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POMEGRANATE JUICE QUALITY AS AFFECTED BY SOME CLARIFICATION AND CONCENTRATION METHODS

Ashour, M. M.S. and Enssaf M.A. El-Hamzy
Food Technology Dept., National Research Center, Cairo, Egypt.

ABSTRACT

The effect of some clarification and concentration methods on pomegranate juice quality was studied. The applied clarification methods were: natural clarification, 0.5 g/L gelatin, 0.4 g/L polyvinylpyrrolidone (PVP) and 0.02% v/v pectinex Ultra Sp-L addition. The clarified pomegranate juice with PVP at pH 3 was concentrated either by vacuum (V.C) or freeze (F.C) to 43.5 and 43.2° Brix, respectively. The effect of frozen storage on chemical characteristics and color indices of concentrated pomegranate juice during storage period was investigated. The results indicated that the PVP method was excellent for clarification and most suitable to prevent undesirable changes in anthocyanin content and browning index. Freeze concentration method caused less changes in chemical characteristics and color indices for reconstituted pomegranate juice. The best results were obtained after 12 months of storage when F.C method was applied. It was noticed that the removal of tannins by using finning agent (PVP) improved color, odor, taste, overall acceptability and the keeping quality of pomegranate juice.

INTRODUCTION

Pomegranate fruit (*Punica granatum)* is widely grown in Mediterranean countries, and has been introduced to most parts of the tropics and subtropics (Ben-Arie *et al.,* 1984). Pomegranate is consumed fresh, and one of the main features of its quality is the red color of its seeds and juice. This color depends on the anthocyanin concentration and changes in the relative amounts of the individual anthocyanins directly affect this quality factor. Delphinidin-3,5- diglucoside is the major anthocyanin in pomegranate juice (Gil *et al.,* 1995).

The brilliant color and high nutritional value of pomegranate juice make it desirable for use in products such as packaged juice sacs, confectionary products, juices and soft drinks, or as a red natural food colorant (Mishkin and Saguy, 1982).

Pomegranate juice contains appreciable amounts of polyphenol and tannin compounds (Botrus *et al*., 1984 and Sherif *et al.,* 1993). Juice exposed to many biochemical changes soon after extraction. Such changes lead to deterioration of the natural taste, odor and color of juice as a result of anthocyanin destruction. Also, discoloration and sedimentation of colloidal compounds usually occurred during storage and cause a cloudy appearance and destroy the red color of the juice.

However clarification is necessary to prevent the formation of cloudy appearance during storage. In addition, taste of the product is improved by means of clarification. If the clarification is not employed, the product has bitter taste due to high tannin content (Civic *et al.,* 1977). For clarification, gelatin, Polyclar L. (Polyvinylpyrrolidone, PVP), Kieselsol, Bontonite, Clays,

etc. may be used as flocculating agents. If the solution of the clarifying agent is added to the juice, a heavy flocculant precipitate forms. As this precipitate settles, it carries down the suspended particles in the juice and leaves a nearly clear supernatant liquid. The reason for this precipitating action is the charge difference between the colloidal materials and the flocculants (Coussin and Ludin, 1963; Lin and Vine, 1990; Garrido *et al.,* 1993 and Bayindirli *et al.,* 1994).

Preservation of fruit juice either by concentration of juice or by addition of sugar (syruping) has been found successful in many fruit juices (Jafri and Sami, 1969). Concentration of the Pomegranate juice that clarified with Polyclar L (Polyvinylpyrrolidone) at the very low temperature (28°C) to 48° and 60° Brix and stored at O°C possible offeres an excellent method of storage of the juice. Both concentrates were shown by a tasting panel to give a pleasing drink on dilution with water with no apparent loss of flavor or color when compared with the original juice before concentration (Coussin and Ludin, 1963).

The effect of storage temperature on the discoloration of pomegranate juice was studied by Sheriff *et al.,* (1993). They reported that the color retention was affected during storage by a number of reactions which might be bleaching discoloration and browning. Yang *et al.,* (1982) declared that the storage temperature was the greatest factor affecting the stability of anthocyanin pigments. These pigments were gradually destroyed with storage and their degradation increased with increasing temperature. However, no satisfactory method has been devised in Egypt for keeping pomegranate juice for long time. Therefore, the present study was designed to evaluate the effects of extraction, pasteurization, clarification and concentration methods as well as storage conditions on the physical and chemical properties and keeping quality of pomegranate juice.

MATERIALS AND METHODS

Mature pomegranate fruits *(Puncia granatum)* were obtained from a private orchard at Giza Governorate Egypt at two successive seasons of 1999 and 2000. The fruits (Variety Manfalouty) were cleaned, sorted, weighted and manually fractionated to peels, flesh seeds, juice and seeds. The obtained fractions were immediately weighed and the percentage of each fraction to the whole weight of fruit was calculated.

Juice extraction and pasteurization :

The fresh fruits were cut into halves and the edible parts containing juice and seeds (flesh seeds) were separated by hand. The juice was extracted in a National Electric Juicer Blender (Type 241, Model MJ-170N, Made in Japan) at the maximum velocity. The red fresh juice was drained and screened through a muslin cloth for the separation of the seeds. The extracted fresh juice was immediately pasteurized in a glass apparatus using vacuum pump at 90°C (internal temperature) for 30 seconds (HTST), then cooled rapidly to 25°C.

Juice clarification:

The pasteurized pomegranate juice was clarified by four different methods as follow:

1- Natural clarification (T1), pomegranate juice was kept in a refrigerator for 3 days without adding any clarifying agent according to the method described by Bayindirli *et al*., (1994).

2- Addition of 0.5 g/L gelatin (T2). Gelatin was dissolved in water at about 40-50°C to produce 5% solution. After the gelatin solution was added to the juice, it was mixed and kept at refrigeration temperature (about 5-6°C) for 12 hours.

3- Pomegranate juice was clarified by treating with Polyclar L (Polyvinylpyrrolidone) 0.4 g/L of juice after adjusting the pH value to 3.0 by citric acid (T3). A distinct sedimentation was observed within 30 minutes (Coussin and Ludin, 1963).

4- Pomegranate juice was clarified by treating with pectic enzyme (0.02% v/v pectinex Ultra Sp-L), and incubated in water bath at 45°C for 2 hours (T4) as reported by Singh *et al.* (1993).

The supernatant juices of four different clarification techniques were decanted, filtered (through Buchner funnel under suction), divided into portions and stored in jars in deep-freeze at – 18°C.

Juice Concentration :

Pomegranate juice that had been clarified with 0.4g of PVP per liter was concentrated using two methods of concentration i.e.

1- Concentration by heating under vacuum (V.C).

2- Freeze concentration (F.C).

Vacuum Concentration (V.C) :

The clarified juice was concentrated in batches (500ml juice/batch) using glass apparatus under vacuum (28mm Hg) at a temperature not exceeding 45°C. The process was continued up to 43.5% T.S.S, then cooled and immediately frozen at – 18°C (El-Hamzy, 1996).

Freeze Concentration (F.C) :

The clarified juice was placed in plastic cups and frozen at – 18°C for 24 hours. The frozen juice was crushed and quickly placed in a basket centrifuge (5 liter capacity) at 5000rpm, under atmospheric conditions, to separate the concentrated juice from the formed ice (which remain inside the basket). The freezing of the juice followed by centrifugation was repeated up to 43.2% T.S.S (El-Hamzy, 1996).

Analytical methods :

The concentrated pomegranate juice was reconstituted to 15.83°Brix. All samples were analyzed immediately after processing, and also periodically at two months intervals up to 12 months for the following attributes.

Total solids and total soluble solids :

Total solids were determined by vacuum oven method. Total soluble solids were measured with an Abbe refractometer at 20°C (A.O.A.C., 1990).

pH value and titratable acidity :

The pH value was measured at 25°C using a Kinck pH meter with glass electrode (Ingold U 456-KN-57). For titratable acidity, a 10g sample of juice in 100ml distilled water was titrated to pH 8.1 with a 0.1N NaOH solution. Titratable or total acids of the sample were expressed as % citric acid (A.O.A.C., 1990).

Ascorbic acid, ash and sugars :

Ascorbic acid and ash were determined according to A.O.A.C. (1990). Reducing and total sugars were determined colorimetrically according to Miller (1957). Non-reducing sugars were calculated by subtracting reducing sugars from the total sugars.

Color, total anthocyanins and total phenolics :

Some color methods analyses were done using UV spectrophotometer (4054 ultrospec plus, LKB). The maximum absorption of pomegranate juice was observed at 525nm. Total monomeric anthocyanin pigment was determined by the method of pH differential according to Fuleki and Francis (1968). Total color density and polymeric color (Abs_{420nm} + Abs_{525nm}) were measured before and after bisulfite bleaching respectively, as described by Pilando *et al.* (1985). Percent polymeric color calculated by [(polymeric color/total color density) x 100], as described by Rommel *et al.* (1990). Anthocyanin degradation index was calculated using the equation (total anthocyanin by single pH determination / total anthocyanin by pH differential method) according to Bayndirli *et al.* (1994). Browning (Abs_{420nm} value after bisulfite bleaching) was measured as reported by Wesche-Ebeling *et al*. (1996).

Hunter L*, a* and b* color parameters were measured using a Hunter Lab Scan XE Model D65 LSXE/UNI. Color Difference Meter (Hunter Associates Lab., Reston VA). Fifty ml of juice were placed in a standard optical cell for measurement after standardization with white tile (L* = + 92.63; a* = - 0.85 and b* = - 0.14). This system was based on the Hunter L*, a* and b* coordinates, L* representing lightness and darkness, + a* redness, - a* greenness, + b* yellowness and – b* blueness (Pilando *et al*., 1985 and Chang *et al.,* 1994).

Total phenolics (as tannins %) were determined by the method of Singleton and Rossi (1964).

Sensory evaluation :

Fresh, clarified pomegranate juice, beside reconstituted juice obtained from the concentrate of pomegranate juice by two different concentration methods at zero time and during storage period were evaluated

organoleptically for color, odor, taste and overall acceptability by a pannel of 10 experienced members. The quality attributes were scored on a scale of 1 to 10 according to Notter *et al.* (1959). Least significant differences were calculated according to the method described by Steele and Torrie (1981).

RESULTS AND DISCUSSION

The physical characteristics of pomegranate fruit are presented in Table (1). The average mature pomegranate fruit was 334 g. The edible parts formed 58.4% of the fruit as juice and seeds. The data also showed that the juice and seeds percentage in the edible parts of fruit were 77.6 and 22.4% respectively. These results were quite similar with the previously reported data of El-Nemr *et al.* (1992).

Table (1) : Physical characteristics of pomegranate fruits.

Characteristics		Values *
Average fruit wt.	(gm)	334.0
Average size	(cm^3)	359.0
Specific gravity	(gm/cm^3)	0.93
Peels	(%)	41.60
Grains (Edible parts)	(%)	58.40
Juice yield	(%)	45.45
Seeds	(%)	12.95
Edible parts:		
Juice	(%)	77.60
Seeds	(%)	22.40

*** Values are means of 25 fruits.**

Effect of pasteurization on chemical characteristics and color indices of pomegranate juice :

Results in Table (2) showed the chemical characteristics and color analysis of fresh and pasteurized pomegranate juices. The obtained results in this table showed that, pasteurization of pomegranate juice had a slight effect on ascorbic acid and total anthocyanins. Ascorbic acid and total anthocyanins contents decreased from 148.48 and 118.90 to 141.37 and 115.06 mg/100g (on dry weight basis)respectively. The retention ascorbic acid and total anthocyanins was 95.2% and 96.8% for pomegranate juice respectively. Pasteurization had no effect on total soluble solids (T.S.S), pH value and ash of pomegranate juice. The results in the same table indicated that pasteurized pomegranate juice had a slight higher percentage of reducing sugars, but lower non-reducing sugars content in dry weight basis compared to fresh juice. These changes could be due to the inversion of sucrose to reducing sugars by heat of pasteurization. Pasteurization of pomegranate juice caused a slight decrease in tannins (2.1% on dry weight basis) compared to fresh juice. Hamed (1999) found that pasteurization caused a reduction in ascorbic acid, total anthocyanins, non – reducing sugars and tannins content.

The results of color indices of fresh and pasteurized pomegranate juices are shown in the same table. It could be noticed that pasteurization caused an increase in color density, polymeric color, % polymeric color and browning index of pomegranate Juice from 4.49 to 5.63; 1.10 to 1.65; 24.50 to 29.31 and 0.671 to 0.766 respectively. Meanwhile, the Hunter values, L*, a* and b* of pasteurized juice increased by about 24, 54 and 41% respectively. The increase in browning index and polymeric color may be due to the effect of pasteurization heat, which increased the rate of browning reactions (Chang *et al*., 1994).

Table (2): Effect of pasteurization on chemical characteristics and color analysis of pomegranate juice.

Components	Fresh juice		Pasteurized juice	
	A	B	A	B
Moisture content (%)	83.23	-	83.20	-
Total soluble solids (%)	16.40	-	16.40	-
Total acidity (%)	1.14	6.80	1.17	6.96
pH value	3.40	-	3.40	-
Total sugars (%)	13.57	80.92	13.60	80.95
Reducing sugars (%)	13.08	78.00	13.19	78.51
Non-reducing sugars (%)	0.49	2.92	0.41	2.44
Ascorbic acid (mg/ 100g)	24.90	148.48	23.75	141.37
Ash (%)	0.139	0.829	0.139	0.827
T.S.S / Acid ratio	14.39	-	-	-
Tannins (%)	0.213	1.270	0.209	1.244
Total anthocyanins (mg/100g)	19.94	118.90	19.33	115.06
Color indices				
Color density.	4.49	-	5.63	-
Polymeric color.	1.10	-	1.65	-
% Polymeric color.	24.50	-	29.31	-
Degradation index.	1.00	-	1.01	-
Browning index.	0.671	-	0.766	-
Hunter values				
L*	3.65	-	4.51	-
a*	10.73	-	16.49	-
b*	2.56	-	3.60	-

- A : On fresh weight basis.
- B : On dry weight basis.

Effect of different clarifying agents on chemical characteristics and color indices of pomegranate juice :

The results of the chemical and color analysis of pomegranate juice produced by four clarification methods are shown in Table (3). From the results, it could be that clarification method T1, T2 and T3 caused a decrease in the T.S.S of pomegranate juice. Meanwhile, the T4 was found to contain more T.S.S than the control ample. The lowest T.S.S was found in pomegranate juice clarified by treating with gelatin (T2, 15.65% T.S.S). Values of pH were different for all these cases. The lowest value was in pomegranate juice clarified by treating with PVP (T3, pH = 3.0). As a result, the ash content decreases during clarification. The lowest ash content of pomegranate juice was found after clarification by 0.5 g/L gelatin (T2), meanwhile the highest ash content was in juice clarified by treating with 0.02% v/v pectic enzyme (T4).

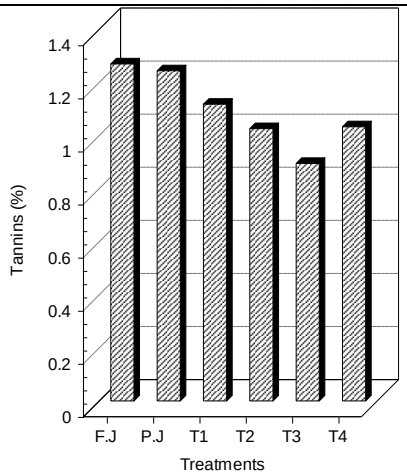

Fig (1): Variation of tannins.

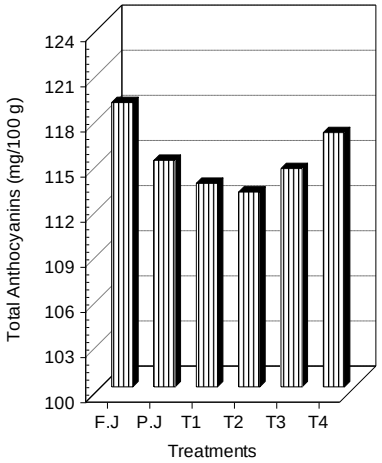

Fig (2): Variation of anthocyanins.

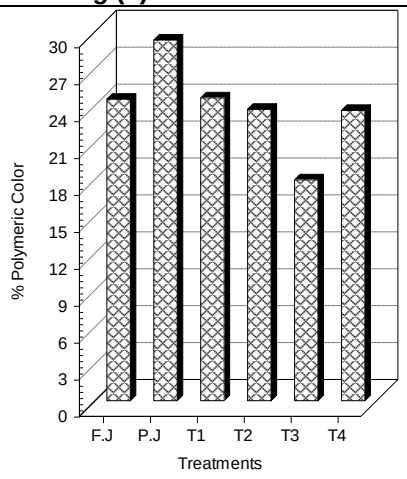

Fig (3): Variation of % polymeric color.

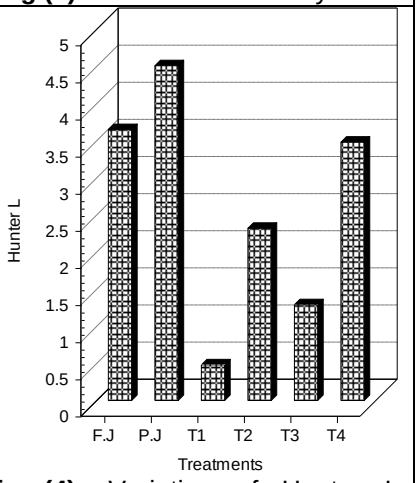

Fig (4): Variation of Hunter L value.

Legend (Fig. 1-4):

F.J: Fresh juice.
P.J: Pasteurized juice.
T1: Natural clarification.
T2: 0.5 g/L gelatin addition.
T3: 0.4 g/L PVP addition.
T4: 0.02 % v/v Pectinex Ultra Sp-L

Table(3): Effect of different clarifying agents on chemical characteristics and color analysis of pomegranate juice.

Components	Clarification methods							
	T1		T2		T3		T4	
	A	B	A	B	A	B	A	B
Total soluble solids (%)	16.20	-	15.65	-	15.83	-	16.45	-
Total solids (%)	16.55	-	15.98	-	16.20	-	16.75	-

Total acidity (%)	1.15	6.95	1.07	6.70	1.41	8.70	1.24	7.40
pH value	3.40	-	3.42	-	3.00	-	3.37	-
Total sugars (%)	13.33	80.54	12.64	79.10	12.95	79.94	13.52	80.71
Reducing sugars (%)	12.99	78.49	12.33	77.16	12.63	77.96	13.17	78.63
Non-reducing sugars(%)	0.34	2.05	0.31	1.94	0.32	1.98	0.35	2.08
Ascorbic acid (mg/100g)	20.50	123.87	15.34	95.99	18.70	115.43	16.92	101.01
Ash (%)	0.118	0.713	0.094	0.588	0.105	0.648	0.128	0.764
Tannins (%)	0.185	1.118	0.164	1.026	0.145	0.895	0.173	1.033
Total anthocyanins (mg/100g)	18.79	113.53	18.05	112.95	18.55	114.51	19.44	116.06
Color indices								
Color density	5.77	-	5.66	-	6.13	-	5.85	-
Polymeric color	1.42	-	1.34	-	1.10	-	1.38	-
% Polymeric color	24.61	-	23.68	-	17.95	-	23.59	-
Degradation index	1.02	-	1.03	-	1.01	-	1.04	-
Browning index	0.724	-	0.574	-	0.521	-	0.594	-
Hunter values								
L*	0.48	-	2.32	-	1.29	-	3.48	-
a*	2.20	-	4.25	-	4.21	-	9.21	-
b*	0.60	-	1.03	-	0.89	-	2.09	-

T1 : Pomegranate juice clarified by the natural clarification.
T2 : Pomegranate juice clarified by treating with gelatin (0.5 g/L).
T3 : Pomegranate juice clarified by treating with PVP (0.4 g/L).
T4 : Pomegranate juice clarified by treating with pectic enzyme (0.02% v/v).
A : On fresh Weight basis. B : On dry weight basis.

Clarification caused also a decrease in ascorbic acid, tannins and total anthocyanins contents of pomegranate juice in all cases. The higher concentrations of total anthocyanins were found in T3 and T4 treatments where it reached to 114.51 mg/100g and 116.06 mg/100g on dry weight basis respectively. The lower concentration of total anthocyanins was found in T1 and T2 treatments. The method of PVP offers an excellent reducing for tannins during clarification of pomegranate juice. Addition of fining agents, like gelatin or PVP, has been related to a decrease (about 25 to 50%) in total phenolics in prune juice (Chang et al., 1994).

Total color density is proportional with anthocyanin and browning index. It reaches to the maximum in pomegranate juice clarified by treating with PVP (T3) and minimum in the case of T2 (0.5g/L gelatin addition). Polymeric color, % polymeric color and browning index were quite high in the case of natural clarification. Similar results were reported by Coussin and Ludin (1963) and Bayindirli *et al*. (1994).

Figures (1-4) clearly showed the relationship between clarification methods (of tannins, total anthocyanins, % polymeric color and hunter L* value) and fresh or pasteurized pomegranate juices.

Effect of concentration methods on chemical characteristics and color indices of pomegranate juice :

Chemical characteristics and color analysis of reconstituted juices obtained from the concentrates of clarified pomegranate juice are shown in Table (4). It is noticed that total acidity of pomegranate juice decreased when using V.C and F.C concentration methods. These decrease percentages were 4.6% and 2.87% respectively. It was also observed that ascorbic acid

content was affected by the method of concentration. The retention percentages were 69.68% and 89.97% in reconstituted pomegranate juice after concentration by V.C and F.C methods respectively.

Regarding sugars content, results showed that F.C method had no marked effect on reducing, non-reducing and total sugars. On the other hand, total anthocyanins and tannins in reconstituted pomegranate juice decreased by V.C and F.C methods especially when using V.C method. The highest percentage loss in total anthocyanins and tannins content were 11.21% and 51.62% respectively, when using V.C method. However, using F.C method caused a minimum loss in total anthocyanins and tannins contents being only 1.83% and 2.79% in reconstituted pomegranate juice respectively. Similar results were reported by Abd El-Latif *et al.* (2000).

Table(4): Effect of concentration method on chemical characteristics• and color analysis of pomegranate juice.

Components	Clarified juice (T_3)		Concentration method			
			V.C		F.C	
	A	B	A	B	A	B
Degree of concentration (T.S.S%)	15.83	-	43.5	-	43.2	-
Total solids (%)	16.20	-	16.15	-	16.10	-
Total acidity (%)	1.41	8.70	1.34	8.30	1.36	8.45
Total sugars (%)	12.95	79.94	13.04	80.74	12.84	79.75
Reducing sugars (%)	12.63	77.96	12.86	79.63	12.53	77.82
Non-reducing sugars (%)	0.32	1.98	0.18	1.11	0.31	1.93
Ascorbic acid (mg/100g)	18.70	115.43	12.99	80.43	16.72	103.85
Tannins (%)	0.145	0.895	0.070	0.433	0.140	0.870
Total anthocyanins (mg/100g)	18.55	114.51	16.42	101.67	18.10	112.42
Color indices						
Color density	6.13	-	6.58	-	6.22	-
Polymeric color	1.10	-	1.87	-	1.71	-
% Polymeric color	17.95	-	28.42	-	27.50	-
Degradation index	1.01	-	1.03	-	1.02	-
Browning index	0.521	-	0.921	-	0.527	-
Hunter values						
L*	1.29	-	2.32	-	1.47	-
a*	4.21	-	7.24	-	5.03	-
b*	0.89	-	1.53	-	1.22	-

• Calculated in reconstituted pomegranate juice (T.S.S = 15.83%).
T3 : Pomegranate juice clarified by treating with PVP (0.4 g/L).
V.C : Vacuum concentration. **A : On fresh weight basis.**
F.C : Freeze concentration. **B : On dry weight basis.**

The result in the same table showed the effect of concentration methods on color indices during process. An increase in color density, polymeric color, % polymeric color, degradation index and browning index was observed. The maximum increase in browning index, polymeric color and % polymeric color was noticed after V.C method. Also V.C method had a markable increase in Hunter L*, a* and b* - values.

From the obtained results it could be concluded that, freeze concentration method was able to reduce the changes of chemical

characteristics and color indices of reconstituted pomegranate juice compared to vacuum concentration method.

Effect of frozen storage on chemical characteristics and color indices of concentrated pomegranate juice:

The changes in some chemical characteristics and color indices of pomegranate juice concentrated by V.C and F.C methods and packed in glass bottles during storage at – 18°C were summarized in Table (5 and 6). An increase in total acidity and reducing sugars of reconstituted pomegranate juice was observed in both concentration methods. The increase percentages of total acidity were 9.28 and 7.69 % in reconstituted juice from the concentrates by using V.C and F.C methods respectively, after 12 months of storage.

A decrease in ascorbic acid, tannins, non-reducing sugars and total anthocyanins contents was found when the storage period progressed in concentrated pomegranate juice of V.C and F.C methods. The percentages loss in ascorbic acid, tannins, non-reducing sugars and total anthocyanins contents were 27.94, 15.94, 10.81 and 22.04% in reconstituted juice from the concentrate by V.C method respectively, after 12 months of storage. Meanwhile, the percentages loss in ascorbic acid, tannins, non-reducing sugars and total anthocyanins contents were 17.90, 22.99, 10.36 and 3.5% in reconstituted juice from the concentrate by F.C method respectively, after the same storage time.

Regarding, the changes in color indices; it was observed that there was a gradual decrease in total color density during storage period. Meanwhile, a gradual increase in polymeric color, % polymeric color, degradation index and browning index was observed during storage period. The results are in agreement with those obtained by Wesche-Ebeling *et al.* (1996). The Hunter L*, a* and b* values of reconstituted pomegranate juice increased gradually during storage period. These results are in agreement with those obtained by Pilando *et al.* (1985) who found an increase in L*, a* and b* values in strawberry juice during storage.

Effect of method of concentration on the acceptability of pomegranate juice during storage period at – 18°C :

Color, odor, taste and overall acceptability of reconstituted juices after concentration at zero time and during storage at – 18°C for 12 months compared to fresh and clarified juices as reference were evaluated. The results were statistically analyzed for the analysis of variance and the data obtained are shown in Tables (7 to 10).

It was found that there was a gradual decrease in the organoleptic evaluation i.e. color, odor, taste and overall acceptability for reconstituted pomegranate juice by increasing the storage period.

Results in the same tables indicated that color, odor, taste and overall acceptability of reconstituted pomegranate juices concentrated by V.C method was markedly affected by increasing the storage period. A significant difference (undesirable) in color, odor, taste and overall acceptability was found between clarified juice and reconstituted pomegranate juice at zero time and during storage period of V.C method, but in the case of F.C method, there was no significant difference between clarified juice (as reference) and reconstituted ones at zero time, while there was a significant difference between fresh and clarified juice.

Freeze concentration was the best treatment for color, odor, taste and overall acceptability of reconstituted pomegranate juice where the obtained scores were 9.2, 9.0, 9.1 and 9.0 at zero time respectively. These scores reveal that the removal of tannins was able to improve both color and taste.

Finally, it could be concluded that freeze concentration method was able to improve both the chemical characteristics and color indices of the pomegranate juice, since it definitely improved the color and taste of the final product. Also, the removals of tannins by fining agent (like gelatin or PVP) improved the taste and the color of the product and help to raise the keeping quality of pomegranate juice.

Table (7) : Effect of the method of concentration on color mean scores* of reconstituted pomegranate juice during storage at – 18°C.

Method of concentration	Storage period in month						
	0	**2**	**4**	**6**	**8**	**10**	**12**
Fresh juice	fg 7.6	fg 7.6	fg 7.6	fg 7.6	fg 7.6	fg 7.6	fg 7.6
Clarified juice	a 9.5	a 9.5	a 9.5	a 9.5	a 9.5	a 9.5	a 9.5
Vacuum concentration (V.C)	gh 7.3	hi 7.0	ij 6.8	jk 6.5	kl 6.2	l 5.9	m 5.5
Freeze concentration (F.C)	ab 9.2	bc 9.1	cd 8.8	de 8.6	e 8.3	f 7.9	g 7.5

*** Mean scores by the same letter are not significantly different at 0.05 level of the probability.**

Table (8) : Effect of the method of concentration on odor mean scores* of reconstituted pomegranate juice during storage at – 18°C.

Method of concentration	Storage period in month						
	0	2	4	6	8	10	12
Fresh juice	gh 7.2	gh 7.2	gh 7.2	gh 7.2	gh 7.2	gh 7.2	gh 7.2
Clarified juice	a 9.1	a 9.1	a 9.1	a 9.1	a 9.1	a 9.1	a 9.1
Vacuum concentration (V.C)	ef 7.7	fg 7.4	gh 7.2	h 6.8	i 6.3	j 5.7	k 5.1
Freeze concentration (F.C)	ab 9.0	abc 8.8	bc 8.7	cd 8.5	de 8.1	ef 7.7	gh 7.2

*** Mean scores by the same letter are not significantly different at 0.05 level of the probability.**

Table (9) : Effect of the method of concentration on taste mean scores* of reconstituted pomegranate juice during storage at – 18°C.

Method of concentration	Storage period in month						
	0	2	4	6	8	10	12
Fresh juice	fgh 7.5	fgh 7.5	fgh 7.5	fgh 7.5	fgh 7.5	fgh 7.5	fgh 7.5
Clarified juice	a 9.3	a 9.3	a 9.3	a 9.3	a 9.3	a 9.3	a 9.3
Vacuum concentration (V.C)	fgh 7.5	gh 7.3	hi 7.0	ij 6.7	jk 6.4	kl 6.1	l 5.7
Freeze concentration (F.C)	ab 9.1	abc 8.9	bcd 8.7	cde 8.5	de 8.3	ef 8.0	fg 7.7

*** Mean scores by the same letter are not significantly different at 0.05 level of the probability.**

Table (10) : Effect of the method of concentration on overall mean scores* of reconstituted pomegranate juice during storage at – 18°C.

Method of concentration	Storage period in month						
	0	2	4	6	8	10	12
Fresh juice	ef 7.1	ef 7.1	ef 7.1	ef 7.1	ef 7.1	ef 7.1	ef 7.1
Clarified juice	a 9.0	a 9.0	a 9.0	a 9.0	a 9.0	a 9.0	a 9.0
Vacuum concentration (V.C)	de 7.5	de 7.4	ef 7.0	fg 6.7	g 6.2	h 5.3	i 4.5
Freeze concentration (F.C)	a 9.0	a 8.9	ab 8.7	ab 8.5	bc 8.2	cd 7.8	de 7.5

*** Mean scores by the same letter are not significantly different at 0.05 level of the probability.**

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تأثير بعض طرق الترويق والتركيز على جودة عصير الرمان

محسن مختار السيد عاشور و إنصاف محمد على الحمزى
قسم الصناعات الغذائية – المركز القومى للبحوث – القاهرة - مصر

يهدف البحث إلى دراسة تأثير بعض طرق الترويق والتركيز على جودة عصير الرمان. وقد كانت طرق الترويق المطبقة هى: الترويق الطبيعى، إضافة ٠,٥جم/لتر جيلاتين، ٠,٤ جم/لتر بولى فينيل بيروليدون (PVP) و ٠,٠٢% حجم/حجم بكتينيكس ألترا Sp-L كإنزيم بكتينى. ولقد استخدمت طريقة التركيز بالحرارة تحت تفريغ (V.C) أو التركيز بالتجميد (F.C) فى تركيز عصير الرمان المروق بإستخدام الـ PVP على pH ٣ حتى ٤٣,٥ و ٤٣,٢ درجة بركس على التوالى. كما درس تأثير التخزين بالتجميد على الصفات الكيماوية ودلائل اللون لعصير الرمان المركز خلال فترة التخزين. وقد أظهرت النتائج أن الـPVP كانت طريقة ممتازة للترويق ومناسبة إلى حد بعيد لمنع التغيرات غير المرغوبة فى محتوى الأنثوسيانين والتلون البنى. و قد سبب التركيز بالتجميد أقل التغيرات فى الصفات الكيماوية ودلائل اللون فى العصير المسترجع. كانت أفضل النتائج المتاحة بعد ١٢ شهر تخزين عندما طبقت طريقة التركيز بالتجميد. أدت إزالة التانينات باستخدام الـ PVP إلى تحسين اللون والرائحة والطعم ودرجة القبول العام وكذلك جودة الحفظ لعصير الرمان.

Table(5): Effect of frozen storage on chemical characteristics• and color analysis of reconstituted pomegranate juice concentrated by vacuum concentration method (V.C).

Components	Zero time		Storage period in month											
			2		4		6		8		10		12	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Degree of concentration (TSS%)	43.50	-	43.50	-	43.50	-	43.45	-	43.45	-	43.45	-	43.40	-
Total solids (%)	16.15	-	16.15	-	16.15	-	16.16	-	16.18	-	16.19	-	16.20	-
Total acidity (%)	1.34	8.30	1.39	8.61	1.40	8.67	1.38	8.54	1.43	8.84	1.44	8.89	1.47	9.07
Total sugars (%)	13.04	80.74	13.04	80.74	13.04	80.74	13.05	80.75	13.07	80.78	13.08	80.79	13.11	80.93
Reducing sugars (%)	12.86	79.63	12.86	79.63	12.86	79.63	12.88	79.70	12.90	79.73	12.91	79.74	12.95	79.94
Non-reducing sugars (%)	0.18	1.11	0.18	1.11	0.18	1.11	0.17	1.05	0.17	1.05	0.17	1.05	0.16	0.99
Ascorbic acid (mg/100g)	12.99	80.43	12.55	77.71	11.66	72.20	11.12	68.81	10.52	65.02	10.69	66.03	9.39	57.96
Tannins (%)	0.070	0.433	0.069	0.427	0.067	0.415	0.064	0.396	0.065	0.402	0.061	0.377	0.059	0.364
Total anthocyanins (mg/100g)	16.42	101.67	16.05	99.38	15.54	96.22	14.85	91.89	13.99	86.46	13.21	81.59	12.84	79.26
- Color indices :														
Color density	6.58	-	6.15	-	5.73	-	5.37	-	4.91	-	4.45	-	3.99	-
Polymeric color	1.87	-	1.95	-	2.01	-	2.15	-	2.27	-	2.42	-	2.55	-
% polymeric color	28.42	-	31.22	-	35.08	-	40.04	-	46.23	-	54.38	-	63.91	-
Degradation index	1.03	-	1.03	-	1.04	-	1.05	-	1.06	-	1.07	-	1.09	-
Browning index	0.921	-	0.950	-	0.982	-	1.010	-	1.041	-	1.093	-	1.147	-
- Hunter values :														
L*	2.32	-	4.48	-	4.63	-	5.19	-	6.15	-	6.73	-	9.26	-
a*	7.24	-	9.21	-	12.06	-	14.01	-	17.22	-	18.49	-	20.15	-
b*	1.53	-	2.56	-	3.10	-	3.31	-	4.39	-	6.44	-	6.58	-

• Calculated in reconstituted pomegranate juice (T.S.S = 15.83%).

A : On fresh weight basis. **B : On dry weight basis.**

Table (6): Effect of frozen storage on chemical characteristics• and color analysis of reconstituted pomegranate juice concentrated by Freeze concentration method (F.C).

Cosmponent	Zero time		Storage period in month											
			2		4		6		8		10		12	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Degree of concentration (TSS%)	43.20	-	43.20	-	43.15	-	43.15	-	43.15	-	43.10	-	43.10	-
Total solids (%)	16.10	-	16.10	-	16.10	-	6.11	-	16.13	-	16.14	-	16.15	-
Total acidity (%)	1.36	8.45	1.37	8.51	1.38	8.57	1.39	8.63	1.41	8.74	1.44	8.92	1.47	9.10
Total sugars (%)	12.84	79.75	12.85	79.81	12.85	79.81	12.86	79.83	12.88	79.85	12.90	79.93	12.91	79.93
Reducing sugars (%)	12.53	77.82	12.54	77.88	12.54	77.88	12.56	77.96	12.58	77.99	12.61	78.13	12.63	78.20
Non-reducing sugars(%)	0.31	1.93	0.31	1.93	0.31	1.93	0.30	1.87	0.30	1.86	0.29	1.80	0.28	1.73
Ascorbic acid (mg/100g)	16.72	103.85	16.27	101.06	15.86	98.51	15.15	94.04	14.46	89.65	14.05	87.05	13.77	85.26
Tannins (%)	0.140	0.870	0.139	0.863	0.138	0.857	0.134	0.832	0.125	0.780	0.117	0.725	0.108	0.670
Total anthocyanins (mg/100g)	18.10	112.42	18.07	112.24	18.02	111.93	17.94	111.36	17.82	110.48	17.70	109.67	17.52	108.48
Color indices :														
Color density	6.32	-	6.25	-	6.19	-	6.11	-	6.02	-	5.92	-	5.81	-
Polymeric color	1.71	-	1.82	-	1.91	-	2.16	-	2.29	-	2.41	-	2.48	-
% polymeric color	27.06	-	29.12	-	30.86	-	35.35	-	38.04		40.71	-	42.69	-
Degradation index	1.02	-	1.02	-	1.03	-	1.03	-	1.04		1.04	-	1.04	-
Browning index	0.525	-	0.551	-	0.574	-	0.601	-	0.634		0.669	-	0.696	-
Hunter values :														
L*	1.47	-	1.86	-	2.33	-	2.33	-	3.65	-	4.54	-	6.48	-
a*	5.03	-	5.23	-	7.73	-	9.85	-	10.73	-	16.85	-	17.65	-
b*	1.22	-	1.59	-	1.89	-	2.72	-	3.63	-	3.71	-	4.32	-

• Calculated in reconstituted pomegranate juice (T.S.S = 15.83%). A : On fresh weight basis. B : On dry weight basis.