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CULTIVATED AREA CHARACTERISTICS ON WONDERFUL POMEGRANATE FRUITS QUALITY UNDER COLD STORAGE CONDITIONS

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Abstract

Pomegranate has been traditionally cultivated since ancient times under diverse agro-climatic conditions and its fruit is one of the high valued crops. This experiment was carried out during two successive seasons of 2017 and 2018 in order to evaluate the effect of Beheira and Minya climate, water and soil conditions on the physico-chemical properties of Wonderful pomegranate fruits under cold storage conditions (5±1°C with 85-90% RH) for 5 months. Fruit weight, volume, length, and diameter, skin and total aril weight, juice weight and color parameters, of skin, aril and juice were measured. Fruits were also analyzed for soluble solids content (TSS), total acidity (TA), ascorbic acid (vitamin C), and total anthocyanin. The obtained results cleared that pomegranate fruit cv. Wonderful produced at Beheira had better physical properties than at Minya location throughout storage period. Minya location was superior in chemical parameters especially total acidity, TSS/acidity and total anthocyanin content. In addition, fruits of wonderful pomegranate 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. Generally, Minya location had better color appearance of pomegranate fruits than Beheira area especially in aril and juice color and chemical quality characteristics. Total solar radiation, mean minimum temperature, RH increased with increase in TSS, Acidity and vitamin C content at Beheira location, whereas, the opposite was trend in the second location (Minya). Also, results noticed that increasing ETo lead to increase of TSS/Acidity ratio and total anthocyanin.

***Keywords*:** Pomegranate Fruit, Wonderful cv., Locations, Quality and Cold storage

Introduction

Pomegranate (*Punica granatum* L.) is one of the preferred fruits in the world and one of the promising exportation fruits in Egypt on the last years (Abd-elghany *et al*., 2012). Because of its high nutritional and therapeutic qualities, a good source of natural antioxidants (Gil *et al*., 2000) such as anthocyanins, flavonoids, and phenolic acids (Zaouay *et al*., 2012). In addition, it is rich in the usual nutrients such as vitamins and minerals (Fawole and Opara, 2013).

Pomegranate is a fascinating fruit tree in arid and semiarid areas, even under desert conditions; since it possesses drought tolerance characteristics and ability to confront water stress (Galindo *et. al*., 2014). In addition, pomegranate is characterized by its ability to grow under a wide range of locations such as tropical or subtropical as well as temperate (Aviram *et al*., 2001). Thus, the cultivated area of pomegranate is increasing continuously recently in Egypt, especially in the new reclaimed areas where the total cultivated area reached about 26351 feddans with fruiting area about 9746 feddans which produced about 89035 tons (Agriculture economic of Egypt, statistics, 2017).

Wonderful pomegranate is later cultivar with high yield, large fruit, rich red aril, high juice, and good palatability (Palu *et al*., 2007). It is also currently one of the most desired planted pomegranate cultivars in Egypt since it offers best balance combination yield and quality (Abd-elghany *et al*., 2012). The pomegranate cv. Wonderful is also known for its health benefits that may help in the prevention of heart disease, cancer and problems associated with aging Anoun, 2004). Currently, the cultivation of pomegranate Wonderful is increasing in Egypt, especially in new reclamation areas, the exposure of fruits to high heat and sunlight lead to some mechanical and physiological damage, which affect its quality and marketing value (Abou El-Waffa, 2002).

Cultivation of many pomegranate cultivars are mostly based amongst many things, like on climatic conditions (Prasad and Bankar 2000; Prasad *et al.*, 2003), and physico-chemical qualities of the cultivar (Tehranifar *et al.*, 2010; Zhuang *et al.*, 2011), which would further determine maturity and markets. Physico–chemical properties of cultivar Wonderful pomegranate were significant differences in all measured factors excluding percentage of aril yield due to different location of cultivation (Mashavhathakha *et al.*, 2014).

The aim of this study is to evaluate the Climatological conditions effects of two different locations (Beheira and Minya Governorates) on postharvest quality attributes of wonderful pomegranate fruits during cold storage at 5^{o} C.

Materials and Methods

This experiment was conducted during two successive seasons of 2017 and 2018 on pomegranate fruits cv. Wonderful grown in private orchards of two different locations. The first site was in Beheira Governorate (83 km Alex/Cairo road) and the second in Minya Governorate (191 km Cairo/ Asuit). Pomegranate trees were 8 years old, grown in sand-loam soil, planted at 3.5 X 3.5m. apart, received common horticultural management as recommended.

Pomegranate fruits were harvested from two locations and were chosen to be similar as possible in color, size and free of any pathological or mechanical injuries. Fruits were intently transported carefully to the laboratory of Agricultural Development Systems (ADS), Faculty of Agriculture, and Cairo University. All fruits were washed in chlorinated water (100 ppm free chlorine) for 10 min., air dried and randomly distributed in callboard cartons, then stored at 5°C in

controlled temperature rooms with 85-90% relative humidity for 5 months. Three replicates for each sampling date (30 days) were used and each replicate consists of 3 fruits. Samples for fruit quality were assessed for different physical and chemical properties at one-month intervals during cold storage period (150 days). The initial quality measurements at harvest for two locations were determined at Table (1, 2).

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

Initial time	Volume	Length	diameter	Weight	Skin weight	Arils weight	Juice weight	Resp. rate	Firmness
	(cm)			(g)				(ml/k/hr)	(Ib/inch^2)
Beheira	513 b	83.27 b	95.83 a	430 b	201 a	278.33 a	172 a	16.17 a	16.67 a
Minya	550 a	87.08 a	83.13 b	462 a	156 b	260 b	125 b	14.78 b	17.00 a

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

Initial time	TSS	Acidity	TSS/Acidity	Ascorbic acid (VC)	Total anthocyanin
	(%)			(mg/100g f. w.)	
Beheira	16.67 a	2.03 a	8.22 b	34.00 a	12.25 b
Minya	13.60 b	1.05 b	13.01 a	29.00 b	14.94 a

Soil and water analysis: Soil texture is loamy sand in both experimental sites. Soil pH and electrical conductivity (EC) were determined by Hanna Instruments HI2550 pH/ORP/EC/TDS/NaCl Benchtop Meter. Soil particle distribution was determined by (Soil Survey Staff, 1993). Both cations and anions were determined with (Rebecca, 2004). $CaCO_3$ was determined using Calcimeter Bernard Method from (Soil Survey Staff, 1993).

Climate parameters: Climatological parameters of both sites were collected using Central Lab of Agricultural Climate, Agricultural Research Center, Giza) such as maximum and minimum and mean temperature (T), relative humidity (RH), solar radiation (Rs) and reference evapotranspiration (ETo)

Fruit Characteristics: At each sampling date fruit characteristics were measured as follows: Fruit weight (gm), Fruit volume (cm^3), Fruit dimensions (length and diameter (cm)), skin weight /fruit (gm), Aril weight /fruit(gm), Juice weight / fruit (gm)

Weight loss percent (%): Fruits were weighed at the beginning and after an interval of 30 days for a period of 150 days storage. The Mass loss % was calculated as the following equation: -

$$\% \text{ Mass loss} = \text{wt. of 1st interval} - \text{wt. of } 2^{ed} \text{ interval} \times 100 / \text{wt. of the first interval}$$

Decay Incidence (%): Fruits which were decayed by different physiological and pathological factors were periodically counted and discarded. Then percentages of decayed fruits were calculated in relation to total number of fruits.

CO_2 Production (ml $kg^{-1}hr^{-1}$): Fruits of each sampling date were weighed and placed in 2-liter jars at room temperature or 20^{o}C. The jars were sealed for 24 hr. with a cap and a rubber septum. O_2 and CO_2 samples of the headspace were removed from a septum with a syringe and injected into Servomex Inst (Model 1450C-Gas Analyzer). to measure oxygen and carbon dioxide production Respiration rate was calculated as ml CO_2/kg/hr (Pesis and Ben-Arie, 1984 and Lurie and Pesis, 1992).

Fruit firmness (Lb/inch^2): 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. (A.O.A.C., 1995).

Fruit quality analysis: 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 dichlorophenol indophenols' method described by (A.O.A.C., 1995).

Total anthocyanins (mg/100g f. w.): Total anthocyanins content was measured colorimetrically at 535 nm of arils juice according to the methods of Flueki and Francis (1968).

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*, a*, b*, C* and h^o). In this system, L*, a* and b* describe a three-dimensional color space, where L* (Lightness) is the vertical axis and its value varies from 100, for perfect white to zero, for black. Chroma (C*) describes the length of the color vector. C* and h^o values are calculated based on a* and b* values according to the Eq.

$$\text{Chroma (C*)} = [(a^*)2+(b^*) \text{ and Hue } (h^o) = \tan G1 (b^*/a^*) \quad (1).$$

Five fruits were measured objectively by averaging three measurements taken around the fruit equator. Color was longitudinally determined on three points of each fruit according to McGuire (1992).

Statistical analysis: The design for this experiment was a completely randomized design (CRD) with three replications. Data were analyzed with the analysis of variance (ANOVA) procedure of MSTATC program. (Steel and Torrie, 1997). Treatments means were compared by Duncan's multiple range tests at 5% level of probability.

Results

Soil and water analysis:

Soil texture is loamy sand in both investigated soils with moderately difference in fine and silt component, while $CaCO_3$ varied between 2.5-3 and 1.5-3.5 % for surface and subsurface soil layers at Beheira and Minya locations, respectively. Soil pH and EC ranged between 8.11- 8.08, 8.15-8.21 and 2.685-2.64 and 6.08-5.75 dS/m in same

sequence. Sodium adsorption ratio values were 6.35-6.47 and 8.18-7.30 for first and second layer of Beheira and Minya locations. Experimental sites were poorly in organic matter content (0.45 %). The total amount of the ETo for both sites were 1094.7 and 1166.7 mm/year for Beheira and Minya, respectively. Meanwhile pH, EC and SAR of irrigation water were 7.6, 7.8; 1.29, 4.31 and 4.60, 8.15 for Beheira and Minya, respectively.

Climate Parameters: Regarding to the effect of the some estimated climatic parameters of the examined sites such as maximum and minimum temperature, relative humidity (RH), daily solar hours (Rs) and evapotranspiration (ET) on the TSS, acidity, TSS/acid ratio, ascorbic acid and total anthocyanin of Wonderful pomegranate fruits during cold storage at 5^0C. Data were revealed that increasing total solar radiation, mean minimum temperature, RH associated with increase in TSS, Acidity and vitamin C content at Beheira site, respectively, whereas, the opposite was trend in the second site (Minya). Also, results noticed that increasing ETo lead to increase of TSS/Acidity ratio and total anthocyanin.

With respect to the irrigation water and soil chemical properties, and their effect on the TSS, acidity, TSS/Acidity, etc. of the pomegranate fruits, resulted data indicated that there was a negative correlation between SAR and EC of soil and irrigation water with TSS, Acidity, Ascorbic acid (at Beheira location and total anthocyanin at Mina location and TSS/acidity cleared the opposite trend. Also, data pointed out that the rate of the increase between Beheira relative to Minya for total Rs, mean RH were 3, 13; 12 % associated with increase in TSS (12%), Acidity (66%) and Ascorbic acid (15%), respectively and caused a reduction in TSS/Acidity (43%) and total anthocyanin.

According to the values of the determined EC and SAR of irrigation water and soil (that consider as an index of salinity), data noticed that there no clearly effect of the pH and $CaCO_3$ content, while there were a great variation in sodium adsorption ratio (SAR) and soil EC, where the highest values were recorded at Minya site. Also, the obtained results showed that values of Minya site was higher than of Beheira site which gave a change rate by 77and 234% for SAR and EC of irrigation water and for soil.

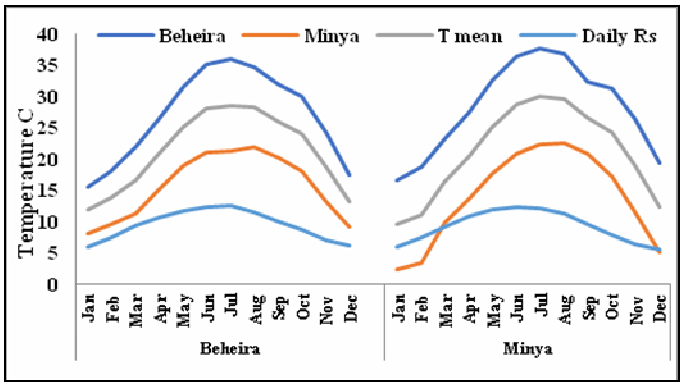

Fig. 1 : Some of the estimated climate parameters

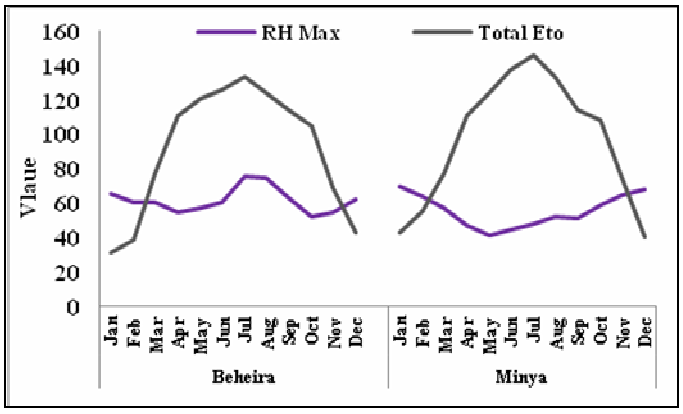

Fig. 2: Relation between relative humidity and ETo

Fruit physical Properties

Fruit weight and volume: The results in (Table 3) illustrated the effect of fruits produced at different two locations (Beheira and Minya) on weight (g) and volume (cm^3) of pomegranate fruits cv. Wonderful throughout cold storage period at 5ºC during 2017 and 2018 seasons. The data cleared that, there is a gradual significantly decrease of both weight (g) and volume (cm^3) of pomegranate fruits with the prolongation of storage period. Meanwhile, pomegranate fruits grown under Beheira conditions showed a higher weight (370.33 g) and volume (397.333 cm^3) compared with Minya location which revealed the least values (330.67 g and 38 5 cm^3) at the end of the storage period (after 150 days).

Table 3: Effect of Beheira and Minya locations on some fruit physical characteristics of pomegranate fruits cv. Wonderful stored at 5 ºC and 85-90% RH as an average of two seasons (2017 and 2018).

Locations	Storage months	Volume cm^3	Length	Diameter	Weight	Ariel weight	Skin weight	Juice weight
			cm		gm			
Beheira	1st	500.00 a	86.37 a	94.72 a	420.00 a	265.00 a	139.00 a	167.00 a
	2nd	445.00 abc	83.32 ab	90.06 ab	398.00 abc	255.00 ab	133.33 a	163.33 a
	3ed	442.50 abc	81.35 ab	87.56 bc	382.50 abc	248.00 ab	131.00 a	159.33 a
	4th	418.33 bcd	79.76 ab	84.95bcd	386.67 abc	235.00 abc	128.33 ab	153.33 a
	5th	397.33 cd	74.33 bc	78.33 def	370.33a-d	230.67 bc	120.00 ab	148.33 a
Minya	1st	486.67 ab	86.37 a	81.56 cd	415.00 ab	241.00 abc	147.67 a	104.33 b
	2nd	465.00 abc	82.70 ab	79.57 cde	381.67 abc	217.00 cd	139.00 a	98.33 b
	3ed	425.00 a-d	79.23 ab	75.65 ef	356.67 bcd	192.00 de	126.00 b	94.33 b
	4th	403.33 cd	76.48 bc	71.33 fg	341.45 cd	184.00 e	119.00 ab	89.00 b
	5th	38 5.00 d	71.27 c	68.56g	330.67 d	178.33e	114.00 ab a	83.00 b

Fruit length and diameter (cm): The results of pomegranate fruits were demonstrated that fruit length and diameter decreased gradually and significantly during storage period at 5ºC reached its minimum values at the 5th month storage. Also, the highest losses of fruit length and diameter were recorded under Minya location at the end duration of

storage period (71.27 and 68.56 cm). Meanwhile, the highest values recorded by Beheira location (74.33 and 78.33 cm) compared with the initial (zero time), as shown in (Table 3).

Skin, Arils and Juice weight (g). Fruit skin, arils and juice weight of the Wonderful pomegranate were estimated during the storage period at 5˚C (as means of two seasons) subjected to different conditions under Beheira and Minya locations. The present results in (Table 3) indicated that both of Beheira and Minya locations showed significant and gradual decrease in fruit skin, arils and juice weight per fruit with the progress of storage period which recorded the least values at150 day storage. Pomegranate fruits grown under Beheira location condition showed remarkable superiority for each of fruit skin (94.72gm), arils weight (265gm) and juice weight (148.33gm) compared with Minya location conditions which recorded the least values. (81.56, 241 and 83gm). On the other side, the initial date (zero time) recorded the highest values.

Weight loss percentage: Data in (Table 4) were revealed that weight loss percentages of Wonderful pomegranate fruits from Beheira and Minya were increased significantly and gradually with advancing storage duration reached the highest value and at 5th month under cold storage. At the end of storage period, fruits of Minya location showed the highest significant weight loss percentage (28.0 %) while the lowest values were obtained from Beheira location (25.60 %).

Table 4: Effect of Beheira and Minya locations on some fruit physical characteristics of pomegranate fruits cv. Wonderful stored at 5 ^{o}C and 85-90% RH as an average of two seasons (2017 and 2018).

Locations	Storage months	Weight loss	decay	TSS	Respiration rate	Fruit firmness
		(%)			(ml/k/hr.)	(Ib/inch^2)
Beheira	1st	8.27 cd	0.0 e	14.50 cd	15.67 c	16.60 a
	2nd	11.95 cd	0.0 e	15.40 bc	12.20 d	14.17 bc
	3^{ed}	15.09 bc	0.0 e	16.67 ab	9.25 e	12.33 d
	4th	21.53 ab	5.33 d	17.03 a	15.30 c	10.66 e
	5th	25.60 a	21.50 b	17.60 a	22.41 a	9.73 e
Minya	1st	7.83 cd	0.0 e	13.00 e	14.28 c	16.77 a
	2nd	11.11 cd	0.0 e	13.50 de	10.61 de	16.07 a
	3^{ed}	16.32 bc	0.0 e	14.33 cde	7.15 f	15.43 ab
	4th	23.32 ab	8.20 c	14.90 cd	14.60 c	12.67 cd
	5th	28.240 a	28.0 a	16.27 ab	20.0 b	10.33 e

Fruit decay (%): Fruit decay percentage results in (Table 4) demonstrated that, not all Beheira and Minya locations had any discarded fruits until three months of storage period at 5˚C. Thereafter, decay percentage showed significant and gradual increase with the progress of storage period. Pomegranate fruits at Minya location exhibited the highest percent of decay at the end of storage period (28.24%) Meanwhile, the incidence of decay under Beheira location conditions had the least percent (21.50%). The results of the present study showed that chilling injury symptoms started to appear after 3 months of storage.

Respiration rate (ml kg^{-1}hr^{-1}): Respiration rate changes of Wonderful pomegranate fruits in response to different two locations of study (Beheira and Minya, as an average of two seasons) are presented in (Table 4). Respiration rate decreased gradually in the beginning of cold storage till third month then it increased gradually with the prolongation of storage period recorded the highest rate at 150 days of storage. Pomegranate fruits grown under Beheira conditions showed an increase significantly for respiration rate compared with Minya location which revealed the least values.

Fruit firmness (Ib/inch^2): Fruit firmness is a major attribute that dictates the postharvest life and quality of fruit. Changes in fruit firmness of pomegranate fruits cv. Wonderful varied after cold storage at 5^{o}C due to different circumstances of locations such as Beheira and Minya as shown in (Table 4). The data cleared that, the fruit firmness decreased gradually and significantly, towards the end of cold storage period recorded the less values after 150 days of storage at 5^{o}C. However, the results indicated that Minya location was the most effective to maintain fruit firmness; since it recorded the highest value (10.33 Ib/inch^2) comparing with the Beheira area which recorded the less value (9.73 Ib/inch^2). On the other side, the initial values of fruit firmness revealed the maximal (16.60 and 16.77 Ib/inch^2) for Beheira and Minya locations, respectively.

Soluble Solid Content (%): The effects of different two locations on soluble solid content of Wonderful pomegranate fruits among the storage months are shown in (Table 4). It is clear that all locations increased soluble solid content (%) gradually during the storage period at 5^{o}**C** reached the maximum percent at the 5th month. In this respect, the pomegranate fruits grown at Beheira location showed a remarkable superiority for soluble solids content (%) compared to those grown at the Minya one.

Fruit color Parameters:

Wonderful pomegranate fruit color is related to the accumulation of anthocyanins pigment group, which is responsible for the color of skin, aril and juice of fruits. The color is expressed as color parameters; bright and dark color reflects Lightness (L*), pure or mixing colors together is defined as Hue angle (h^{o}) and Chroma (C*) reflects the color vividness, or saturation. The absolute color is a combination of these three aspects (McGuire, 1992). The pomegranate color changes throughout the storage period of this study were clarified at the two successive seasons of 2017 and 2018.

(1) Fruit skin color: Peel color of pomegranate is the most essential quality, directly attracting consumer attention (Shaarawi and Nagy, 2017). Changes in skin color of wonderful pomegranate fruits showed a marked significant gradual increase of Lightness and Chroma (C*) color

parameters either in Beheira or Minya locations in correlation with cold storage time progress for five months at 5°C. The results illustrated in (Fig. 3) were revealed that, the highest significant intensity Lightness (L*) and Chroma saturation color (C*) values (50.42 and 27.05) were noticed in the skin fruits of Beheira area compared with the same initial values (43.53 and 18.60) at the harvest time. On the opposite side, the pure red color as Hue angel (h°) indication recorded a gradual significant reduction trend with the least (h°) value (10.39) in the peel fruits of Beheira location. This trend was the same in both investigated seasons.

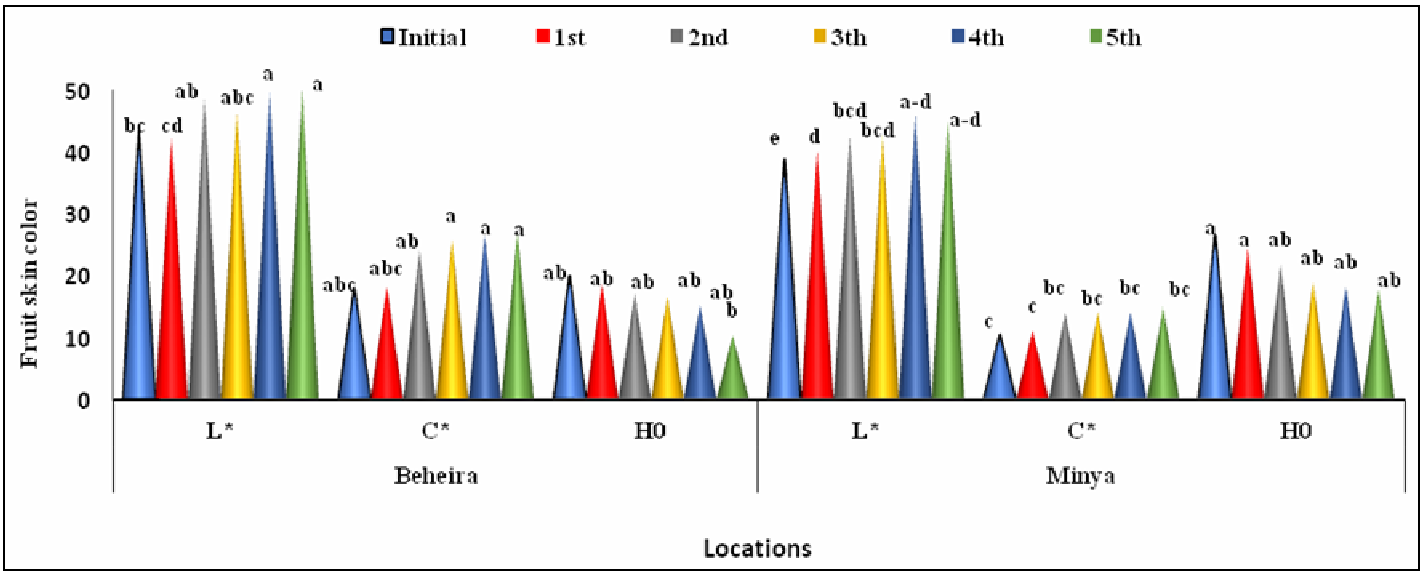

Fig. 3: Effect of Beheira and Minya locations on fruit skin color (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful stored at 5 °C and 85-90 % RH average of 2017 and 2018 seasons.

(2) Fruit arils color: Due to the consumer demand for healthy products, arils are the edible part of a pomegranate fruit with rich-anthocyanin pigment meets the consumer acceptance. The two pomegranate locations Beheira and Minya recorded a significant and gradually increase in wonderful pomegranate arils fruits with extending storage period at 5°C as revealed in (Fig. 4). Minya location produced pomegranate fruits with higher parameters color aril values (43.73 and 14.61) compared with Beheira location which have pomegranate aril values (41.96 and 10.78) in Lightness (L*) and Chroma (C*) elements compared to their initial values (35.53 and 5.57) as an average of both seasons of study. Meanwhile, a noticeable reduction with a similar trend of hue angle (h°) red color values (16.23 and 12.36) were related to Minya and Beheira locations of the aril of pomegranate fruits, respectively.

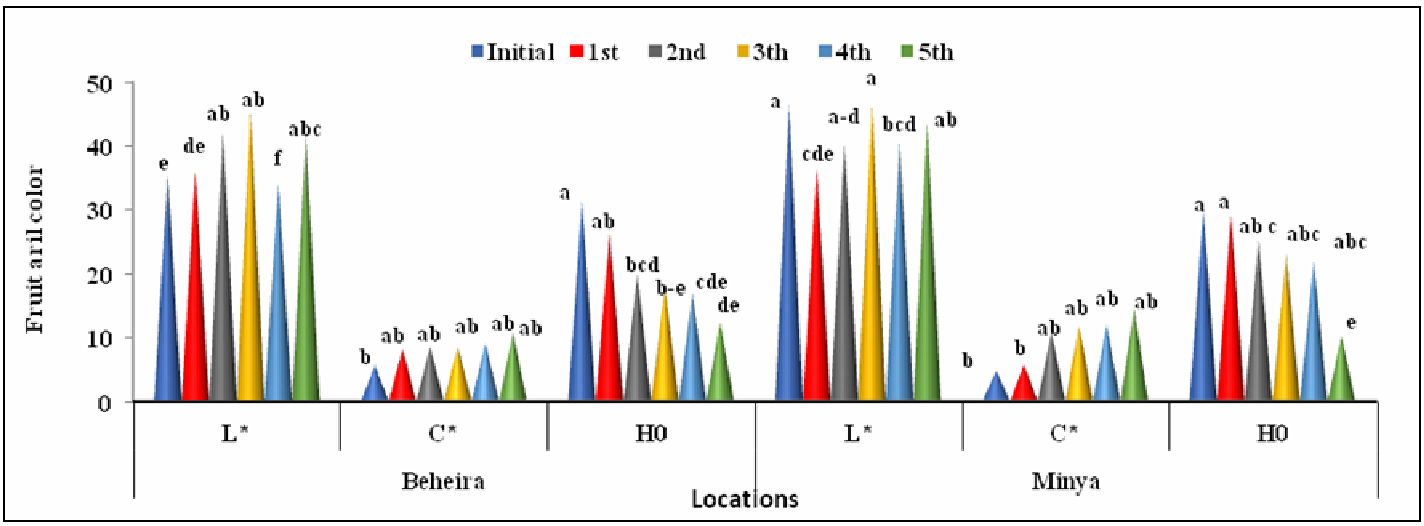

Fig 4: Effect of Beheira and Minya locations on fruit aril color (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful stored at 5 ° C and 85-90 % RH as an average of 2017 and 2018 seasons.

(3) Fruit Juice color: Results in (Fig. 5) cleared that the two pomegranate locations (Beheira and Minya) exhibited significant and gradual increment of pomegranate fruit juice with bright red color expressed as Lightness (L*) and Chroma (C*) color factors with increasing storage period at the two seasons of study. The highest great significant values of lightness (L*) of e pomegranate juice fruit (50.54 and 44.04) were recorded at the Minya location followed by Beheira one, respectively. Meanwhile, the least values of Chroma (C*) color parameters (23.57 and 11.99) were observed in the pomegranate fruit juice produced in Minya and Beheira too, respectively. On the other hand, hue angle (h°) ratings of juice color appeared a noticeable reduction of the radiance of juice color with the least value (113.80) compared with initial value at harvest (329.5) at the Beheira area as an average of the two seasons of investigations

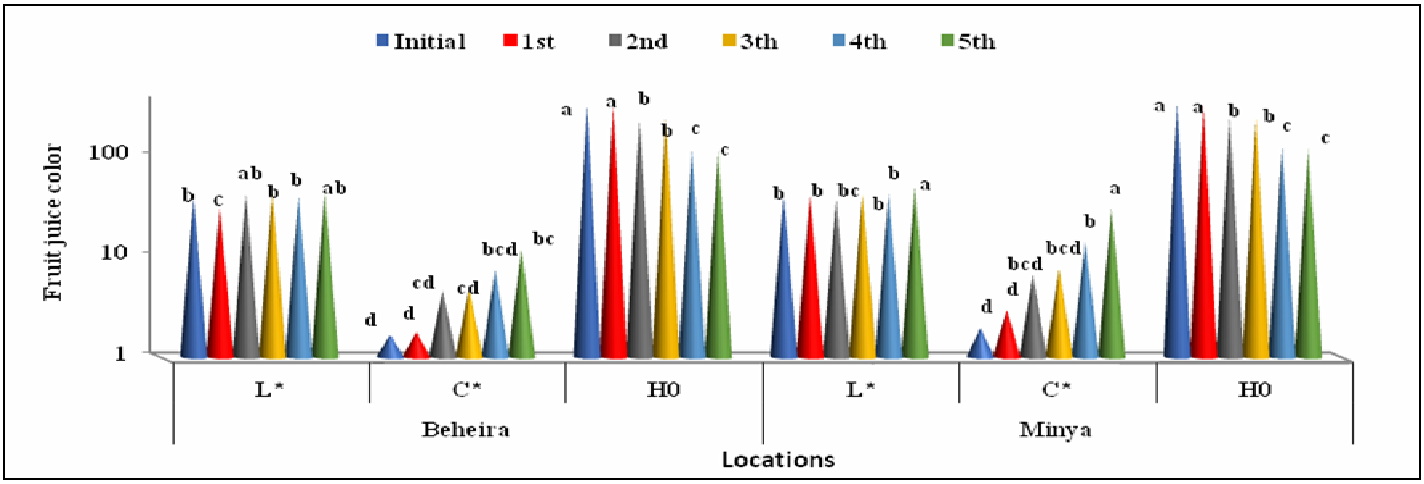

Fig 5: Effect of Beheira and Minya locations on fruit juice color (Lightness, Chroma and Hue angle) of pomegranate fruits cv. Wonderful stored at 5 ^{0} C and 85-90 % RH as an average of 2017 and 2018 seasons

Fruit Chemical Properties

Total Acidity Percentage: Fruit acidity is an important factor affecting consumer acceptance, the pomegranate's organic acid composition varies between varieties (Serrano, 2012). The effect of different growing locations on Wonderful pomegranate fruits acidity content (%) is shown in (Table 5). Generally, it is quite clear that the reduction in total acidity content is proportional with the advancement of storage period till reach the minimum decrease after 150 days under cold storage at 5**°C** during the mean of two successive seasons under study. However, the results indicated that Minya location was the most effective to reducing acidity percent comparing with Beheira location which recorded the higher values of acid content at the end of the storage period.

Ascorbic acid content (mg/100g f. w.): The results in (Table 5). illustrated the effect of different two locations (Beheira and Minya) fruits on ascorbic acid content (vitamin C) of Wonderful pomegranate fruits during cold storage. The vitamin C values had a gradually and significantly decrease during 150 days of storage at 5**°C** reached the lowest values at the end of storage period. On the other hand, the Beheira location showed superiority over Minya location in ascorbic acid content of Wonderful pomegranates.

Total anthocyanins (mg/100g f. w.): Pomegranate fruit is known to be one of the major sources of anthocyanin (Fischer *et al.*, 2011). Anthocyanins represent a group of widespread natural phenolic compounds in plants, and are responsible for their colors (Mazza and Minyati, 1993). Results in (Table 5) showed a significant reduction in total anthocyanin of Wonderful pomegranate fruits with the advancement of storage period for the different two locations (Minya and Beheira). Thus, 150 days of cold stored fruits scored the lowest values of fruit total anthocyanin content. The differences among the studied storage periods were significant. On the other hand, the Minya location recorded obvious superiority over Beheira location in this regard.

Table 5: Effect of Beheira and Minya locations on some chemical characteristics of pomegranate fruits cv. Wonderful stored at 5 ^{0} C and 85-90 % RH as an average of two seasons (2017 and 2018).

Locations	Storage months	Total acidity	TSS/Acidity	Ascorbic acid	Total anthocyanin
		(%)		(mg/100g f. w.)	
Beheira	1st	2.02 a	7.18 d	41.00 a	12.33 c
	2nd	1.79 b	8.60 d	37.33 ab	11.44 cd
	3^{ed}	1.05 c	15.88 bc	36.33 ab	11.05 de
	4th	0.87 d	19.57 bc	34.00 bcd	10.74 de
	5th	0.72 de	24.44 ab	30.00 def	10.12 e
Minya	1st	1.03 c	12.62 cd	35.67 bc	14.51 a
	2nd	0.73 de	18.49 bc	31.00 cde	13.89 ab
	3^{ed}	0.62 e	23.11 ab	28.33 ef	13.40 b
	4th	0.62 e	24.03 ab	26.67 ef	12.28 c
	5th	0.60 e	27.12 a	23.00 f	11.46 cd

Discussion

It's clear from the above results that physical or chemical properties of pomegranate fruits cv. Wonderful during cold storage at 5^{0}C had a positive affect by Beheira and Minya locations. In this concern, the total amount of the ETo for both sites were 1094.7 and 1166.7 mm/year for Beheira and Minya, respectively. Also, its increasing ETo lead to increase of TSS/Acidity ratio and total anthocyanin. The rate of the increase between Beheira relative to Minya for total Rs, mean RH were 3, 13; 12 % associated with increase in TSS (12%), Acidity (66%) and Ascorbic acid (15%), respectively and caused a reduction in TSS/Acidity (43%) and total anthocyanin. On the other side, pomegranate fruits grown under Beheira location conditions showed a higher juice weight (148.33gm) compared with Minya location conditions which recorded the least values (83 gm). The aril juice is approximately 40.5% of a mature pomegranate fruit (Varasteh *et al.*, 2009).

The development of gray mold increased during the storage and shelf life periods of pomegranates could reach up to 30% (Tedford *et al* 2017). Also, Varasteh *et al.,* (2017) reported that some shriveling symptoms and micro cracks appeared on the peel of pomegranate fruits cv. Rabbab-e-Neyriz' after 3 months of storage at 2˚C with 90% relative humidity. The results are in accordance of those reported with (Caleb *et al.* (2012) and Varasteh *et al*. (2017), which found that weight loss in pomegranate fruit increased during storage period. In addition, the weight loss reduces the attractiveness of pomegranate fruits by changing the shape, browning the rind in pomegranate fruits during storage is mainly related to the peel, up to the arils.

The values obtained in this study for soluble solids are in agreement with those indicated by Mirdehgha *et al*. (2007), who reported variations between 10% and 18%, increase. Also, Martinez *et al*. (2010), found 12.36-16.32% variation in soluble solids in Spanish pomegranate varieties. It has been indicated that respiration rate of pomegranate fruit declined with storage time extension and decrease in storage temperature (Thanaa Sh. M. Mahmoud *et al.,* 2019 and Gross *et al.*, 2016).

Generally, color of pomegranate fruit is an important quality attributes affecting marketability, consumer's acceptance, and commercial value (Faten, Abdel-Salam *et al*., 2018 Meanwhile, the color of Croatian pomegranate fruits with deep red color tends to have great consumer appeals on market. These results of study are in accordance with those reported with Ercisli *et al*. (2012), they explained 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. In the other side, Diaz-Mula *et al*. (2009) were reported that hue angle (h^o) values in fruits with red skin color indicate an increase in red coloration. (The intense coloration was evident by increases in the L* and C* values as well as by decrease in the hue angel (h^o). 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 (Faten, Abdel-salam *et al*., 2018). Overall, these results indicated that the color of fruit peel and aril was better maintained at 5°C for 3 months, when red coloration (L*) and intensity (C*) for peel and arils were considerably higher than the perceived fruit color at harvest. Juice color, was slightly lighter and more red saturated after storage than at harvest (higher values of *L**, *C**, *h*◦). In general, juice color attributes after storage were not affected by either postharvest treatment or storage condition (Palou *et al*., 2007).

The change of TA during storage in pomegranate fruits could be the result from ripening process, as previously reported (Eman *et al.,* 2019 and Sayyari *et al*., 2011).The decrease in fruit acidity during storage period may be due to the metabolic changes in fruits or due to the use of organic acids in respiratory process (Echeverria and Valich, 1989). Silva (2011) reported the average levels of citric acid of 0.46% and 0.51% in Wonderful and Molar pomegranate varieties, respectively.

Fruit storage duration is believed to cause a decline in the concentration of ascorbic acid reported by Miguel *et al*. (2010). Pomegranates have low ascorbic acid content compared to many other fruits, ranging from 0.49 to 30 mg 100 g^{-1} of juice Barrachina *et al.* (2012) The variations between 10 and 36 mg 100 g^{-1} of ascorbic acid in pomegranate juice reported by Sayyari *et al*. (2010). Ascorbic acid is lost due to the activities of phenol oxidase and ascorbic acid oxidase enzymes during storage reported by Abd El-Moneim *et al.* (2019).

Conclusions

The presented data suggested that physical, chemical properties and color parameters of pomegranate fruits cv. Wonderful during cold storage at 5°C are affected by not only climatic conditions of the cultivated area but also soil location and irrigation water properties, where the results cleared that one or more of the following: i) highly temperature combined with RH had strongly affect on plant stress, ii) Minya site was higher than of Beheira site which gave a change rate by 77 and 234% for SAR and EC of irrigation water and for soil, iii) Beheira location conditions had better physical properties than at Minya location throughout storage period. Meanwhile, Minya location had better chemical parameters, iv) In addition, fruits of wonderful pomegranate had higher gradual increment brightness red color effect of lightness (L*) and Chroma (C*) in all fruit parts (skin, aril and juice) compared with its values at harvest, v) Hotter location had better color appearance of pomegranate fruits than the other especially in aril and juice color and chemical quality characteristics, and vi) Other color parameters changed with fluctuations of total anthocyanin content during cold storage period.

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