Thermal Post Harvest Treatments for Improving Pomegranate Fruit Quality and Shelf Life

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ABSTRACT

The experiment was carried out during 2006 and 2007 seasons on Balady pomegranate fruits to study the effect of thermal post-harvest treatments through intermittent warming (33°C for 3 days and 20°C for 24 h) to reduce chilling injury and improving keeping quality of the fruits under test during storage at 0°C and 5°C with 85- 90% RH.

Heat treated fruits remained 60 days of storage except the fruits stored at 0°C which remained 45 days of storage. Intermittent warming (IW) had significant effect on juice volume, titratable acidity, soluble solids content, vitamin C, anthocyanin and weight loss of the fruit while intermittent warming (33°C for 3 days and transfer to 20°C for 24 h and storage at 5°C) and (20°C for 24 and stored at 5°C) were noticed reduced chilling injury. As the storage period reduced, juice volume and titratable acidity while SSC%, anthocyanin content and weight loss increased during storage period in all treatments.

Keywords: Pomegranate, intermittent warming, storage, quality, chilling injury.

INTRODUCTION

The pomegranate fruits (*Punica granatum* L.) are mainly consumed fresh and as juice that can be used in beverages and for flavoring and coloring drinks, jam, jelly and grenadine (Ewaidah, 1987). The fresh fruits are only available from middle of September until the beginning of November. Refrigeration has been recommended for storage and transport of pomegranates (Kader *et al.*, 1984, Lutz and Hardenburg, 1977). However, the high cost of refrigeration and disorders (mainly fungal growth and chilling injury symptoms) were associated with fruit during refrigerated storage (El-yaten and Kader, 1984).

Currently, there is a greater interest in pomegranate juice due to its high antioxidant activity that makes it appealing for the production of health supplements and mutraceuticals. Those activities are suggested to be related in part, to the three major anthocyanidins found in fruit seeds extract (Noda *et al*., 2002, Singh *et al*., 2002, Pierce and Kader, 2003 and Miguel *et al*., 2004). It is best maintained at a temperature of 0-5°C. Incidence and severity of chilling injury depend on temperature and duration. On the other hand, Segal (1981) reported that the peel of Wonderful pomegranate fruits undergoes browning during storage at temperatures below 14°C. The difference in the minimum safe temperature may be related to differences in pre-harvest temperatures and cultural practices (EL-Yaten and Kader, 1984). Intermittent warming treatment (1 day at 20°C every 7 days followed by a shelf life period of 7 days at 15°C) reduces low temperature injury and maintains fruit quality (Artes *et al.*, 2000 and Wang, 2000) by maintaining high levels of phospholipidis, increasing the degree of unstauration of fatty acids, increasing spermidine and spermine levels and stimulating free radical scavenging enzymes (Wang, 2000).

The aims of the present work were to study the following:

1. The effect of storage temperature on fruit quality and storability of pomegranates.
2. The effect of intermittent warming (IW) on pomegranate fruits stored at 5°C that is considered a safe temperature for chilling injury.
3. The effect of the above treatments [different storage temperatures including 5°C that is considered a safe temperature for chilling injury (IW)] on the physical (weight loss and volume of 100 gm arils) and the chemical (SSC, titratable acidity, vitamin C and anthocyanin content) characteristics of the pomegranate fruits.

MATERIALS AND METHODS

This investigation was carried out during 2006 and 2007 seasons. Balady fresh pomegranate fruits were harvested from a private orchard in Assiout Governorate, Egypt. The fruits were delivered to the Post-harvest Center of Horticulture Crops, Faculty of Agriculture, Alexandria University. Pomegranate fruits had initial quality at the same day of harvest as shown in Table (1).

Sound selected pomegranate fruits (uniform in size and free of mechanical damage, physiological crashing or pathological disorders) were washed using fresh tap water, then dried by electric fan. Dried fruits were divided into five groups each one contained a 60 fruits represented each treatment, then packed in three carton

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boxes at the dimensions of 50 ×30 × 20 for length, width and height, each one represented one replicate.

Table 1. The initial quality of the fruits

Replicates	Length (cm)	Width (cm)	Fruits weight (g)	Peal weight (g)	Arils weight (g)	Weight of 100g/ arils	SSC (%)	Juice weight (g)	Volume of juice/ 100 g	Acidity (%)	V.C. 100mg/100ml
Season 1											
1	7.55	7.85	391.3	164.95	223.45	40.8	15.7	351.9	122.5	2.2	2.5
2	6.75	7	325.95	130.1	192.85	42.6	15.9	302.25	122.5	2	3.55
3	3.75	7.3	385.35	148.6	233.25	37.8	15.8	346.95	122.5	2.5	3.15
Season 2											
1	6.75	7.6	343.75	119.7	219.95	33.9	15.8	335.25	139.66	2.2	2.4
2	6.85	7.6	377.3	140.6	226.85	38.5	15.7	349.45	139.66	2.0	2.75
3	7.05	7.55	414.65	165.65	244.45	32.8	16.3	363.05	139.66	2.5	3.2

Tested fruits were subjected to the following treatments:

1. Stored fruits at 0°C (T_1).
2. Stored fruits at 5°C (T_2).
3. Stored fruits at 5°C and every one week the fruits were transferred to 20°C for 24h then returned at 5°C. [Intermittent warming (IW_1)] (T_3).
4. Stored fruits at 33°C for 3 days then transferred to 20°C for 24 h and stored at 0°C [Intermittent warming (IW_2)] (T_4).
5. Stored fruits at 33°C for 3 days and transferred to 20°C for 24 h and stored at 5°C [Intermittent warming (IW_3)] (T_5).

Nine pomegranate fruits were taken to determine the initial physio-chemical properties, determinations were also followed up in 15 days intervals throughout the experimental working period as follows:

Weight loss%:

Ten labeled pomegranate fruits for every treatment were initially weight to calculate fruit weight loss percent during the storage period in relation to its original weight.

Volume of 100 g arils juice:

Pomegranate fruits were hand peeled then three samples of 100g of each treatment arils were taken (one sample from each 3 fruits). Each sample was squeezed to obtain the pomegranate juice. The volumes of the above obtained juice were recorded.

Chilling injured fruits:

The number of injured fruits was recorded and calculated as percentage from the total number of the sample.

Soluble solids content % (SSC):

SSC of pomegranate was determined in the above obtained juice by the use of a hand refractometer according to Chen and Mellenthin (1981).

Titratable Acidity (TA):

Titratable acidity was measured in the juice of composite sample of the flesh of the fruits of each replicates by titration against diluted calibrated alkaline solution of known normality. Data are reported as titratable acidity percentage and expressed as 100 mg citric acid/ 100ml aril juice.

Ascorbic acid (v.C) contents:

For ascorbic acid (v.C) determination, 5 ml of samples of fruit juice + 5 ml metaphosphoric acid were added to each sample, then each sample was titrated with 2.6 dichlorophenol indophenol solution. The ascorbic acid content was expressed as milligrams of ascorbic acid per 100 ml of fruit juice, according to AOAC (1980).

Arils Anthocyanin content (mg/ 100g arils):

Anthocyanin of arils juice was determined following the method of Fuleki and Francis (1968). Three samples of 50 g arils of each treatments were extracted in 100 ml mixture of ethanol and HCl (85:15).

Five milliliters of the above extraction centrifugated for 10 min were measured spectrophotometrically at 535 nm and aril anthocyanin content was calculated as mg/ 100g sample.

The termination of the experiment was done by the occurrence of peel disorders (Shrinkage, drying and off shining). All data were statistically analyzed according to Snedecor and Cochran (1980). The individual comparisons were carried out by using the least significant differences (LSD) according to SAS Institute (1985).

RERSULTS AND DISCUSSION

(1) Physical analysis:

1- Fruit weight loss (%):

From the tabulated data (Tables 2 and 3) it was noticed that pomegranate weight loss percentages were higher in IW_2 (33°C and transfer at 0°C) and IW_3 (33°C and transfer at 5°C) compared with all other treatments in both seasons. These results were in line those reported also by (Arte's *et al*., 2000) on Sweet pomegranates and Tayel (2001) on peaches.

Weight loss increased slightly and gradually from the beginning of cold storage till the end.

The weight loss is mainly due to a result of water loss from the fruit tissues and partially of the respiration process and the higher storage temperature (EL-Yaten and Kader, 1984) and (EL-Nagar and EL-Saedy, 2005).

2- Juice volume (ml/ 100 gm arils):

The data in Tables 4 and 5 showed that the highest juice volume was noticed for fruits stored at 33°C for 3 days and transferred to 20°C for 24 hr, then stored at 0°C in both seasons. The lowest volume was in T_3 and T_5 in both seasons (EL-Naggar and EL-Saedy, 2005). The trend of juice volume decreasing with the progress of the storage period until 45 days in both seasons of the study. These results were in agreement with those previously reported by many researchers such as

Morton, (1987), Waskar *et al*. (1999) and EL-Naggar and EL-Saedy (2005).

Table 2. Effect of thermal post-harvest treatments on weight loss(%) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	0	1.70	3.586	4.960	-	2.562^{C}
5°C storage	0	2.92	4.460	6.050	7.403	4.167^{B}
IW_1	0	2.73	4.626	7.346	9.703	4.882^{A}
IW_2	0	4.67	6.80	8.806	-	5.069^{A}
IW_3	0	3.19	4.90	6.193	7.636	4.384^{A}
Means (A)	0^{E}	3.045^{D}	4.87^{C}	6.67^{B}	8.25^{A}	

	A	B
L.S.D	0.272	0.749

Table 3. Effect of thermal post-harvest treatments on weight loss(%) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	0	1.573	2.99	4.363	-	2.23^{E}
5°C storage	0	1.743	3.55	5.20	6.193	3.337^{D}
IW_1	0	2.423	4.183	6.58	9.010	4.44^{C}
IW_2	0	4.313	7.120	9.433	-	5.217^{A}
IW_3	0	3.950	5.90	7.116	8.34	5.062^{A}
Means (A)	0^{E}	2.800^{D}	4.75^{C}	6.54^{B}	7.85^{A}	

	A	B
L.S.D	0.248	0.519

Table 4. Effect of thermal post-harvest treatments on juice volume (ml/100 g arils) of Balady pomegranate cv. fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	122.50	117.65	94.00	95.11	-	107.315^{A}
5°C storage	122.50	107.99	84.44	80.366	75.11	94.08^{B}
IW_1	122.50	90.0	80.88	71.0	69.54	86.78^{C}
IW_2	122.50	99.33	106.166	81.89	-	102.47^{A}
IW_3	122.50	92.22	87.69	81.66	77.33	92.281^{B}
Means (A)	122.50^{A}	96.739^{B}	84.34^{C}	77.67^{D}	73.97^{D}	

	A	B
L.S.D	6.703	5.25

Table 5.Effect of thermal post-harvest treatments on juice volume (ml/ 100 g arils) of Balady pomegranate cv. fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	139.66	89.08	94.66	93.11	-	104.132^{B}
5°C storage	139.66	105.33	88.55	86.33	98.66	103.71^{B}
IW_1	139.66	88.0	103.77	78.88	77.33	97.53^{C}
IW_2	139.66	94.66	110.78	118.89	-	116.00^{A}
IW_3	139.66	92.066	79.33	70.00	85.11	93.235^{C}

Means (A)	139.66^{A}	95.132^{B}	90.554^{BC}	78.406^{D}	87.037^{BC}

	A	B
L.S.D	7.603	4.88

3- Chilling injury:

The data in Tables 6 and 7 indicated that in both seasons the intermittent warming (33°C for 3 days and transfer to 20°C for 24 h and storage at 0°C) and control (fruits were stored at 0°C after 15 days of storage) showed chilling injury which increased during storage period, where the treatment IW_3 at (33°C for 3 days and transfer to 20°C for 24 h and storage at 5°C) showed that no chilling injury symptoms and treatment IW_1 at (5°C and every one week the fruits were transferred to 20°C for 24h then returned at 5°C) reduced the chilling injury during storage. The obtained results were in agreement with those found by Artes and Tomas (2004) who found that the intermittent warming during the storage at 0°C prevented fungal development, although increased susceptibility to chilling injury symptoms like pitting where storage at 5°C considerably reduced chilling injury symptoms although the fungal attack was not completely inhibited. The warming treatments led to very good keeping quality of fruits.

(2) Chemical analysis:

1- Soluble solids Content (SSC):

The data introduced in Tables 8 and 9 indicated that, in both seasons, there was a significant effects on among treatments. Fruits that stored at 5°C had higher S.S.C% values compared with the fruits were stored at 0°C. On the other hand, in both seasons there were a significant effect on fruits stored at 5°C and transferred to 20°C for 24 hr and transferred to 5°C (IW_1), and fruits stored at 33°C for 3 days and transferred to 5°C (IW_3) had higher SSC%, compared with those stored at 33°C for 3 days and transferred to 0°C (IW_2). The obtained results were in agreement with those found by Arte's *et al*. (2000), Tayel (2001) and EL-Naggar and EL-Saedy (2005).

S.S.C values of Balady pomegranate fruits increased slightly and gradually from the begining of cold storage till the end of both seasons of the study.

This result was in agreement with the results of Koksal (1989) who attributed the SSC increasing to the loss of moisture leading to concentration of the soluble solids in Gok Bahce pomegranate fruits. However, Padule and Keskar (1988); Nanda *et al.* (2001) and Pierce and Kader (2003) observed decreases in SSC after cold storage of Ganesh, and wonderful pomegranates.

Table 6. Effect of thermal post-harvest treatments on chilling injury(%) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)				Means (B)
	15	30	45	60	
0°C storage	6.6	15.16	26.6	46	23.89^{A}
5°C storage	0.0	6.6	11.06	17.76	5.858^{C}
IW_1	0.0	0.0	6.6	12.15	4.683^{D}
IW_2	8.83	15.73	17.73	28.83	17.78^{B}
Means (A)	3.85^{D}	9.37^{C}	15.49^{B}	26.18^{A}	

* Angular transformation

IW_3: no chilling injury symptons

	A	B
L.S.D	1.874	1.874

Table 7. Effect of thermal post-harvest treatments on chilling injury (%) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)				Means (B)
	15	30	45	60	
0°C storage	6.6	11.06	28.83	33.3	19.94^{A}
5°C storage	0.0	6.6	13.7	24.6	11.22^{B}
IW_1	0.0	2.2	6.6	13.3	5.52^{C}
IW_2	6.6	15.53	24.43	37.53	21.025^{A}
Means (A)	3.3^{D}	8.85^{C}	18.395^{B}	27.18^{A}	

*Angular transformation

IW_3: no chilling injury symptons

	A	B
L.S.D	2.767	2.767

Table 8. Effect of thermal post-harvest treatments on SSC (%) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	15.80	15.56	16.13	15.73	-	15.80^{B}
5°C storage	15.80	16.46	16.20	15.93	16.20	16.12^{A}
IW_1	15.80	15.93	16.40	16.53	15.86	16.10^{A}
IW_2	15.80	15.66	15.46	15.73	-	15.66^{B}
IW_3	15.80	16.66	16.00	16.20	16.00	16.01^{A}
Means (A)	15.80^{B}	16.155^{A}	16.200^{A}	16.222^{A}	16.022^{A}	

	A	B
L.S.D	0.242	0.1781

Table 9. Effect of thermal post-harvest treatments on SSC (%) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	15.93	16.40	15.866	15.60	-	15.95^{B}
5°C storage	15.93	16.80	15.93	15.87	16.33	16.173^{A}
IW_1	15.93	15.73	16.27	16.53	16.13	16.12^{A}
IW_2	15.93	15.93	15.900	15.87	-	15.89^{B}
IW_3	15.93	15.86	15.47	16.13	16.33	15.92^{B}
Means (A)	15.93^{A}	16.089^{A}	15.89^{A}	16.178^{A}	16.27^{A}	

	A	B
L.S.D	0.4117	0.188

2- Titratable acidity % (TA):

The data of TA values are illustrated in Tables 10 and 11 showed that in the first season, there was no significant differences between all treatments except the fruits stored at 33°C for 3 days and transfer to 20°C for 24 h and storage at 5°C (IW_3) which had the lowest acidity. On the other hand, in the second season there was no significant differences among all treatments applied except storage at 0°C which had the lowest acidity. These results agree with those observed by Wasker *et al*. (1999) and EL-Yaten and Kader (1984). The major acid accounting for titratable acidity in pomegranate arils is citric acid (Kulkarni and Aradhydo, 2004). The data in the present study also pointed out that there was general decrease in TA values until 45 days of storage in both seasons (BettyHess *et al*., 2004).

3- Vitamin (C):

The data of the present investigation Tables 12 and 13 indicated that vitamin C values of Balady pomegranate, in the first season were significantly higher with IW_2 (33°C at 0°C) and IW_3 (33°C at 5°C) compared with both the control fruits and IW_1 (20°C) treatments. In the second season, it was noticed that IW_2 (33°C at 0°C) had significantly lower vitamin C compared with control fruits. The results obtained herein were supported with those found by EL-Helaly and Sobieh (2002). Vitamin C values of Balady pomegranate fruits during the period of cold storage showed irregular trend in both seasons.

4- Arils Anthocyanin content (mg/ 100 gm airls):

IW treatments clearly affected total anthocyanin content of pomegranate Tables 14 and 15. Generally, IW_3 (33°C at 5°C) had the highest anthocyanin content in both seasons. The above mentioned results agree with those of Arte's et al. (1998) who declared that red colour of the pomegranate arils (Mollar cv.) was kept better under IW treatment. Also, Arte's et al. (2000) reported that only some increases in total anthocyanin content were detected in IW.

The increase in the total anthocyanin content of pomegranate arils after harvest and the first period during storage may be due to the continued biosynthesis of phenolic compounds after harvest related to the ripening process (Miguel et al. 2004). The increasing of anthocyanin concentration after harvest was reported previously in pomegranates (Gill et al., 1995 and Holcroft et al., 1998) and that was correlated with the activity of the enzymes of the anthocyanin biosynthetic pathway.

Table 10. Effect of thermal post-harvest treatments on titratable acidity (%) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	1.86	1.11	0.463	0.386	-	0.808^{A}
5°C storage	1.86	0.936	0.636	0.49	0.69	0.788^{A}
IW_1	1.86	0.866	0.706	0.43	0.616	0.762^{A}
IW_2	1.86	0.876	0.700	0.470	-	0.7866^{A}
IW_3	1.86	0.4500	0.643	0.48	0.56	0.664^{B}
Means (A)	1.86^{A}	0.7511^{B}	0.662^{B}	0.467^{C}	0.6222^{B}	

	A	B
L.S.D	0.1532	0.0534

Table 11. Effect of thermal post-harvest treatments on titratable acidity (%) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	1.68	0.830	0.673	0.610	-	0.948^{A}
5°C storage	1.68	0.69	0.566	0.526	0.686	0.830^{B}
IW_1	1.68	0.94	0.576	0.430	0.623	0.852^{B}
IW_2	1.68	0.746	0.646	0.403	-	0.869^{B}
IW_3	1.68	0.596	0.850	0.520	0.613	0.850^{B}
Means (A)	1.68^{A}	0.742^{B}	0.664^{B}	0.492^{D}	0.641^{C}	

	A	B
L.S.D	0.096	0.045

Table 12. Effect of thermal post-harvest treatments on v.C (mg/ 100 ml juice) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	4.216	1.69	1.65	4.38	-	2.9866^{C}
5°C storage	4.216	4.0	2.96	6.18	4.73	4.4207^{A}
IW_1	4.216	2.40	2.80	5.97	2.56	3.59^{B}
IW_2	4.216	4.40	2.72	7.20	-	4.637^{A}
IW_3	4.216	2.80	2.02	8.57	3.366	4.35^{A}
Means (A)	4.216^{B}	3.071^{CD}	2.862^{D}	6.908^{A}	3.55^{C}	

	A	B
L.S.D	0.5313	0.3414

Table 13. Effect of thermal post-harvest treatments on v.C (mg/ 100 ml juice) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	2.783	2.047	2.93	5.303	-	3.658^{C}
5°C storage	2.783	7.12	3.786	5.476	4.633	4.76^{A}
IW_1	2.783	5.07	2.720	6.86	2.966	4.08^{B}
IW_2	2.783	3.023	2.77	6.053	-	3.267^{D}
IW_3	2.783	1.693	2.986	6.73	3.433	3.525^{CD}
Means (A)	2.783^{D}	4.628^{B}	3.16^{D}	6.357^{A}	3.677^{C}	

	A	B
L.S.D	0.452	0.3016

Table 14. Effect of thermal post-harvest treatments on arils anthocyanin content (mg/100 g arils) of cv. Balady pomegranate fruits in 2006 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	0.478	0.711	0.579	0.667	-	0.609^{B}
5°C storage	0.478	0.691	1.22	0.714	0.560	0.734^{A}
IW_1	0.478	0.90	0.637	0.557	0.609	0.6366^{B}
IW_2	0.478	0.742	0.749	0.7926	-	0.6906^{B}
IW_3	0.478	1.067	0.895	0.627	0.826	0.7791^{A}
Means (A)	0.478^{C}	0.8864^{A}	0.920^{A}	0.633^{B}	0.665^{B}	

	A	B
L.S.D	0.1432	0.0955

Table 15. Effect of thermal post-harvest treatments on arils anthocyanin content (mg/100 g arils) of cv. Balady pomegranate fruits in 2007 season

Treatments	Storage period (days)					Means (B)
	0	15	30	45	60	
0°C storage	0.472	0.741	0.570	0.537	-	0.580^{D}
5°C storage	0.472	0.974	0.946	0.567	0.4830	0.688^{C}
IW_1	0.472	1.056	0.938	0.584	0.5276	0.7158^{B}
IW_2	0.472	1.001	0.666	0.529	-	0.667^{C}
IW_3	0.472	0.8193	0.8567	0.783	0.9716	0.7806^{A}
Means (A)	0.472^{C}	0.950^{A}	0.913^{A}	0.645^{B}	0.660^{B}	

	A	B
L.S.D	0.0609	0.0331

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الملخص العربي

المعاملات الحرارية لتحسين الجودة وفترة حياة ثمار الرمان

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أجريت الدراسة فى خلال موسمى ٢٠٠٦، ٢٠٠٧ على ثمار الرمان البلدى مكتملة النمو بهدف دراسة تأثير المعاملات الحرارية المختلفة فيما بعد الجمع على تحسين الجودة وإطالة فترة حياة الثمار.

وقد أظهرت النتائج أن الحرارة المتقطعة تؤثر على أضرار البرودة حيث تقلل من أضرار البرودة على ثمار الرمان عند التخزين على درجة ٣٣°م لمدة ٣ أيام ثم نقلها على ٢٠°م لمدة يوم وكذلك عند التخزين على درجة ٢٠°م لمدة ٢٤ ساعة وكذلك تؤثر تأثيراً معنوياً على حجم العصير والحموضة ونسبة المواد الصلبة الكلية فى العصير فى كلا الموسمين وكذلك فيتامين ج ومحتوى الأنثوسيانين والفقد فى الوزن لثمار الرمان المخزنة. ووجد أن معاملة ٣٣°م لمدة ٣ أيام ثم ٢٤ ساعة على ٢٠°م ثم تنقل إلى ٥°م وأيضاً المعاملة ٢٠°م لمدة يوم كل أسبوع ثم تنقل إلى ٥°م أفضل المعاملات لتقليل أضرار البرودة، كما لوحظ أنه بزيادة فترة تخزين الثمار تقل نسبة الحموضة وحجم العصير فى الثمار بينما تزيد نسبة المواد الصلبة الكلية ومحتوى الأنثوسيانين والفقد فى الوزن فى كلا موسمى التجربة.