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Thermal Poststorage Treatment for Maintaining Fruit Quality and Extending Storage Life of Pomegranate Wonderful Cultivars

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Abstract

Cold storage is a widely used method for prolonging pomegranate fruit shelf life. However, low storage temperature may result in fruit decayed and chilling injury. So, this experiment was conducted to investigate the effect of different storage temperature (5, 10, and 20 °C with 85-90% RH) for maintaining quality criteria and storage period prolongation of pomegranate fruits cv. wonderful during 2018 and 2019 seasons. Fruit quality characteristics i.e., fruit weight, volume, length, and diameter, total aril weight, total juice weight and color parameters, of skin, aril and juice were investigated. Soluble solids content (TSS), total acidity (TA), ascorbic acid content (vitamin C), and total anthocyanin content were measured periodically for a storage period of 30 days for 5, 3 and 2 months respectively. Results indicated that pomegranate fruits stored at 5°C showed lower weight loss percent and higher firmness than that occurred in fruit stored at 10 and 20°C with more expand storage period. Pomegranates stored at 5°C recorded the highest fruit weight, fruit volume, aril weight and juice weight with the lowest fruit specific gravity after four months. While, the highest fruit length and diameter were noted at 10°C storage after the third month. The highest anthocyanin content was recorded for pomegranate fruits after five storage months at 5 ° C. Lightness (L) and Chroma (C*) colour parameters in skin and aril of wonderful pomegranate fruits had higher gradual increment compared with its values at harvest. Meanwhile, hue angle (H^0) color parameter clarified remarkable reduction trend throughout different storage temperatures such as 5, 10 and 20 °C with expanding storage periods. On the other side, fruit juice colour (Lightness (L*) and Chroma (C*)) cleared a significant decrease with a noticeable increment for hue angle (h^o) respectively compared with initial value at harvest. From these results it can be concluded that cold storage at 5°C was better than storage at 10 and 20 °C for expanding the market duration of pomegranate fruits.

***Keywords*:** Pomegranates, Wonderful cv., Fruit quality, Color parameter, Storage temperature and duration

1. Introduction

Worldwide consumer demand for pomegranate (***Punica granatum* L.**) fruits is increasing steadily due to its nutritional and health promoting benefits. This necessitates the need to supply markets with high quality pomegranates for extended periods. However, pomegranate is a highly perishable fruit in spite of low respiration rate [1]. The pomegranates are classified as non-climacteric fruit due to rates of ethylene production, low respiration rates, and also, the fruit does not continue ripening off the tree [2]. The peel is a highly contents of phenolic and tannin so, it has been used in the Middle East as colorants for textiles [3]. The high antioxidant activities of pomegranate fruit are attributed to high levels of polyphenolic compounds, which act as good free radical scavengers [4].

Wonderful' pomegranate is the most cultivated and consumed globally [5]. Wonderful' is desirable because its bioactive compounds are better maintained during a prolonged storage duration compared to other cultivars. Fruit quality properties of 'Wonderful' were recorded through five storage months [6]. Pomegranate fruit may be stored for several months at temperatures below 10°C to prolong the marketing value [7]. Although it is sensitive to low

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temperature, low temperature storage is still an effective means to maintain the freshness of pomegranate for several months [8]. Optimum storage conditions have been reported to range between 0 to 10°C, depending on fruit cultivar. Furthermore, storage of pomegranates at ambient temperature reduces the shelf life mainly due to increased desiccation resulting in a brownish colored tough peel [9].

Storage temperature duration and variety are among the most important factors affecting fruit viability and quality and avoiding chilling injury. The minimum safe storage temperature is 5°C. Meanwhile, 7°C was the best temperature for long term storage to avoid chilling injury [10]. Postharvest conditions like storage temperature and relative humidity percent could be used extending storage periods by keep fruit quality [11].

Several postharvest disorders could occur during short and/or long-term storage. Apart from the external postharvest quality defects, such as moisture loss, leading to appearance of browning spots on the skin surface [12], internal quality of the fruit could also affect Moreover, decline in the total soluble solids and titratable acidity [13]. In addition, the reduction of fruits skin color caused by anthocyanins degradation ([14]. Pomegranate fruit 'Wonderful' was disposed to chilling injury and quality loss when stored longer than one month at temperatures between -3°C and 5°C or upon transfer from cold storage to 20°C.

The objective of this study is to investigate the effectiveness of some different storage temperature (5, 10, and 20 °C) on maintaining quality criteria and storage period extension of wonderful cv. of pomegranate fruits.

2. Experimental

2.1. ***Fruits samples:*** Pomegranate fruit cv. Wonderful was harvested from a private orchard at Cairo Alex Road (about 83 km from Cairo), Egypt. Fruits were harvested at maturity stage from 8 years old trees in sand-loam soil, planted at 3.5 X 3.5m apart and received common horticultural practices during 2018 and 2019 seasons. Fruits were chosen to be similar as possible in color and size, and free of any noticeable pathological or mechanical injuries. Fruits instantly transported to the post-harvest lab of Agriculture Development System (ADS), Faculty of Agriculture; Cairo University.

2.2. ***Treatments:*** All received fruits similar in shape, color, and firmness were selected, washed, in chlorinated water (100 ppm free chlorine) for 10 min., air dried and packed in carton boxes (30 cm width * 37 cm length * 15 cm height). Pomegranate fruit were stored at three different temperatures (5, 10 and 20°C) in controlled temperature rooms (Bally sectional Prefab wall, Ins. USA) with relative humidity 85-90 % for 5, 3 and 2 months respectively. Each treatment constituted three replicates for each sampling time (30 days) and each replicate consisted of 3 pomegranate fruits intervals through storage period. Samples for fruit quality were evaluated for different physical and chemical properties at one-month intervals during cold storage period. The maturity indices measurements *2.12.* were determined at Tables (1, 2 and 3).

Table 1: Fruit physical characteristics of wonderful pomegranate fruits at harvest

Fruit maturity indices	Volume	Length	diameter	Weight	Aril weight	Juice weight	Firmness
	cm^3	cm		gm			(Newton)
	557.60	82.77	95.42	464.67	236.67	174	77.24

Table 2: Fruit chemical characteristics of Wonderful pomegranate cultivar at harvest

Fruit maturity indices	TSS	Acidity	TSS/Acidity	Ascorbic acid (VC)	Total anthocyanin
	(%)			(mg/100g f. w.)	
	15.93	4.1	3.86	54	8.75

Table 3: Fruit colour characteristics of wonderful pomegranate fruits at harvest

Skin			**Aril**			**Juice**		
L	C	h°	L	C	h°	L	C	h°
2.3. 49.81	***2.4. 26.50***	***2.5. 18.60***	***2.6. 36.06***	***2.7. 8.16***	***2.8. 17.83***	***2.9. 44.04***	***2.10. 11.99***	***2.11. 113.8***

2.3. ***Fruit physical characteristics:*** Fruit weight (gm), Fruit volume (cm3), Fruit dimensions (length and diameter (cm)), Fruit aril and Juice weight (gm) were measured during each sampling date (30 days).

2.4. ***Weight loss percent (%):*** Fruits were weighed at the beginning and after an interval of 30 days. The mass loss % was calculated as the following equation:

Mass loss (%) = (wt. of 1st interval – wt. of 2nd interval) x100 / wt. of the 1st interval

2.5. ***Fruit firmness (Newton):*** Fruit firmness was measured using Ametek pressure tester, fitted with an 8 mm hemispherical probe (probe penetration 2 mm). Firmness of three fruits from each replicate was measured at two opposite points on the equator of each fruit, results calculated as Newton units [15].

2.6. ***Fruit color measurements:*** Skin, arils and juice color was measured by using Minolta colorimeter (Minolta, 300, Osaka, Japan) on the basis of the CIELAB color system (L*, C* and h°). C* and h° values are calculated based on a* and b* values according to McGuire (1992).

2.7. ***Fruit quality analysis:*** Freshly prepared juice of pomegranate fruits samples was used for TSS, TA and ascorbic acid determinations [15]**.** TSS content was measured using a T/C hand refractometer. Total Acidity (TA) expressed as malic acid was determined by titrating 5 ml juice with 0.1N sodium hydroxide using phenolphthalein as an indicator. Ascorbic acid content (VC) was measured using 2, 6 di-chlorophenol indophenols' method.

2.8. ***Total anthocyanin (mg/100g f. w.):*** Total anthocyanin content was measured calorimetrically at 535 nm of arils juice according to the methods of [16].

2.9. ***Statistical analysis:*** The design for this experiment was a completely A randomized design (CRD) with three replications. Data were analyzed with the analysis of variance (ANOVA) procedure of MSTATC program [17]. Treatments means were compared by Duncan's multiple range tests at 5% level of probability.

3. Results and Discussion

3.1. ***Fruit physical Characteristics:*** Fruit weight (g), volume (cm^3), and Specific Gravity ($gm\backslash cm^3$): The data in Table (4) studied the effect of different storage temperatures such as 5, 10 and 20 °C with expanding storage periods on weight, volume and specific gravity of pomegranate fruits (Wonderful cv.) during the average of 2018 and 2019 seasons. It is clear from the results that fruit weight and volume were reduced gradually along the storage period. While, specific gravity appeared the opposite trend. Pomegranate fruits stored at 5°C recorded the highest weight and volume followed by stored fruits at 10°C. On the other hand, pomegranate fruits stored at 20 °C recorded the lowest fruit weight and volume. The highest specific gravity (1.11 g/cm3) recorded by fruit stored at 10°C after two months followed by fruit stored at 20 °C (0.90 g/cm3). While, stored fruit at 5 °C calculated the lowest fruit specific gravity after four months (0.82 g/cm3).

3.2. ***Fruit length, and diameter (mm***): The results representing the effect of different storage temperatures such as 5,10 and 20 °C with extending storage periods on fruit length, and diameter (mm) of pomegranate fruits (Wonderful cv.) were listed in Table (5). Fruit length and diameter were decreased significantly with the advancing of the storage period during the average of both seasons. The lowest fruit length and diameter were logged after storage at 5 °C for 5th month (60 and 64.74 mm). While, the highest fruit length and diameter were noted at 10°C storage after the third month (77 and 88.45 mm) compared with stored fruits at 20 °C (73.35 and 82.85 mm) for 2nd month.

3.3. ***Aril and Juice Weight/ fruit (g***): It can be seen from data presented in Table (5) there were gradual and non-significant decreases of aril and juice weights of pomegranate fruits cv. Wonderful during different storage temperatures till the storage period ended. Pomegranate fruits stored at 5 °C recorded the highest aril weight (230 g) after 5th month followed by stored fruit at10 °C (225 g) compared with stored fruit at 20 °C which recorded the least aril weight (182.50 g) after 2nd month. Also, juice weight of pomegranate fruits clarified the same trend during the average of both seasons. Pomegranate fruit quality assessment is based on different important external properties includes fruit size, and fruit shape. These attributes vary depending on growing region, cultivar differences and degree of maturity [13]. Results recorded that fruit attributes such as weight, length, volume, aril weight per fruit and number of aril/fruit are closely correlated therefore; any of these traits could be utilized as an indicator of fruit size. The number of arils per fruit was highly correlated with fruit size with larger fruit containing greater numbers of arils [18].

3.4. ***Fruit Weight Loss (%):*** Pomegranate is highly susceptible to weight loss due to the high porosity of the fruit peel which permits free water vapor movement [19], and the susceptibility could depend on storage conditions. The effect of different storage temperatures with expanding storage periods on cumulative weight loss percentage of pomegranate fruits cv. Wonderful were showed in Table (6). The data showed significant increase in fruit weight loss

with increasing the storage temperatures and durations. Pomegranate fruits cv. Wonderful stored at ***3.5.*** 20 °C recorded the highest weight loss percentage (29.74 %) after two storage months, followed by fruits stored at 10 °C for three months (25.84 %.), and either fruits stored at 5°C recorded the least percent of weight loss (23.42 %) after five storage months during the average of two study seasons. This view point is buttressed by Fawole and Opara [13], who reported that storage of both 'Bhagwa' and 'Ruby' at 5°C, 7°C, 10°C and 22°C showed increase in weight loss with storage temperatures and duration up to 16 weeks. In this respect, Fawole *et al.* [5] recorded that pomegranates fruit "wonderful" stored at 5°C have weight loss percentage below 10% after the first month. Temperature is a crucial variable, influencing the respiration rate of many fruits [20].

3.6. ***Fruit Firmness (Newton):*** Firmness (N) of pomegranate fruits cv. Wonderful showed a gradual and significant reduced with the prolonging of storage period at 5,10 and 20 °C during the mean of two seasons under study (Table, 6). Fruits stored at 5 °C was more effective in keeping fruit firmer (70.96 N) after the 5th week of storage followed by stored fruit at 10 °C (68.44 N) after 3rd week of storage. While, the least fruit firmness was recorded by fruit stored at 20 °C (64.59 N) after 2nd storage week. These results are consistent with Nanda *et al.*[21] who obtained that pomegranate fruit firmness of 'Ganesh' variety, were decreased from 1st to 2nd storage months at 8, 15 and 25 °C. Fruit firmness of Wonderful pomegranates increased after one month of storage at 5 °C then decreased, this was attributed to the loss of moisture from the fruits, which led to the occurrence of the initial hardness as a result of the increase in the strength of the fruit peel [22].

Table 4. Effect of storage temperatures on fruit weight (gm), fruit volume (cm^3) and specific gravity ($gm\backslash cm^3$) of pomegranate fruits in average of 2018 and 2019 seasons.

Months	Fruit physical characters								
	Fruit Weight (g)			Fruit Volume (cm^3)			Specific Gravity (gm/cm^3)		
	5°C	10°C	20°C	5°C	10°C	20°C	5°C	10°C	20°C
1st	439 a	420 a	352 abc	516.7a	500.0a	400.0cd	0.85b	0.85b	0.89bb
2nd	435 a	406 ab	285 bc	490 ab	366.7de	315.0e	0.89b	1.15a	0.91b
3rd	402.50 ab	269.50 c	-	466.7 abc	366.7de	-	0.83b	1.10a	-
4th	350 abc	-	-	425 bcd	-	-	0.82b	-	-
5th	347.50 abc	-	-	408.3cd	-	-	0.85b	-	-

Table 5. Effect of storage temperatures on fruit length (cm), fruit diameter (cm) aril weight (g) and juice weight (g) of pomegranate fruits in average of 2018 and 2019 seasons.

Months	**Fruit physical characters.**											
	Fruit Length(cm)			**Fruit Diameter (cm)**			**Aril Weight (g)**			**Juice weight (g)**		
	5°C	**10°C**	**20°C**	**5°C**	**10°C**	**20°C**	**5°C**	**10°C**	**20°C**	**5°C**	**10°C**	**20°C**
1st	**80.15ab**	**81.35ab**	**82.41 a**	**85.88 bc**	**90.06 a**	**84.91bc**	**236.70 a**	**236.70 a**	**230.00 a**	**167.00 a**	**161.00a**	**130.00b**
2nd	**71.0 d**	**77.0 bc**	**73.35 cd**	**79.0 d**	**88.45 ab**	**82.85 cd**	**233.30 a**	**231.70 a**	**182.50 b**	**165.30 a**	**153.70ab**	**97.50 c**
3rd	**71.0 d**	**77.0 bc**	**-**	**70.7 9 e**	**88.45 ab**	**-**	**233.30 a**	**225.00 a**	**-**	**158.00 a**	**148.30ab**	**-**
4th	**60.04 e**	**-**	**-**	**64.74 f**	**-**	**-**	**231.70 a**	**-**	**-**	**147.30 ab**	**-**	**-**
th	**60.04 e**	**-**	**-**	**64.74 f**	**-**	**-**	**230.00 a**	**-**	**-**	**146.70ab**	**-**	**-**

Table 6. Effect of storage temperatures on weight loss (%) and firmness (N) of pomegranate fruits in average of 2018 and 2019 seasons.

Months	Fruit physical characters.					
	Weight Loss %			Firmness (N)		
	5°C	10°C	20°C	5°C	10°C	20°C
1st	7.51g	15.64 e	20.83 cd	75.55 a	73.92 ab	67.99 e
2nd	8.08 g	20.93 cd	29.74 a	73.48 abc	68.73 de	64.59 f
3rd	11.76 f	25.84 b	-	72.58 bc	68.44 de	-
4th	18.88 d	-	-	71.03 cd	-	-
4th	23.42 bc	-	-	70.96 cd	-	-

3.7. Fruit color attributes:

3.7.1. ***Fruit peel color****:* This study showed that changes in fruit peel color parameters (L*, C* and h0) were influenced by cold storage temperatures and storage duration (Fig. 1). In general, fruit peel intensity lightness (L*) and Chroma saturation (C*) increased gradually during the cold storage duration at 5, 10 and 200C respectively, was concomitant with decrease in hue angle (h0) parameter. The results were revealed that, the highest intensity Lightness (L*) values (50.53, 50.42 and 49.81) were noticed in the skin fruits after five, three and two-weeks storage at 5 ,10 and 20°C respectively compared with harvest time value

3.7.2. (49.81). Also, Chroma saturation color (C*) revealed the same trend. On the other side, peel hue angle (h◦) decreased significantly with progress the cold storage and recorded the least values at the end of storage period.

3.7.3. ***Fruit aril color***: Arils are the edible part of a pomegranate fruit with rich-anthocyanin pigment meets the consumer acceptance. The pomegranate arils fruits cv. wonderful revealed a significant and gradually increase in intensity lightness (L*) and Chroma saturation (C*) with extending cold storage period at 5, 10 and 200C respectively (Fig. 2). Arils hue angle decreased gradually and significantly which recorded the least values at the end of storage period (13.43, 11.83 and 15.50) compared to their initial value (17.83) as an average of both seasons of study.

3.7.4. ***Fruit juice color:*** Consumer appeal and preference for pomegranate juice was influenced by juice color which an important quality parameter. Pomegranate fruits cv. Wonderful cleared significant and gradual decrease of fruit juice color with red color expressed as Lightness (L*) and Chroma (C*) color factors till the third month of storage (30.47 and38.33) then increased till the end of storage period at 5 and 100C respectively (Fig. 3). Also, the same trend of Chroma (C*) color parameters (1.68, 1.83 and 9.7) was observed. On the other side, hue angle (ho) ratings of juice color appeared a noticeable increment with the highest value (324, 323 and 237) respectively compared with initial value at harvest (113.8) as an average of both seasons of investigations.

These results of study are in accordance with those reported with Ercisli *et al.* [23], they revealed that Chroma (C*) is one of the most important appearances used to define the quality of fruit color and has a critical impact on the consumer acceptance. The increase in Chroma (C*) values could be as a result of biosynthesis and an accumulation of anthocyanin pigments in the peel, resulting in intense red coloration [24]. Pomegranate fruits cv. wonderful had higher gradual increment brightness red color effect of lightness and Chroma in all fruit parts (skin, aril and juice) compared with its values at harvest. Meanwhile, hue angle color parameter cleared a noticeable reduction trend throughout cold storage period (Yousef et al., 2020). Overall, these results defined that fruit peel and aril color was better at 5°C for 3 months when peel and arils color parameters (red coloration (L*) and intensity (C*)) were considerably higher than fruit color at harvest. Initial increase in pomegranate peel color during the first three months of storage although external appearance deteriorated up till the end of storage (5 months at 5 and 10 ◦C) [6].

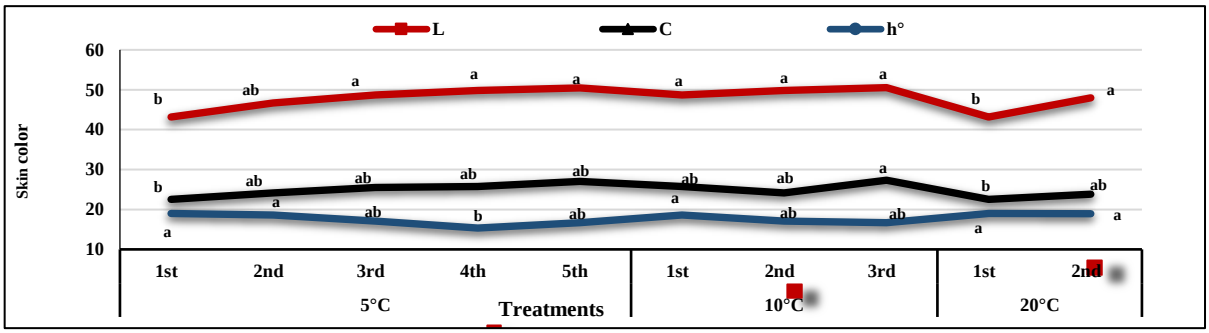

Fig. 1. Skin colour parameters (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful as affected by storage temperatures in average of 2018 and 2019 seasons.

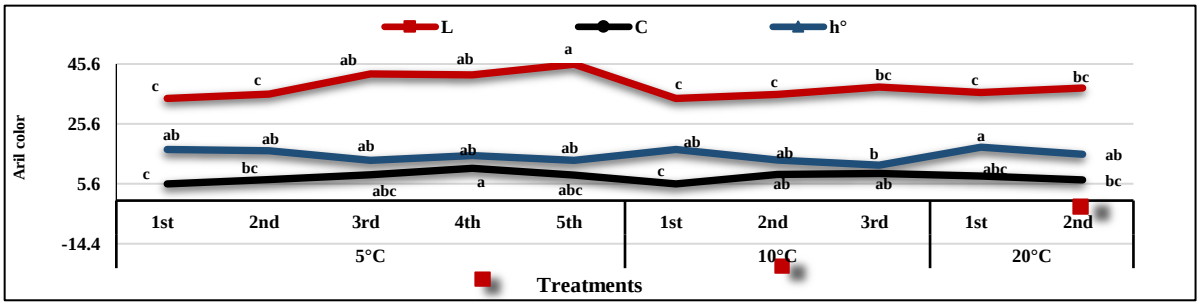

Fig. 2. Arils colour parameters (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful as affected by storage temperatures in average of 2018 and 2019 seasons.

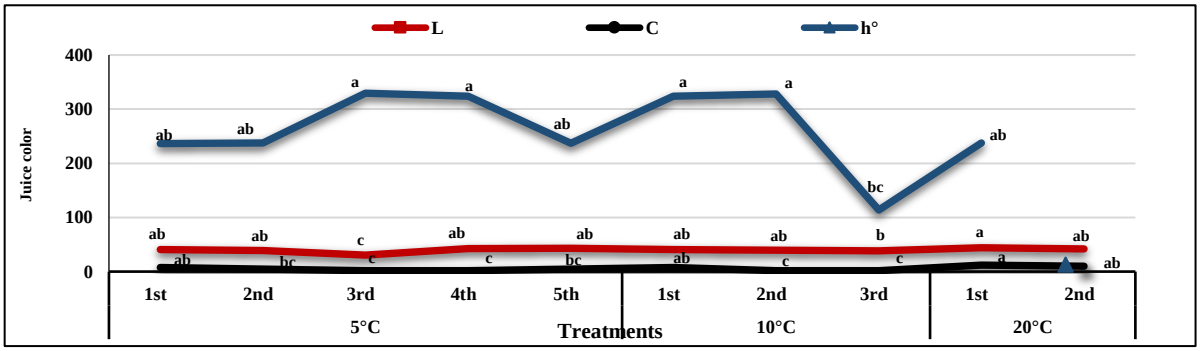

Fig. 3. Juice colour parameters (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful as affected by storage temperatures in average of 2018 and 2019 seasons.

Table 7. Effect of storage temperatures on SSC (%), TA (%) and TSS/Acid Ratio (%) of pomegranate fruits in average of 2018 and 2019 seasons.

Characters / Months	Fruit Chemical Characteristics								
	TSS (%)			Fruit Acidity (%)			TSS/Acid Ratio (%)		
	5°C	10°C	20°C	5°C	10°C	20°C	5°C	10°C	20°C
1st	15.43d	15.40 d	15.90 cd	1.69 a	0.90 b	0.91b	9.26 e	17.11 d	18.86 d
2nd	15.90 cd	16.33 bc	17.07 ab	0.97 b	0.60 c	0.28 d	16.39 de	27.22 c	62.99 a
3rd	15.95 cd	17.67 a	-	0.54 c	0.28 d	-	29.54 c	62.85 a	-
4th	16.10 cd	-	-	0.37 d	-	-	43.97 b	-	-
5th	16.47 bc	-	-	0.26 d	-	-	64.38 a	-	-

Table 8. Effect of storage temperatures on ascorbic acid and total anthocyanin (mg\100gm F.W.) of pomegranate fruits in average of 2018 and 2019 seasons.

Characters / Months	Ascorbic acid			Anthocyanin		
	mg\100gm F.W					
	5°C	10°C	20°C	5°C	10°C	20°C
1st	48.67a	40.33bc	38.67bc	8.75 e	11.87 a	8.75 e
2nd	41.33b	28.33d	21.00e	9.25 de	8.75 e	10.44 bc
3rd	35.33c	21.33e	-	10.04 c	9.95 cd	-
4th	23.33de	-	-	10.83 b	-	-
5th	20.00e	-	-	11.15 ab	-	-

3.8. Fruit Chemical Characteristics:

3.7.1. TSS (%), Acidity (%), and TSS/Acid Ratio: The results in Table (7) showed that the content of soluble solids and TSS/Acid ratio increased gradually throughout different storage temperatures (5, 10 and 20oC) with the advancing of the storage period until it reached the highest value at storage period ended. The highest TSS percentage revealed by stored fruits at 10°C (17.67) after third month of storage followed by stored fruits at 20 °C (17.07) and the lowest TSS percentage recorded after 5th month storage at 5 °C (16.47). On the other hand, the highest TSS to acid ratio observed after five months of storage at 5 °C (64.38) followed by stored fruit at10 and 20 °C (62.85 and 62.99 respectively) without any significant differences. On the contrary, the total fruit acidity decreased gradually until it reached the lowest percent at the end of storage period. Fruit pomegranates stored at 5 °C recorded less acidity (0.26 %) compared to those stored at 10 and 20 °C (0.28 and .28 %). The pomegranate fruits taste is determined by the level of juice TSS and the ratio between the TSS and TA [25]. Chemical properties such as TSS, acidity and TSS: acid ratios have been used to describe taste (flavor) with regards to the sweetness [26]. The pomegranate juice sweetness depends on sugars types, while, its acidic tastes are as a result of its organic acids, majorly. So, the sweet pomegranate cultivars having high sugar content and low organic acid levels meanwhile, sour cultivars have higher organic acid and low sugar content levels ([27]. These studies are in agreement with Fawole and Opara [9] who reported that TSS contents changes of pomegranate varied, depending on cultivar types, fruit maturity, storage conditions and agro-climatic regions during storage and at harvest. While, the acidity decreases found for Bhagwa' and 'Ruby' pomegranates which stored at 5°C, 7°C and 10°C for 4 months.

3.7.2 Ascorbic acid content (mg\100gm. F.W.): Ascorbic acid is an important quality factors, which is very sensitive to degradation due to its oxidation during storage. The ascorbic acid content decreased gradually and significantly affected by different storage temperatures (5, 10 and 20oC) reached the lowest content at the end of storage period for pomegranate fruits cv. Wonderful during the average of two seasons as shown in Table (8). The stored pomegranate fruits at 5°C showed superiority in their vitamin C content compared with stored fruits at10 and 20°C during all storage periods. The highest ascorbic acid content obtained from fruits stored at 5°C, while the lowest content recorded from fruits stored at 20°C. This is comparable with Opara *et al.* [28], who reported that refrigeration significantly enhanced vitamin C retention. Ascorbic acid reduction may be due to the irreversible oxidation of dehydro-L-ascorbic acid (DHAA) to 2, 3-diketo-Lgulonic acid. Further, activity of ascorbic acid is reduced by the presence of oxygen, alkalinity and high temperatures [29].

3.7.3 Total anthocyanin (mg\100gm F.W.): Anthocyanin is the main phenolic compounds responsible for the purple-red colors of pomegranate. Pomegranate fruit anthocyanin were found to possess higher antioxidant activity than Vitamin-C, Vitamin-E, and β-carotene [30]. Total anthocyanin content of pomegranate fruits cv. Wonderful had a gradual and significant increase with the advance of storage period throughout the different storage temperatures (5, 10 and 20oC) during the average of two successive seasons (Table 8). Pomegranate fruits stored at 5 °C resulted in significantly the highest content of anthocyanins after 5th storage month (11.15mg/100g f. w.) followed by stored fruits at 20oC after 2nd storage month (10.44 mg/100g f. w.) compared with stored fruits at 10°C which recorded the less increase of anthocyanins concentration after 3rd storage month (9.95 mg/100g f. w.). Anthocyanin compounds are responsible for the characteristic red coloration in pomegranate fruit peel and juice (Artés et al.; 1998). It is clear at this study that the percentage of anthocyanins increased at low temperatures (5 and 10°C) compared to fruits stored at 20 °C. In addition, the anthocyanin percentage increased with the length of storage period. These results agreed with, Fawole and Opara [31] who reported that the focus of total juice anthocyanin increased between harvest and after

four storage months at 5°C, 7°C and 10°C for 'Bhagwa' and 'Ruby'. Also, Miguel *et al.* [32] found that anthocyanin concentration increased for 'Assaria' pomegranate fruit grown in Portugal after the first month of storage at 5°C.

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