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EFFECT OF PASTEURIZATION, PACKAGE TYPE AND PACKAGING CONDITIONS ON ORANGE JUICE QUALITY DURING STORAGE

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ABSTRACT

The effects of pasteurization, type of package (laminated carton package and polyamide-polyethylene package) and packaging under modified atmosphere (vacuuated packages, vacuuated then Co_2 filled packages and vacuuated then N_2 filled packages) on chemical and microbial quality of "Baladi" orange juice during storage were studied. Pasteurization did not affect total soluble solids content. pH value slightly decreased but total acidity slightly increased. Total sugars showed little decrease, although there was an increase in reducing sugars. Ascorbic acid contents decreased considerably (12.5%) after pasteurization. Carotenoids decreased by about 2% after pasteurization, while browning index increased by 15.7%. Concerning microbial count, total bacterial count was clearly affected by the heat of pasteurization, also yeasts and molds count was greatly decreased.

During cold storage of packaged orange juice total soluble solids decreased slightly, also pH values decreased, while total acidity increased. The best results were obtained with modified atmosphere especially with Co_2 and with laminated carton packages. Reducing sugars showed slight increase but total and non-reducing sugars decreased all over the storage period in both types of packages. Ascorbic acid decreased gradually during storage period, when using modified atmosphere with Co_2 the decrease was only 52.86% in laminated carton packages, while it was 57.14% in polyaminde-polyethylene packages after 12 weeks of storage, these values were less than with other treatments. Carotenoids content decreased at the end of storage period by about 7.62% in laminated carton packaged under modified atmosphere with Co_2 and vacuuated conditions, this value increased to 9.45% and 9.15% in polyamide-polyethylene packages under the same conditions, respectively. The reduction percentage was less with other treatments. Browning index increased by 2.30 and 2.38 times with vacuuated and modified atmosphere with Co_2 in polyamide-polyethylene packages, while changes were lower in laminated carton packages (2.16 and 2.36 times) with the same treatments. Total bacterial, yeasts and molds count were clearly increased during storage period but increment in laminated carton packages with modified atmosphere especially Co_2 was lower than other treatments and packages. It is recommended to use laminated carton packages with Co_2 modified atmosphere for longer shelf life of pasteurized Baladi orange juice.

Keywords: Orange juice, pasteurization, packaging conditions, storage, browning, carotenoids, ascorbic acid.

INTRODUCTION

Orange (*Citrus sinensis*) is a classical source of ascorbic acid. It's the main citrus in Egypt and allover the world (Ashurst, 1995). The area cultivated with citrus fruits in Egypt reached 334,058 feddan in 1999 which yielded 2,465,813 tons (Anon, 2000), the same book also stated that orange is a main export fruit. The exported quantities was 225,000 tons in 98/99 season adding 260 million Egyptian pounds to the national income.

Orange fruits and juice make a significant contribution to the daily requirements of vitamin C. In addition supplementary nutritional value is obtained from organic acid, inorganic salts and carbohydrates. The world tend to use the food produced without adding chemicals or preservative materials or other treatments which may change their original properties.

Production of pasteurized juice (especially orange juice) has developed considerably. About 15% of fruit production was processed to orange juice. Significant part of the orange juice produced in Egypt goes for export especially to European Economic Community (Ensaf, 1996).

Food packaging is a growing industry in Egypt, and is becoming an indispensable part of our daily life. Selection of package materials and technique adds values to the food product itself and contributes much to consumer health and to the producer profit margin.

In the last years, many alternation have occurred in fruit juice making and beverage markets. Unless aseptic packaging is used, the production of such non-carbonated products is a relatively high risk venture with microbial spoilage controlled largely by chemical preservatives. Hence, the development of aseptic packages, the machinery to handle them and the process plant to deliver a suitably pasteurized form with minimal heat damage is a most important part of the growth of the market. Juice industry in all the world aim to produce good nutritional value and sensory qualities orange juice. To achieve such goal, a good pasteurization and packaging conditions have to be worked out.

This work was carried out to evaluate the effect of pasteurization, package type and packaging conditions on chemical and microbiological qualities of fresh or pasteurized orange juice stored at 6°C to prolong its shelf life and improve its exportability.

MATERIALS AND METHODS

Materials :

1- Egyptian Baladi orange (*Citrus sinensis*) fruits were used in this study (average 5 : 7 fruits/kg). The samples were brought from the local market at Kafr El-Sheikh city, Egypt.

2- Packaging materials:

The packaging materials used in this study were:

a- Laminated carton packages consist of four layers P/PE/AL/PE (paper-polyethylene-Aluminum foil-polyethylene).

b- Polyamide-polyethylene packages consist of two layers (PA/PE).

The two different packages were obtained from Arab Pharmaceutical Packaging Company, Cairo, Egypt.

3- Modified atmosphere:

Modified atmosphere was obtained in the packages using vacuuated atmosphere, carbon dioxide 100% and nitrogen 100%. The Co_2 and N_2 gases were obtained from Nedol Commercial Establishment, Cairo. They were used to insure complete replacement of the original package atmosphere.

Methods:

1- Extraction and pasteurization of orange juice:

Fruits were washed, halved and juice was extracted by pulping rotary machine. The extracted juice was screened through two layers of cheese cloth. Most of extracted juice was immediately pasteurized. The pasteurization was carried out using SAFGARD PRESVAC home pasteurizer USA, Model P-5000 at 70.5°C for 24 min., then juice was cooled rapidly to 25°C. Fresh and pasteurized of orange juice samples were analyzed and pasteurized juice was stored there after.

2- Preparation of packages:

Packages of 30 × 22 cm surface area were prepared from each packaging material. The machine used for filling the packages, wether under vacuum or not, and sealing was Vacuumaster, France model depose (AUDIONUAC VM 3019).

3- Packaging of pasteurized orange juice:

After preparation of the packages, each 300 ml of pasteurized orange juice were placed into one package and primarily sealed according to the sealing characteristics for each package material. The modified atmosphere within the package was created by making one opening at any end of the package and use it as an inlet for gas injection according to the following treatments:

1- Packages were filled and sealed without further treatment (for comparison, T_1).
2- Packages were filled, vacuuated and sealed (T_2).
3- Packages were filled, vacuuated, sealed and filled with Co_2 gas (T_3).
4- Packages were filled, vacuuated, sealed and filled with N_2 gas (T_4).

Packages of all treatments were stored in the refrigerator at 6°C.

Chemical attributes:

Fresh and pasteurized orange juice were analyzed immediately after processing, then analyses were carried out weekly at the first month of storage while during the 2nd and 3rd month of storage samples were done periodically every two weeks.

- Total soluble solids, total acidity, pH value and ascorbic acid were determined according to the methods described by A.O.A.C, (1990).
- Carotenoids were extracted from orange juice according to the method of Luh *et al*. (1958), and measured colorimetrically at 450 nm using spectrophotometer (JE NWAY6100). Carotenoids content were calculated as β carotene.
- The browning index was determined by the method of Meydov *et al*. (1977).
- Reducing and total sugars were determined according to the method of Nelson and Somogi (1944), while the value of non-reducing sugars was calculated by difference.

Microbiological analysis :

Viable plate counts :

Viable plate count of different juice treatments were determined using pour plate count technique. Standard plate count agar medium was used according to A.P.H.A. (1992).

Yeasts and Molds count :

Yeasts and Molds in orange juice were determined using surface spread plate technique and malt extract agar medium was used according to Galloway and Byrger (1952).

RESULTS AN DISCUSSION

Total soluble solids, pH and total acidity of orange juice:

Total soluble solids :

The results shown in Table (1) indicated that, pasteurization of orange juice at 70.5°C for 24 min. had no effect on total soluble solids (T.S.S) content of orange juice. Fresh juice total soluble solids content was 11.8%. These results are in agreement with those recommended in some countries (Ashurst, 1995 and with those found by Abd El-Fadeel (1978), Habiba, (1982) and Ensaf (1996). However, slight reduction could be observed with prolonging storage time of all treatments. This result may be explained by the fact that T.S.S. of citrus juices are about 80% sugars, 10% citric acid and its salts, with the remainder made of nitrogenous compounds and other minor soluble substances (Ting and Rouseff, 1986). Slight loss of total sugars may be due to the change in the solids value of juice.

Type of packages and modified atmosphere did not show any definite effect on the T.S.S. of stored juice.

pH value and total acidity :

The titratable acidity of citrus fruit juices play a vital role in the determination of legal maturity of the fruit. Acidity is also an important attribute and is considered a major factor in the acceptability of both citrus fruits and juices and acceptable are at about 1.0% acid and pH 3.5 (Lombard, 1963).

Results tabulated in Table (1) also indicate that, both pH values and total acidity of orange juice were not effected by pasteurization. Akinyele *et al*., (1990) reported that, pasteurization of orange juice increased the total acidity, but Ensaf (1996) indicated that, pasteurization reduced total acidity, while pH value was unchanged.

pH values were unchanged after one week storage of all treatments, but a slight reduction in pH value began after 2, 3, 6 and 4 weeks for T_1, T_2, T_3 and T_4, respectively. The results also indicate that, the decrement in pH values of laminated carton packages were less than that observed with polyamide-polyethylene packages for all treatments. The more rapid decrease of pH value in T_1 samples may be mainly due to microbial growth resulting in the production of organic acids from sugars and the continous drop in pH values.

Table (1): Effect of pasteurization; packaging conditions and type of package on total soluble solids, pH and total acidity of orange juice stored at 6˚C (%)

Storage period (week)	Laminated Carton packages				Polyamide – Polyethylene packages			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
	Total soluble solids :							
Zero	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80
1	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80
2	11.80	11.80	11.80	11.80	11.80	11.80	11.80	11.80
3	11.75	11.77	11.77	11.75	11.74	11.76	11.77	11.75
4	11.73	11.75	11.74	11.72	11.72	11.73	11.74	11.72
6	11.70	11.73	11.72	11.70	11.70	11.71	11.71	11.70
8	11.68	11.71	11.70	11.69	11.68	11.69	11.68	11.68
10	11.66	11.70	11.68	11.67	11.65	11.67	11.66	11.66
12	11.64	11.68	11.66	11.65	11.63	11.65	11.64	11.64
	pH :							
Zero	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
1	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
2	3.6	3.7	3.7	3.7	3.6	3.7	3.7	3.7
3	3.5	3.6	3.7	3.7	3.4	3.6	3.7	3.7
4	3.2	3.6	3.7	3.6	3.0	3.5	3.7	3.6
6	2.8	3.4	3.6	3.5	2.8	3.2	3.6	3.4
8	2.6	3.2	3.4	3.3	2.6	3.0	3.4	3.2
10	2.4	3.2	3.2	3.0	2.3	2.5	3.2	3.0
12	2.2	2.8	3.2	2.8	2.0	2.3	3.0	2.5
	Total acidity :							
Zero	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
1	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
2	1.15	1.14	1.14	1.14	1.15	1.14	1.14	1.14
3	1.16	1.15	1.14	1.14	1.17	1.15	1.14	1.14
4	1.19	1.15	1.14	1.15	1.20	1.16	1.14	1.15
6	1.22	1.17	1.15	1.16	1.22	1.18	1.15	1.17
8	1.23	1.19	1.17	1.17	1.23	1.19	1.17	1.18
10	1.24	1.19	1.19	1.19	1.25	1.23	1.19	1.20
12	1.26	1.22	1.19	1.22	1.27	1.25	1.21	1.25

Control (fresh juice) : T.S.S = 11.80%; pH = 3.7% ; Total acidity = 1.14 %

T_1 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C

T_2 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C

T_3 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C

T_4 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated, filled with N_2 gas and stored at 6 ˚C

High decrease in pH value reflexes worse keeping quality of the juice. Consequently, the investigated treatments can be arranged on the base of keeping better quality juice for longer time beginning with T_3 as the best one followed by T_4, T_2 and T_1 in a decreasing order. So, it could be stated that, using modified atmosphere, especially Co_2 has a noticeable effect on preserving orange juice.

Total sugars, reducing and non-reducing sugars of orange juice :

Citrus fruits contain simple sugars as reducing sugars (glucose and fructose) and non-reducing sugar (sucrose) Ashurst (1995).

The results shown in Table (2) indicated that, pasteurization caused a very slight decrease in total sugars. Such results coincide with those reported by Abd El-Gawad (1983) and Ensaf (1996). Total sugars value was unchanged after one week storage of all treatments. The content was decreased gradually to reach between 10.14 - 10.18 gm/100gm after 12 weeks of storage in all treatments. From Table (2), it could be concluded that there were no noticeable effects of using the two different types of packages and different conditions on total sugars content.

Ascorbic acid of orange juice:

The results shown in Table (3) indicated that, pasteurization of orange juice had a marked effect on ascorbic acid, fresh juice ascorbic acid content was 80 mg/100gm, while after pasteurization became 70 mg/100 gm. Such decrease could be due to partial destruction caused by heat of pasteurization in the presence of oxygen. These results are in agreement with those of El-Ashwah *et al*., (1975), Abd El-Fadeel (1978) and Ensaf (1996).

After one week of storage ascorbic acid values decreased in all treatments but it was more pronounced in case of T_1 in both laminated carton and polyamide-polyethylene packages. Ascorbic acid gradually decreased in T_1 along the storage period reaching 20 mg/100gm in laminated carton package while it was 26, 33 and 28 mg/100gm for T_2, T_3 and T_4 respectively in the same package after 12 weeks of storage. Concerning polyamide-polyethylene packages ascorbic acid values after 12 weeks of storage were 16, 24, 30 and 27 mg/100gm for T_1, T_2, T_3 and T_4 respectively. The more rapid decrease in ascorbic acid in T_1 samples can be explained by oxidation due to the amount of oxygen in the head space plus the dissolved oxygen in the juice.

Consequently, the investigated treatments can be arranged on the base of keeping better quality juice (higher ascorbic acid content) for longer time beginning with T_3 as the best followed by T_4, T_2 and T_1 in a decreasing order. So, we can say that using modified atmosphere has a definite effect in preserving ascorbic acid content especially using Co_2 gas in laminated carton packages more than in polyamide-polyethylene packages. These results correlated to those of Inns (1987).

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Table (3): Effect of pasteurization; packaging conditions and type of package on ascorbic acid of orange juice stored at 6 ^{O} C (mg / 100g).

Storage period (week)	Laminated Carton packages				Polyamide – Polyethylene packages			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Zero	70	70	70	70	70	70	70	70
1	65	67	67	67	65	67	67	67
2	60	63	65	64	58	60	63	62
3	53	58	60	58	50	55	58	56
4	48	53	55	50	45	50	53	48
6	40	45	48	45	36	40	45	42.5
8	31	38	40	36	28	33	38	33.5
10	25	30	35	30.5	20	26	33	30
12	20	26	33	28	16	24	30	27

Control (fresh juice) : 80 mg/100gm

T_1 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C

T_2 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C

T_3 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C

T_4 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated, filled with N_2 gas and stored at 6 ˚C

Carotenoids of orange juice :

Pigments (Carotenoids) of mandarin and orange are mainly found in the juice sacs. The amounts of color pigments found in the citrus cultivars will vary with the variety, stage of maturity, seasonal variations and even the growing region. The carotenoids pigments can be important from the nutritive standpoint as source of vitamin A. (Ashurst, 1995).

The results shown in Table (4) indicated that, pasteurization of orange juice led to reducing carotenoids content by about 2.1%. Such results are confirmed with those of El-Sayed (1966), Abd El-Gawad (1983) and Ensaf (1996). After one week of storage carotenoids content was unchanged in all treatments except T_1, which was decreased with the two types of packages. The decrement of carotenoids in T_2 and T_3 were smaller than that occurred in T1 and T4 during storage period for both types of packages. The results in Table (4) also indicated that, the decrements occurred with polyamide-polyethylene packages were higher than that happened with laminated carton packages for all treatments. The loss of some carotenoids during pasteurization may be due to the partial destruction by pasteurization heat. In addition, the microbial growth also decreased the total carotenoids along the storage period. It's also noticeable that the decrease of carotenoids was more obvious in T_1 samples, this could be due to the amount of oxygen in the head-space, in addition to the dissolved oxygen. Using modified atmosphere has a preserving effect on juice carotenoids, especially vacuuated and Co_2 filled. Laminated carton packages showed less carotenoids loss. Rother (1963) stated that carotenoids are more stable to heat with a minimal oxygen content, and the damage of color and flavor depends on the amount of oxygen present.

Table (4): Effect of pasteurization; packaging conditions and type of package on carotenoids of orange juice stored at 6˚C (mg/100g)

Storage period (week)	Laminated Carton packages				Polyamide – Polyethylene packages			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Zero	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1	0.327	0.328	0.328	0.328	0.327	0.328	0.328	0.328
2	0.325	0.327	0.327	0.326	0.324	0.327	0.327	0.325
3	0.323	0.325	0.325	0.324	0.322	0.324	0.324	0.322
4	0.320	0.322	0.322	0.321	0.318	0.320	0.320	0.319
6	0.315	0.317	0.317	0.316	0.314	0.316	0.315	0.314
8	0.310	0.312	0.311	0.311	0.308	0.310	0.310	0.309
10	0.305	0.307	0.308	0.306	0.300	0.304	0.303	0.302
12	0.300	0.303	0.303	0.301	0.294	0.298	0.297	0.295

Control (fresh juice) : 0.335 mg/100gm

T_1 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C

T_2 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C

T_3 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C

T_4 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated, filled with N_2 gas and stored at 6 ˚C

Browning of orange juice :

Color of orange juice is an important quality factor, carotenoids are responsible for orange colors. Also, colors of orange products changes from acceptable orange to rejected brown which is mainly due to enzymatic and non-enzymatic browning reactions (Ashurst, 1995).

Data in Table (5) showed that, color index of orange juice was affected by pasteurization, fresh juice color index was 0.070, while after pasteurization it increased to 0.081. After one week of storage color index increased in all treatments, this gradual increase continued during all the storage period. These values reached to 0.200 and 0.202 for T_1 in laminated carton package and polyamide-polyethylene package at the end of storage period. Color index values for T_2, T_3 and T_4 after 12 weeks of storage were 0.175, 0.186, 0.183 and 0.193, 0.192 and 0.200 for samples in laminated carton packages and polyamide-polyethylene packages, respectively.

Also, results in the same Table (5) show that, the browning took place at the same rate in all investigated treatments during the first three weeks of storage and was over the whole period of storage correlated to the level of available oxygen. So, samples under vacuum have less browning values probably because of the less oxygen present in the package. This result is in agreement with that of Mannheim and Passy (1979);Lee and Nagy (1988); Mottar (1989) and Olga & Svanberg (1995).

Table (5): Effect of pasteurization; packaging conditions and type of package on browning of orange juice stored at 6˚C (Optical density at 420 nm.).

Storage period (week)	Laminated Carton packages				Polyamide – Polyethylene packages			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Zero	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
1	0.085	0.082	0.085	0.085	0.087	0.085	0.087	0.087
2	0.092	0.090	0.092	0.092	0.097	0.095	0.096	0.096
3	0.099	0.096	0.095	0.097	0.120	0.099	0.110	0.118
4	0.115	0.110	0.112	0.118	0.135	0.120	0.130	0.133
6	0.130	0.125	0.122	0.128	0.150	0.135	0.140	0.148
8	0.145	0.137	0.140	0.150	0.175	0.150	0.152	0.168
10	0.165	0.150	0.165	0.170	0.190	0.170	0.175	0.190
12	0.200	0.175	0.183	0.192	0.202	0.186	0.193	0.200

Control (fresh juice) : 0.070

T_1 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C

T_2 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C

T_3 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C

T_4 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated, filled with N_2 gas and stored at 6 ˚C

Total bacterial, yeasts and molds count of orange juice :

Shelf life of fruit juice is affected by microbial load, when the number is 300-700 organisms/ml the shelf life is about 3-4 weeks, while 5000 organisms/ml, means a shelf life about 1-2 weeks (Mc Allister, 1980).

Data shown in Table (6) present the total bacterial count of orange juice. Results revealed that, bacterial count of fresh orange juice was 7×10^3 CFU/ml. Pasteurization had a great effect on destroying most of microbial count to become less than 1×10^3 CFU/ml. After two weeks bacterial count was also less than 1×10^3 CFU/ml. in all treatments except T_1 in both two different packages. The bacterial count was gradually increased during storage period to reach 5×10^3 CFU/ml. in T_1 after four weeks for both types of packages, at the end of storage, this number was 11×10^3 CFU/ml. and 13×10^3 CFU/ml. in laminated carton packages and polyamide-polyethylene packages, respectively. After eight weeks of storage bacterial count number of T_2 was more than 5×10^3 CFU/ml., and reached 9×10^3 and 10×10^3 CFU/ml. after 12 weeks in laminated carton packages and polyamide-polyethylene packages, respectively. Concerning T_3, bacterial count was changed after four weeks of storage to be 1×10^3 CFU/ml. and reached 5×10^3 CFU/ml. in laminated carton packages after 12 weeks. In polyamide-polyethylene packages it was 1×10^3 CFU/ml. after three weeks and reached to 6×10^3 CFU/ml. at the end of storage. Bacterial count of T_4 became more than 5×10^3 CFU/ml. after 10 weeks of storage in laminated carton package and reached 6×10^3 CFU/ml. after 12 weeks. In polyamide-polyethylene packages, bacterial count number became more than 5×10^3 CFU/ml. after eight weeks of storage and 8×10^3 CFU/ml. at the end of storage.

Table (6): Effect of pasteurization; packaging conditions and type of package on total bacterial count and yeasts and molds count of orange juice stored at 6˚C (CFU / ml)

Storage period (week)	Laminated Carton packages				Polyamide – Polyethylene packages			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
	Total bacterial count :							
Zero	< $1x10^3$	<$1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	<$1x10^3$	< $1x10^3$	< $1x10^3$
1	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$
2	$1x10^3$	< $1x10^3$	<$1x10^3$	<$1x10^3$	$2x10^3$	< $1x10^3$	<$1x10^3$	<$1x10^3$
3	$2x10^3$	$1x10^3$	< $1x10^3$	$1x10^3$	$3x10^3$	$1x10^3$	$1x10^3$	$1x10^3$
4	$5x10^3$	$2x10^3$	$1x10^3$	$2x10^3$	$5x10^3$	$2x10^3$	$2x10^3$	$3x10^3$
6	$6x10^3$	$2x10^3$	$2x10^3$	$2x10^3$	$7x10^3$	$4x10^3$	$3x10^3$	$3x10^3$
8	$7x10^3$	$4x10^3$	$2x10^3$	$4x10^3$	$8x10^3$	$5x10^3$	$3x10^3$	$5x10^3$
10	9 x 10^3	$7x10^3$	$3x10^3$	$4x10^3$	10 x 10^3	$8x10^3$	$4x10^3$	$6x10^3$
12	11 x 10^3	$9x10^3$	$5x10^3$	$6x10^3$	13 x 10^3	10 x 10^3	$6x10^3$	$8x10^3$
	Yeasts and molds count :							
Zero	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$
1	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$
2	$1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$	< $1x10^3$
3	$2x10^3$	< $1x10^3$	< $1x10^3$	$2x10^3$	$2x10^3$	$3x10^3$	$1x10^3$	$2x10^3$
4	$3x10^3$	$2x10^3$	$2x10^3$	$3x10^3$	$3x10^3$	$3x10^3$	$1x10^3$	$4x10^3$
6	$4x10^3$	$2x10^3$	$2x10^3$	$3x10^3$	$4x10^3$	$5x10^3$	$3x10^3$	$4x10^3$
8	$5x10^3$	$4x10^3$	$3x10^3$	$4x10^3$	$5x10^3$	$6x10^3$	$3x10^3$	$5x10^3$
10	$6x10^3$	$6x10^3$	$4x10^3$	$5x10^3$	$7x10^3$	$7x10^3$	$5x10^3$	$6x10^3$
12	$8x10^3$	$7x10^3$	$6x10^3$	$5x10^3$	$9x10^3$	$8x10^3$	$6x10^3$	$7x10^3$

Control (fresh juice) : Total bacterial count = 7 $x10^3$ CFU/ml.; yeasts and molds count = 2 $x10^3$ CFU/ml.

T_1 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C

T_2 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C

T_3 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C

T_4 : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated, filled with N_2 gas and stored at 6 ˚C

Regarding yeasts and molds count, results tabulated in Table (6) indicate that, yeasts and molds count of fresh juice was 2×10^3 CFU/ml. and after pasteurization it was less than 1×10^3 CFU/ml. The result also revealed that, yeasts and molds count grow in the same trend of bacterial count, and counts in most treatments at the end of storage period were less than bacterial counts in the same treatments.

It's obvious that pasteurization destroyed most of microorganisms responsible for spoilage and led to great reduction in their counts. However, practical experience shows that small portion of microorganisms can survive into the pasteurized juice, although their activity may not be apparent for a few days following the shock of processing. The more increase in microbial count was observed in T_1 samples, that's because of the presence of oxygen in the head space. So, it could be stated that using modified atmosphere has a noticeable inhibitory effect on microbial growth and on preserving juice

especially using Co_2 gas, which does not permit all aerobic microorganisms to grow, this may be the main reason for the preserving effect of Co_2. Consequently, the investigated treatments can be arranged on the base of keeping less microbial count for longer time beginning with T_3 as the best followed by T_4, T_2 and T_1 in a decreasing order. Juice samples packaged in laminated carton were superior to those of polyamide-polyethylene packages. The use of the first type package led to loss microbial growth than the second one. The results stated by Seiler and Oarakul (1982) and Inns (1987) are in agreement with the results obtained in this work.

From our results it could be stated that, the investigated treatments can be arranged on the base of keeping quality of juice for longer time beginning with T_3 as the best one followed by T_4, T_2 and T_1 in a decreasing order. So, using modified atmosphere, especially Co_2 gas has noticeable effect in preserving juice. In addition, juice samples packaged in laminated carton packages were superior to those packaged in polyamide-polyethylene packages.

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تـأثير البسـترة ونـوع العبـوة وظـروف التعبئـة علـى جـودة عصـير البرتقـال أثنـاء التخزين

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تم دراسة تأثير البسترة ونوع العبوة (عبوة كرتونية مبطنة برقائق الألومنيوم وعبوة من أكياس البولى أميد – بولى ايثيلين) والتعبئة فى جو معدل (عبوات مفرغة من الهواء – عبوات مفرغة ثم ملئت بغاز ثانى أكسيد الكربون وعبوات مفرغة ثم ملئت بغاز النتروجين) على جودة عصير البرتقال البلدى كيميائياً وميكروبياً أثناء التخزين. لم يكن هناك تأثير للبسترة على محتوى المواد الصلبة الذائبة الكلية، وكان هناك إنخفاض بسيط فى رقم الحموضة وزيادة طفيفة فى الحموضة الكلية. وأظهرت السكريات الكلية انخفاضاً قليلاً على الرغم من ارتفاع نسبة السكريات المختزلة. وأنخفض محتوى حمض الأسكوربيك انخفاضاً ملحوظاً (١٢,٥%) بعد البسترة وانخفضت الكاروتينويدات بمقدار ٢% بعد البسترة بينما زاد معدل التلون البنى بحوالى (١٥,٧%). وفيما يختص بالعد الميكروبى، تأثر العد الكلى للبكتريا بصورة واضحة بحرارة البسترة وانخفض العد الكلى للفطريات والخمائر بدرجة كبيرة. وأثناء التخزين البارد للعصير المعبأ انخفضت المواد الكلية الذائبة ببطئ وانخفض رقم الحموضة أيضاً، بينما زادت الحموضة الكلية. وكانت أفضل النتائج المتحصل عليها مع الجو المعدل خاصة بثانى أكسيد الكربون وفى عبوات الكرتون المبطنة برقائق الألومنيوم. زادت كمية السكريات المختزلة زيادة بسيطة بينما نقصت السكريات الكلية والسكريات الغير مختزلة أثناء فترة التخزين فى كلا النوعين من العبوات. وانخفض حمض الأسكوربيك تدريجياً أثناء التخزين، وعندما استخدم الجو المعدل بثانى أكسيد الكربون كان الانخفاض ٥٢,٨٦% فقط فى عبوات الكرتون المبطنة برقائق الألومنيوم بينما كان الانخفاض ٥٧,١٤% فى عبوات البولى اميد – بولى ايثيلين بعد ١٢ أسبوع من التخزين وكانت هذه القيم أقل عنها فى المعاملات الأخرى. وانخفض أيضاً محتوى الكاروتينويدات فى نهاية فترة التخزين بحوالى ٧,٦٢% فى عبوات الكرتون المبطنة برقائق الألومنيوم تحت ظروف التخزين فى جو معدل بثانى أكسيد الكربون وجو مفرغ فقط، هذه القيمة ارتفعت الى ٩,٤٥%، ٩,١٥% فى عبوات البولى اميد – بولى ايثيلين تحت نفس الظروف من التخزين على التوالى، وكانت النسبة المئوية للإنخفاض أقل عنه فى المعاملات الأخرى. أرتفع معامل التلون البنى بمعدل ٢,٣ مرة، ٢,٣٨ مرة فى الجو المفرغ فقط، الجو المعدل بثانى أكسيد الكربون فى عبوات البولى اميد – بولى ايثيلين، بينما كانت التغيرات أقل فى حالة عبوات الكرتون المبطنة برقائق الألمونيوم (٢,١٦ مرة، ٢,٣٦ مرة) مع نفس المعاملات. وزاد بوضوح العد الكلى لكل من البكتريا والخمائر والأعفان أثناء التخزين ولكن الزيادة فى عبوات الكرتون المبطنة برقائق الألومنيوم والجو المعدل وخاصة بثانى أكسيد الكربون كانت أقل عنه فى المعاملات والعبوات الأخرى. ونوصى باستخدام عبوات الكرتون المبطنة برقائق الألومنيوم وجو معدل بثانى أكسيد الكربون لإطالة فترة الصلاحية لعصير البرتقال البلدى المبستر.

Table (2): Effect of pasteurization; packaging conditions and type of package on total sugars, reducing sugars and non-reducing sugars of orange juice stored at 6˚C (gm/100gm)

Storage period (week)	Laminated Carton package												Polyamide – Polyethylene package											
	Treatment (1)			Treatment (2)			Treatment (3)			Treatment (4)			Treatment (1)			Treatment (2)			Treatment (3)			Treatment (4)		
	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S	T.S	R.S	N.R.S
Zero	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57	10.22	5.65	4.57
1	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55	10.22	5.67	4.55
2	10.21	5.68	4.53	10.22	5.68	4.54	10.22	5.68	4.54	10.22	5.68	4.54	10.21	5.68	4.53	10.22	5.68	4.54	10.22	5.68	4.54	10.21	5.68	4.54
3	10.21	5.68	4.53	10.21	5.68	4.53	10.21	5.68	4.53	10.21	5.68	4.53	10.21	5.68	4.53	10.21	5.68	4.53	10.22	5.68	4.54	10.21	5.68	4.53
4	10.20	5.69	4.51	10.21	5.70	4.51	10.21	5.70	4.51	10.21	5.70	4.51	10.20	5.69	4.51	10.20	5.70	4.50	10.21	5.70	4.54	10.21	5.70	4.51
6	10.20	5.69	4.51	10.20	5.71	4.49	10.21	5.71	4.50	10.20	5.71	4.49	10.20	5.69	4.51	10.20	5.71	4.49	10.21	5.71	4.50	10.20	5.71	4.49
8	10.18	5.70	4.48	6.20	5.71	4.49	10.20	5.72	4.48	10.18	5.71	4.47	10.18	5.70	4.48	10.18	5.71	4.47	10.20	5.72	4.48	10.18	5.71	4.47
10	10.16	5.71	4.45	10.18	5.72	4.46	10.20	5.72	4.48	10.18	5.72	4.46	10.16	5.71	4.45	10.18	5.72	4.46	10.18	5.72	4.46	10.16	5.72	4.45
12	10.16	5.72	4.44	10.18	5.72	4.46	10.18	5.73	4.45	10.16	5.73	4.43	10.14	5.72	4.42	10.16	5.73	4.43	10.18	5.73	4.45	10.16	5.72	4.45

Control (fresh juice) : Total sugars 10.24; reducing sugars 5.62 and non reducing sugars 4.62 gm/100gm.

Treatment (1) : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and stored at 6 ˚C.

Treatment (2) : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated and stored at 6 ˚C.

Treatment (3) : Juice was pasteurized at 70.5 ˚C for 24 min then packaged, vacuuated , filled with CO_2 gas and stored at 6 ˚C.

Treatment (4) : Juice was pasteurized at 70.5 ˚C for 24 min then packaged and vacuuated, filled with N_2 gas and stored at 6 ˚C.

T.S = Total sugars R.S = Reducing sugars N.R.S = Non-reducing sugars