-235.

Berlinet, C., V. Ducruet, P. Brat, J.M. Brillouet, M. Reynes and E. Guichard, 2003. Effects of PET packaging on the quality of an orange juice made from concentrate. International conference Engineering and Food, ICEFg, 7-11 March, Montepellier, France.

Biala, J.B., 1981. Respiration and ripening in Fruits – retrospect and prospect In J. friend and M.J . Rhodes (Eds.) Recent advances in the biochemistry of Fruits and vegetables. London : Academic press, pp: 1-39.

Botrus, D., T.F. zykina, L.I. Kostinskaya and G.A. Golovchenko, 1984. Polyphenols compounds in pomegranate. 124 Vysshvchebn. Zaved .Pishch .Tekhnal., (3): 117-119.

Ducruet, V., N. Fournier, P. Saillard, A. Feigenbaum and E. Guichard, 2001. Influence of packaging on the aroma stability of strawberry syrup during shelf life. J. Agric. Food chem. . 49(5): 2290-2297.

Eiroa, M.N.U., V.C.A. Junqueira and F.L. Schmidt, 1999. Alicyclobacillus in orange juice ; occurrence and heat resistance of spores . Journal of Food Protection, 62(8): 883-886.
Fennema, O.R., 1996. Food chemistry, 3rd Ed., Marcel Dekker, New York. Ny .
FMC., 2004. FMC Food Tech .http://www.fmctechnologies.com/ Food Tech .aspx (accessed December 23..
Fuleki, T. and F.J. Francis, 1968. Quantitative methods for anthocyanins and determination of total anthocyanin and degradation index for cranberry juice. J.Food Sci., 33: 78-83.
Genard, M. and C. Bruchou, 1992. Multivariate analysis of within tree-factors accounting for the variation of peach fruit quality . Sci. Hortic. 52: 37-51.
Hu, Y.S., V. Prattipati, S. Mehta, D.A. Schiraldi, A. Hiltner and E. Baer, 2005. Improving gas barrier of PET by blending with aromatic polyamides, Polymer., 46: 2685-2698.
Kennedy, J.F., Z.S. Rivera, L.L. lioyd, F.P. Warner and K. Jumel, 1992. L. Ascorbic acid stability in aseptically processed orange juice in Tetra Brik cartons and the effect of oxygen. Food Chem.. 45: 327-331.
Kimball, D.A . 2002. Procesado de citricos, Ed. Acribia, Zaragoza, spain.
Lee, H.S. and S. Nagy, 1996. Chemical degradative indicators to monitor the quality of processed and stored citrus products In chemical markers for processed and stored citrus products In Chemical Markers for processed and stored foods (T.C. Lee and H.J. Kim, eds.) pp 86-106, American Chemical Society, Washington, DC.
Maria, R., B. Yulissa, I. Asuncion and L. Antonio, 2007 . Quality and shelf life of orange juice aseptically packaged in PET bottles . Journal of Food Engineering, 79: 234-242.
Martinez, l., D. Djenane, I. Cilla, J.A. Beltran, and P. Roncales, 2006. Effect of varying oxygen concentration on the shelf life of fresh pork sausages packaged in modified atmosphere . Food Chemistry, 94: 219-225.
Meilgaard, M., G.V. Civille and B.T. Carr, 1999. Selection and training of panel members. In sensory Evaluation Techniques, 3rd Ed., pp: 133-159, CRC Press, Boca Raton, Fl.
Moyssiadi, T., A. Badeka, E. Kondyli, T. Vakirtzi, I. Savvaidis and M.G. Kontominas, 2004. Effect of light transmittance and oxygen permeability of various packaging materials on keeping quality of low fat pasteurized milk . International Dairy Journal, 14: 429-436.
Muratore, G., C.M. lanza, A. Baiano, P. Tamagnone, A.C. Nicolosi and M.A. Del Nobile, 2005. The influence of using different packaging on the quality decay kinetics of Cuccia. Journal of Food Engineering, 73: 239-245.
Polydera, A.C., N.G. Stoforos and P.S. Taoukis, 2003. Compartive Shelf life study and vitamin C loss Kinetics in pasteurized and high pressure processed reconstituted orange juice . J. Food Eng., 60: 21-29 .
Shakpo.,1.0 and J.O. Arawande, 2011. Effects of storage and packaging materials on some physicochemical properties and sensory and microbiological parameters of pineapple juice . Pakistan Journal of of Scientific and industrial Research (54)/ 1: 14-18.
Sharma, R.R and Dinesh Singh, 2013. Effect of different packaging materials on shelf-life and quality of apple during storage. Indian Journal of Horticulture., 76(1): 39-48.
Siegmud, B., K. Derier and W. pfannhauser, 2012. Chemical and sensory effects, of glass and laminated carton packages on food products, Still a controversial topic . Food Sci& Tech, 54: 921-930.
Thai, C.N. and R.L. Shewfelt,, 1991. Modelling sensory color quality of tomato and peach : Neural networks and statistical regression . ASAE/ CSAE Annual International Meeting, Paper No. 90-6038 .Pretoria , South Africa.
Will, F., E. Schopplein, M. Ludwig, A. Steil, A. Turner and H. Dietrich, 2000. Analytical and sensorial alterations of orange juice after hot bottling in PET and glass. Dtsch. Lebensmitt. Rundsch, 96(8): 279-284.
Zerdin, K., M.L. Rooney and J. Vermue, 2003. The vitamin C content of orange juice packed in an oxygen scavenger material . Food Chem., 82: 387-395.