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Modern Vision to Enhancement Pomegranate Storage

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Abstract: This experiment was carried out during two consecutive seasons (2017 and 2018) in the postharvest laboratory of Agricultural Development System (ADS) project in Faculty of Agriculture, Cairo University, Egypt. The experiment aimed to investigate the efficiency of using Pergrina moringa oil, Stinopetala moringa oil and Algae oil each at two concentrations (500 and 1000 ppm) as a natural ecofriendly product compared to untreated fruits as a control on quality and storability of wonderful pomegranate fruits under cold storage conditions (5°C and 85-90% RH). It was observed that two different trends were detected with the advancement of storage duration during both seasons. Hence, percentage of fruit weight loss (WL), decay percent (DP), total soluble solids, (TSS), ascorbic acid (VC) and total anthocyanin content (TAC) were increased; however, fruit firmness, titratable acidity %, antioxidant activity and pectinase content were relatively reduced. Therefore, it could be generally concluded that all postharvest treatments significantly decreased the percentage of both fruit weight loss, decay, fruit juice and total acidity below less than the control (untreated fruits), whereas Stinopetala moringa oil at 500 ppm treatment was superior, while Algae oil at 1000 ppm ranked the latest in this concern. Besides, fruit flesh firmness, total anthocyanin content by using Algae oil at 500 ppm and decreased by using other treatments during both experimental seasons.

Key words: Pomegranate fruits · Pergrina moringa oil · Stinopetala moringa oil · Algae oil · Cold storage

INTRODUCTION

Pomegranate (*Punica granatum* L.) 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 [1]. This turns the pomegranate tree into a valuable option for fruit culture in regions that must face up to the need of coping water scarcity and where the growing of other fruit species is unsustainable [2]. The pomegranate cultivar Wonderful is known for its sweet taste, plentiful juice and health benefits that may help with heart disease, cancer and problems associated with aging. It is loaded with antioxidants, vitamins, potassium, folic acid and iron [3]. Consumption and the availability of pomegranate fruit in the market are restricted mainly to the harvesting season due to high demand and lack of appropriate postharvest technology to extend the storage life and maintain fruit quality [4]. Physiological, physicochemical, phytochemical, mechanical, microbial and sensory attributes of pomegranate fruit are influenced by postharvest storage conditions such as temperature, packaging and relative humidity that could be used to maintain fruit quality to prolong storage periods [5]. The fruit may be stored for several months at temperatures from 5 to 10°C to extend the marketing value depending on the cultivar [6]. However, several postharvest disorders could occur during short or long-term storage. Some of them are external quality defects, such as loss in moisture leading to appearance of husk scald (browning of the skin surface) and color as a result of degradation of anthocyanin, moreover the development of decay and the other changes in the internal quality of the fruit, such as reduction in the total soluble solids and increment in the titratable acidity. The primary storage problem of pomegranate is desiccation of the fruit resulting in a brownish colored tough peel and browning of arils.

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Moringa oleifera (family: Moringaceae) is one of such alternatives, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers [7]. Fresh *Moringa oleifera* leaves have been shown to have high zeatin content. Moringa leaves collect ted from various parts of the world were found to have high zeatin concentrations (up to 200 mg/g) of leaves [8]. Cytokinins are naturally occurring plant hormones known to be critical regulators of various aspects of plant growth and development, including cell division, leaf senescence, apical dominance, lateral root formation, stress tolerance and nutritional [9, 10]. In this concern, Iqbal [11] affirmed that Moringa leaf extract is abundant with various growth hormones, particularly zeatin and micronutrients in sufficient quantities and suitable proportions that increase the growth and yield components.

Algae extract containing some macro and micronutrients i.e. (N, P, K, Ca, Mg and S) and (Zn, Fe, Mn, Cu, Mo and Co) as well as some growth regulators, polyamines and vitamins required to be applied for improve fruit quality in different fruits orchards [12-14].

Many researches have reported that shrink films wrapping and coatings reduce the occurrence of these problems [15-17]. Film wrapping almost inhibited weight loss by reducing the transpiration rate and preserved the fruit freshness for whole storage time.

Moreover, pomegranate usage is increasing rapidly and cultivation spreads in many areas in Egypt, especially in the newly reclaimed lands and the north Nile delta region. The Wonderful cultivar is widely cultivated in California, while the last few years, it has replaced the native Egypt cultivars. Now, Wonderful is the main pomegranate cultivar in Egypt. Therefore, this study aimed to investigate the effects of moringa oils and algae oil as a natural product on quality and storability of wonderful pomegranate fruits during cold storage conditions.

MATERIALS AND METHODS

Fruit: Mature Wonderful pomegranate (*Punica granatum* L.) fruits were harvested in the last week of December during two successive seasons 2017 and 2018 from seven years old trees grown at the experimental station of National Research Centre, Al-Nobaria, Al-Behera governorate, Egypt. Pomegranate fruits were selected for uniformity in size, shape and color. Diseased, sunburn, bruised and injured fruits were discarded, then were transferred directly to the laboratory at the Agricultural Development Systems (ADS) project, Faculty of Agriculture, Cairo University.

Treatments: Selected fruits were washed with running tap water, air dried, placed into plastic baskets and divided into seven similar groups to carry out the following coating treatments:

- Control (tap water).
- Pergrina moringa oil at 500 ppm.
- Pergrina moringa oil at 1000 ppm.
- Stinopetala moringa oil at 500 ppm.
- Stinopetala moringa oil at 1000 ppm.
- Algae oil at 500 ppm.
- Algae oil at 1000 ppm.

After postharvest coating treatment the fruits were packed in storage carton boxes in one layer and stored at 5°C and 85-90% relative humidity (RH) for 60 days. Each treatment constituted three replications for each sampling date (15 days) and each replicate consisted of 3 fruits. Fruits quality measurements were assessed after each sampling date (15 days).

Physical Properties Assessments

Fruit Weight Loss (FWL): Fruits were weighed at the beginning and after an interval of 7 days for a period of 45 days storage. The fruit weight loss percent was calculated by standard procedure as the following equation. Fruit weight loss % = wt. of 1st interval – wt. of 2^{ed} interval x100 / wt. of first interval.

Decay Percentage (%): Decayed fruits by different physiological and pathological factors were periodically counted and discarded. Then the decay percentages were calculated in relation to total number of fruits during whole storage.

Fruit Firmness: fruit firmness was determined using Ametek pressure tester. Firmness of 3 fruits from each replicate was measured at two opposite points on the equator of each fruit. Results were calculated as Ib inch^{-2} [18].

Soluble Solids Content (SSC, %): SSC content was measured using a T/C hand refractometer Instrone, Brix-readings 0 - 30 ranges (Model 10430, Bausch and Lomb Co. Calif., USA) and express in percentage.

Chemical Properties Assessments

Titratable Acidity (TA, %): total acidity content (expressed as citric 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 [18].

Total Anthocyanins Content (TAC): Anthocyanin of arils juice (mg/100g arils) was measured colorimetrically at 535 nm in arils juice according to the methods of [19].

Total Antioxidant Content (TAC): Antioxidant activity in the pomegranate arils was assessed by using the free radical DPPH method [20].

Pectinase Activity (PA): Sample of 0.5 ml of supernatant enzyme extraction were used and mixed in acetate buffer then incubated at 45°C for l0 min for pectinase. The reaction was stopped with 3 ml of 3, 5-dinitrosalicylic acid reagent, the color was obtained after heating for 10 min. and measured at wavelength of 570 nm and expressed as one unit of pectinase activity liberates 1 M mol D-galactouronic acid in milliliter per min [21].

Statistical Analysis: The design for this experiment was a completely randomized design (CRD) with three replications. The collected data on various parameters were statistically analyzed using variance (ANOVA) procedure of MSTATC program. Since some recorded data were nil, the data were modified to be statistically analyzed according to the description of "problem data" by [22]. The least significant differences (LSD) was used to compare means at the 5% level of probability.

RESULTS AND DISCUSSIONS

The Impact of Using Different Concentrations and Coating Type (Moringa and Algae Oils) on Fruit Physical Properties

Fruit Weight Loss Percentage: Concerning the effect of the tested postharvest treatments, Table (1) demonstrates that all evaluated postharvest treatments succeeded in reducing weight loss percentage of pomegranate fruits during storage duration in comparison with untreated fruits "control" in both seasons under study. Generally, the treatment of Pergrina moringa oil proved to be the most efficient treatment in this concern, followed by Stinopetala moringa oil, during the two seasons of study.

Table 1: The impact of using different concentrations and type of moringa oils and algae oil on fruit weight loss Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	0.00	3.80	6.40	11.50	19.24	8.19 A
Pergrina moringa oil at 500 ppm	0.00	2.64	4.70	6.80	8.85	4.60 B
Pergrina moringa oil at 1000 ppm	0.00	2.75	5.20	6.98	8.85	4.75 B
Stinopetala moringa oil at 500 ppm	0.00	3.10	5.40	7.03	9.38	4.98 B
Stinopetala moringa oil at 1000 ppm	0.00	3.59	5.59	7.39	9.38	5.19 B
Algae oil at 500 ppm	0.00	3.40	6.05	7.42	9.58	5.29 B
Algae oil at 1000 ppm	0.00	2.39	5.49	7.05	9.06	4.80 B
Mean	0.00 D	3.09 C	5.54 B	8.84 A	9.51 A	
LSD for the interaction effect between treatments and storage periods at 5% = 1.49						
Treatment			Second season			Mean
Control	0.00	3.44	5.68	18.50	11.21	7.77 A
Pergrina moringa oil at 500 ppm	0.00	2.74	4.08	6.07	8.31	4.24 E
Pergrina moringa oil at 1000 ppm	0.00	2.66	4.62	6.47	8.27	4.40 E
Stinopetala moringa oil at 500 ppm	0.00	2.98	5.47	6.21	8.76	4.68 D
Stinopetala moringa oil at 1000 ppm	0.00	3.55	5.89	7.47	8.72	5.13 B
Algae oil at 500 ppm	0.00	3.22	5.77	7.28	8.43	4.94 BC
Algae oil at 1000 ppm	0.00	2.34	4.63	7.88	8.89	4.75 CD
Mean	0.00 E	2.99 D	5.164 C	8.55 B	8.94 A	
LSD for the interaction effect between treatments and storage periods at 5% = 0.49						

Table 2: The impact of using different concentrations and type of moringa oils and algae oil on decay percentage of Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	0.00	0.00	9.44	17.19	26.37	10.60 A
Pergrina moringa oil at 500 ppm	0.00	0.00	0.00	7.35	8.51	3.17 D
Pergrina moringa oil at 1000 ppm	0.00	0.00	0.00	8.40	17.86	5.25 C
Stinopetala moringa oil at 500 ppm	0.00	0.00	0.00	10.16	18.44	5.72 D
Stinopetala moringa oil at 1000 ppm	0.00	0.00	0.00	9.14	19.66	5.76 C
Algae oil at 500 ppm	0.00	0.00	0.00	16.35	24.98	8.27 B
Algae oil at 1000 ppm	0.00	0.00	0.00	8.53	17.37	5.18 C
Mean	0.00 D	0.00 D	1.35 C	11.02 B	19.03 A	
LSD for the interaction effect between treatments and storage periods at 5% = 1.31						
Treatment	Second season					Mean
Control	0.00	0.00	8.99	16.44	25.33	10.15 A
Pergrina moringa oil at 500 ppm	0.00	0.00	0.00	6.84	8.09	2.99 E
Pergrina moringa oil at 1000 ppm	0.00	0.00	0.00	8.63	16.3	4.99 D
Stinopetala moringa oil at 500 ppm	0.00	0.00	0.00	7.87	16.66	4.91 D
Stinopetala moringa oil at 1000 ppm	0.00	0.00	0.00	8.41	18.54	5.39 C
Algae oil at 500 ppm	0.00	0.00	0.00	16.35	24.06	8.08 B
Algae oil at 1000 ppm	0.00	0.00	0.00	10.61	17.36	5.59 C
Mean	0.00 D	0.00D	1.29 C	10.73 B	18.05 A	
LSD for the interaction effect between treatments and storage periods at 5% = 0.64						

As for the effect of storage periods**,** it is quite clear from Table (1) that pomegranate fruits showed gradual losses in their weight with the advancement of storage period. Therefore, 60 days storage period under cold storage recorded the highest value, whereas the lowest value was obtained after 15 days under cold storage in both seasons. The statistical analysis emphasizes that the differences between the aforementioned cold storage periods were significant. Considering the interaction effect between storage period and tested postharvest treatments, data presented in Table (1) show that the interactions of 15 days storage duration under cold storage at 5 ±2°C recorded the lowest percentages of weight loss during both seasons of study. On the opposite, the highest percentage of weight loss was observed on those of 60 days storage period combinations, particularly those treated with tap water "control" and Algae oil at 500 ppm in both seasons. The other combinations showed intermediate values in this concern. The obtained results are in similar to those obtained by El-Anany *et al*. [23] and Shirzadeh and Kazemi [24] on apple fruit and Hassan *et al*. [25] on tangerine citrus fruit. They found that fruit treated with edible coating showed a significant delay of weight loss (%) during cold storage compared to the uncoated fruits (control). Pear fruits cv. Le Conte coated with Moringa oil (MO) progress in reducing the weight loss percentages during cold storage periods for 105 day [26].

Fruit Decay Percentage: Analyzing the effect of postharvest treatments, Table (2) demonstrates that Pergrina moringa oil showed to be superior in reducing fruit decay percentage followed by Stinopetala moringa oil treatments. Evaluating the effect of storage periods, data presented in Table (2) illustrate that fruit decay percentage showed a steadily increment with extending the storage periods in both seasons of this study. However, the storage period of 60 days cold at 5°C scored the highest significant fruit decay percentages, followed by those cold stored for 45 days. On the other hand, 15 and 30 days cold storage durations in the two seasons of the study produced the lowest fruit decay percentages. Examining the interaction effect between storage periods and the tested postharvest treatments, it is evident from Table (2) that all combinations of 0, 15 and 30 days resulted in preventing fruit decay percentage of pomegranate fruits. On contrast, the highest fruit decay (%) was recorded by the interactions of 60 days cold storage period, particularly those interacted with control in both seasons. The remained interactions of the tested

Table 3: The impact of using different concentrations and type of moringa oils and algae oil on fruit firmness Wonderful pomegranate fruits under cold storage.

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	34.70	32.98	31.2	28.9	26.9	30.94 A
Pergrina moringa oil at 500 ppm	34.70	34.15	32.82	30.4	28.96	32.24 A
Pergrina moringa oil at 1000 ppm	34.70	33.99	32.56	30.4	28.78	32.09 A
Stinopetala moringa oil at 500 ppm	34.70	33.83	32.37	29.89	28.61	31.88 A
Stinopetala moringa oil at 1000 ppm	34.70	33.7	32.49	29.8	28.49	31.84 A
Algae oil at 500 ppm	34.70	33.61	32.5	29.8	28.51	31.82 A
Algae oil at 1000 ppm	34.70	33.93	32.49	29.99	28.79	31.98 A
Mean	34.70 A	33.74 A	32.35 AB	29.88 BC	28.43 C	
LSD for the interaction effect between treatments and storage periods at 5% = 2.46						
Treatment	Second season					Mean
Control	33.07	32.28	29.85	27.76	25.24	29.64 D
Pergrina moringa oil at 500 ppm	33.24	32.97	30.13	29.19	27.57	30.62 BC
Pergrina moringa oil at 1000 ppm	33.27	32.71	31.53	29.34	27.46	30.86 AB
Stinopetala moringa oil at 500 ppm	33.51	33.13	30.43	28.54	27.12	30.55 C
Stinopetala moringa oil at 1000 ppm	33.24	32.28	31.58	28.39	27.40	30.58 BC
Algae oil at 500 ppm	33.73	33.12	30.85	29.39	27.23	30.86 AB
Algae oil at 1000 ppm	33.54	32.52	32.02	29.68	27.89	31.13 A
Mean	33.37A	32.71 B	30.91 C	28.90 D	27.13 E	
LSD for the interaction effect between treatments and storage periods at 5% = 0.68						

storage periods ranked intermediate and the differences among the different storage periods interactions were Moringa oil decreased fruit decay significantly in most cases. The obtained results are in conformity with those obtained by [27]. Who found that Coconut oil reduce microbial activity due to containing of lauric acid which adds antimicrobial property to the coatings and impart moisture barrier to the hydrophilic coatings. The reducing decay (%) of Le Conte pear fruits coated with MO (Moringa) and JO (Jojoba) was due to the effects of these coatings on delaying senescence [26].

Fruit firmness (Lb inch^{-1}): Data in Table (3) reveal that prolonging the storage period, increased generally softness of pomegranate fruits. The longer the storage period (60 days), the more was the softness of pomegranate fruits against for freshly harvested Wonderful pomegranate fruits in both seasons. The differences between storage periods on decreasing fruit firmness were pronounced and reach the level of significance in most cases in the second season. Concerning the specific effect of tested postharvest treatments, it is so clear to notice that the response of fruit firmness to the different investigated postharvest coating treatments was statistically absent and could be safely neglected especially in the first season. Table (3) shows that differences among various combinations (storage duration ×postharvest treatments) were insignificant, except those of control-treated fruits after 60 days storage with the two earlier sampling dates (after 15 and 30 days) regardless of postharvest treatments in the first season. Such a trend for the interaction effect was not evident in the second season. Anyhow, control (tap water) exhibited the lowest fruit firmness statistically during two experimental seasons. Moreover, Algae oil at 1000 ppm inducing the highest fruit firmness in both seasons. The rest treatments gave in between values in this concern. These results are also in agreement with those obtained by Jahanshahi *et al*. [28] they arrived that edible coating such as jojoba and moringa oils may help in maintaining firmness and provide gloss to coated fruits. In this regarding, Jojoba oil (JO) coating on Le Conte fruits was more effective in firmness retention compared to the other treatments (Arabic Gum and moringa oil) reported by [26].

Total Soluble Solid Percentage (T.S.S %): Data shown in Table (4) reveal that T.S.S of Wonderful pomegranate fruits was affected by using the different tested postharvest treatments in both seasons. However, the highest value of this parameter was recorded by Algae oil treatments in both seasons. Besides, Algae oil at 1000 ppm treated fruits in the season significantly increased T.S.S as compared with the other treatments.

Table 4: The impact of using different concentrations and type of moringa oils and algae oil on total soluble solids (TSS) percentage Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	15.47	15.50	15.60	15.97	16.07	15.72 A
Pergrina moringa oil at 500 ppm	15.47	15.53	15.73	16.00	16.10	15.77 A
Pergrina moringa oil at 1000 ppm	15.47	15.83	15.90	16.00	16.07	15.85 A
Stinopetala moringa oil at 500 ppm	15.47	15.53	16.00	16.00	16.18	15.84 A
Stinopetala moringa oil at 1000 ppm	15.47	15.70	16.47	16.47	17.07	16.24 A
Algae oil at 500 ppm	15.47	15.80	16.20	16.20	17.07	16.23 A
Algae oil at 1000 ppm	15.47	16.00	16.47	16.80	17.47	16.44 A
Mean	15.47 A	15.70 A	16.05 A	16.26 A	16.58 A	
LSD for the interaction effect between treatments and storage periods at 5% = 2.28						
Treatment	Second season					Mean
Control	16.18	15.50	14.77	15.21	15.56	15.45 E
Pergrina moringa oil at 500 ppm	15.33	15.62	16.04	16.19	15.73	15.78 D
Pergrina moringa oil at 1000 ppm	15.81	15.77	15.18	16.40	15.87	15.81 CD
Stinopetala moringa oil at 500 ppm	15.61	15.51	16.04	16.11	16.19	15.89 CD
Stinopetala moringa oil at 1000 ppm	15.90	15.96	16.25	16.30	16.97	16.27 B
Algae oil at 500 ppm	15.50	15.65	15.78	16.09	16.61	15.92 C
Algae oil at 1000 ppm	15.83	16.36	16.45	16.66	16.89	16.44 A
Mean	15.74 C	15.77 C	15.79 C	16.14 B	16.26 A	
LSD for the interaction effect between treatments and storage periods at 5% = 0.27						

Referring to the effect of the cold storage period, Table (4) shows that T.S.S. of Wonderful pomegranate fruits progressively increased with advancing the storage periods till reach the maximum increase after 60 days under storage in both seasons of study. As for the interaction effect between the tested postharvest treatments and storage periods, data in the same table indicated that all combinations succeeded in increasing T.S.S of Wonderful pomegranate fruits as compared with the initial readings with few exceptions especially with control treatment in the second season. The superiority was evident for the combinations of 60 days storage period in most cases in both seasons. The highest values of this parameter were scored with Algae oil at 1000 ppm-treated fruits under cold storage for 60days during two experimental seasons. On the contrary, the lowest values of this parameter were related to the combination of 15 days storage period in both seasons with all the treatments. The aforementioned results are in parallel to those recorded by Yousef *et al*. [29] who found that avocado fruits treated with moringa recorded the highest soluble solid content. They added that essential oils positively affected postharvest quality factors including total soluble solids,

Fruit Chemical Properties

Total Acidity Percentage: It is quite evident that the reduction in fruit total acidity content is proportionate with the advancement of storage period (Table, 5). Hence the highest value of fruit total acidity content (irrespective the initial readings) was recorded with fifteen days cold stored fruits. The reverse magnitude was detected with the fruits stored for sixty days in both seasons. The specific effect of tested postharvest treatments, Table (5) indicated that all tested treatments decreased to some extent, total fruit acidity over control during both seasons. Moreover, the data in Table (5) reflected a real picture to the relative higher response to the cold storage duration from one hand and the lower (very slight) on to the investigated postharvest treatments from the others. Accordingly, all the combinations of two studied factors (storage duration x postharvest treatments) for 15 and 30 days cold storage, generally exhibited similar values and did not significantly differed. in the first season. However, with the advancement of cold storage period differences became more pronounced and, in most cases, varied significantly, especially as seven combinations of the latest cold storage duration were compared to (after 15 and 30 days).

Table 5: The impact of using different concentrations and type of moringa oils and algae oil on total acidity percentage Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	1.05	0.65	0.63	0.60	0.52	0.69 A
Pergrina moringa oil at 500 ppm	1.05	0.63	0.48	0.48	0.45	0.61 A
Pergrina moringa oil at 1000 ppm	1.05	0.70	0.48	0.43	0.40	0.61 A
Stinopetala moringa oil at 500 ppm	1.05	0.62	0.53	0.50	0.47	0.63 A
Stinopetala moringa oil at 1000 ppm	1.05	0.70	0.65	0.46	0.43	0.65 A
Algae oil at 500 ppm	1.05	0.63	0.60	0.45	0.45	0.63 A
Algae oil at 1000 ppm	1.05	0.77	0.73	0.42	0.40	0.67 A
Mean	1.05 A	0.67 B	0.59 BC	0.47 CD	0.44 D	
LSD for the interaction effect between treatments and storage periods at 5% = 0.12						
Treatment	Second season					Mean
Control	1.04	0.730	0.627	0.603	0.490	0.698 BC
Pergrina moringa oil at 500 ppm	1.04	0.763	0.673	0.557	0.470	0.701 B
Pergrina moringa oil at 1000 ppm	1.053	0.777	0.553	0.487	0.410	0.656 D
Stinopetala moringa oil at 500 ppm	1.053	0.813	0.640	0.607	0.533	0.729 A
Stinopetala moringa oil at 1000 ppm	1.010	0.770	0.647	0.560	0.447	0.687 BC
Algae oil at 500 ppm	1.043	0.643	0.623	0.593	0.477	0.676 CD
Algae oil at 1000 ppm	1.043	0.803	0.700	0.563	0.437	0.709 AB
Mean	1.040 A	0.757 B	0.638 C	0.567 D	0.466 E	
LSD for the interaction effect between treatments and storage periods at 5% = 0.05						

Generally, it could be concluded that the lowest fruit juice total acidity was always in concomitant to the Stinopetala moringa oil at 500 ppm treated fruits after 60 days during two seasons of study. The aforementioned results go on the same line with those obtained by Mehdi *et al*. [30] on banana and papaya fruits by Shirzadeh and Kazemi [24] on apple fruits and by Cruz *et al*. [31] on pear fruits. They detected edible coating of fruits including AG, JO and MO enhanced fruit quality. Titratable acidity of pomegranate fruits cv. Wonderful were decreased by using all packaging materials [32].

Ascorbic acid (V.C mg/100 ml juice): Ascorbic acid is lost due to the activities of phenol oxidase and ascorbic acid oxidase enzymes during storage [32]. Data in Table (6) show that all tested postharvest treatments statistically increased V.C of Wonderful pomegranate fruits, with the superiority of Pergrina moringa oil at 500 ppm-treated fruits as compared with control in both seasons. As for the effect of storage periods, Table (6) show that V.C of Wonderful pomegranate fruits decreased with prolonging the storage periods in both seasons. Therefore, 0 and 15 days storage periods scored the highest values in this criterion, while 60 days storage period recorded the lowest values in this respect. Such trend was real during both seasons. Referring to the interaction effect between postharvest treatments and storage periods, data in Table (6) precise that the combination of 15 days storage period "regardless of the initial reading" showed to be the most promising in producing the highest values of V.C, especially those treated by Pergrina moringa oil at 500 ppm in both seasons. On contrast, the lowest values of this parameter was scored by the combination of 60 days storage periods, particularly those of untreated fruits in both seasons. The rest of the combinations came in-between the abovementioned treatments in both seasons. The obtained results are coincided with those scored by [14].

Total Antioxidant Activity (µG/ml): It is obvious from Table (7) that the increment in antioxidant activity of Wonderful pomegranate fruits is in proportional with the advance of storage period. Thus, sixty days of cold stored fruits scored the highest values of antioxidant activity. On the contrary, the freshly harvested fruits (zero day storage) scored the lowest values in this respect. Other values of cold storage periods occupied an intermediate position between the previously mentioned two categories. The differences between the studied storage periods were significant during both seasons. Concerning the specific effect of postharvest treatments,

Table 6: The impact of using different concentrations and type of moringa oils and algae oil on ascorbic acid (gm/100 gm f.w.) Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	10.97	10.64	10.2	10	7.89	9.94 A
Pergrina moringa oil at 500 ppm	10.97	10.95	10.9	10.94	9.41	10.63 A
Pergrina moringa oil at 1000 ppm	10.97	10.94	10.9	10.79	9.36	10.59 A
Stinopetala moringa oil at 500 ppm	10.97	10.92	10.84	10.64	9.27	10.54 A
Stinopetala moringa oil at 1000 ppm	10.97	10.9	10.79	10.78	9.27	10.53 A
Algae oil at 500 ppm	10.97	10.86	10.66	10.5	9.15	10.43 A
Algae oil at 1000 ppm	10.97	10.9	10.87	10.73	9.36	10.57 A
Mean	10.97 A	10.87 A	10.74 A	10.61 A	9.10 B	
LSD for the interaction effect between treatments and storage periods at 5% = 1.09						
Treatment	Second season					Mean
Control	11.71	10.79	10.02	9.36	7.44	9.86 D
Pergrina moringa oil at 500 ppm	11.1	11.06	10.99	10.97	9.08	10.64 A
Pergrina moringa oil at 1000 ppm	11.12	10.95	10.6	10.61	9.48	10.55 AB
Stinopetala moringa oil at 500 ppm	11.05	10.85	10.94	10.42	9.21	10.50 BC
Stinopetala moringa oil at 1000 ppm	11.28	10.82	10.76	10.6	9.55	10.60 A
Algae oil at 500 ppm	11.14	10.94	10.78	10.28	9.08	10.44 C
Algae oil at 1000 ppm	11.08	10.85	10.59	10.34	9.63	10.50 BC
Mean	11.21 A	10.89 B	10.67 C	10.37 D	9.067 E	
LSD for the interaction effect between treatments and storage periods at 5% = 0.21						

Table 7: The impact of using different concentrations and type of moringa oils and algae on antioxidant Activity (µg/ml) Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	19.80	24.10	33.15	40.00	50.00	33.41 B
Pergrina moringa oil at 500 ppm	19.80	24.30	33.30	40.60	51.34	33.87 B
Pergrina moringa oil at 1000 ppm	19.80	30.70	43.50	57.60	59.50	42.22 A
Stinopetala moringa oil at 500 ppm	19.80	30.80	42.40	55.00	58.00	41.20 A
Stinopetala moringa oil at 1000 ppm	19.80	34.10	51.00	54.10	66.00	45.00 A
Algae oil at 500 ppm	19.80	26.00	33.00	41.90	50.00	34.14 B
Algae oil at 1000 ppm	19.80	26.10	49.40	55.20	70.90	44.28 A
Mean	19.80 E	28.01 D	40.82 C	49.20 B	57.96 A	
LSD for the interaction effect between treatments and storage periods at 5% = 3.93						
Treatments	Second season					Mean
Control	19.52	24.11	30.73	38.53	47.30	32.04 D
Pergrina moringa oil at 500 ppm	19.62	20.40	29.91	39.33	50.20	31.89 D
Pergrina moringa oil at 1000 ppm	19.85	29.39	42.68	56.10	58.32	41.27 B
Stinopetala moringa oil at 500 ppm	19.26	29.26	41.76	51.27	56.13	39.54 C
Stinopetala moringa oil at 1000 ppm	18.55	32.73	50.26	53.60	65.70	44.17 A
Algae oil at 500 ppm	19.29	25.13	29.24	37.85	49.08	32.12 D
Algae oil at 1000 ppm	18.35	24.87	45.73	51.50	66.84	41.46 B
Mean	19.21 E	26.56 D	38.62 C	46.88 B	56.22 A	
LSD for the interaction effect between treatments and storage periods at 5% = 0.83						

Table 8: The impact of using different concentrations and type of moringa oils and algae oil on total anthocyanin (mg/100g) Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatment	0	15	30	45	60	Mean
Control	14.13	11.30	7.53	5.08	3.36	8.28 B
Pergrina moringa oil at 500 ppm	14.13	13.56	12.23	10.53	6.57	11.40 A
Pergrina moringa oil at 1000 ppm	14.13	12.34	10.23	9.06	7.64	10.68 AB
Stinopetala moringa oil at 500 ppm	14.13	11.50	8.68	6.06	3.47	8.76 AB
Stinopetala moringa oil at 1000 ppm	14.13	11.27	9.34	7.03	4.48	9.25 AB
Algae oil at 500 ppm	14.13	11.31	9.87	7.34	5.99	9.72 AB
Algae oil at 1000 ppm	14.13	12.43	10.65	9.77	8.59	11.14 A
Mean	14.13 A	11.96 AB	9.79 ABC	7.83 B	5.72 C	
LSD for the interaction effect between treatments and storage periods at 5% = 4.66						
Treatment	Second season					Mean
Control	13.50	13.10	5.95	5.21	2.88	8.13 D
Pergrina moringa oil at 500 ppm	12.89	12.05	11.22	9.66	8.67	10.90 A
Pergrina moringa oil at 1000 ppm	12.50	12.00	9.96	9.67	6.34	10.09 B
Stinopetala moringa oil at 500 ppm	13.95	11.24	7.23	6.15	3.29	8.37 D
Stinopetala moringa oil at 1000 ppm	12.92	11.11	9.21	7.23	4.47	8.99 C
Algae oil at 500 ppm	12.53	10.40	9.83	6.96	5.56	9.06 C
Algae oil at 1000 ppm	13.76	10.64	9.88	9.15	7.59	10.20 B
Mean	13.15 A	11.51 B	9.04 C	7.72 D	5.55 E	
LSD for the interaction effect between treatments and storage periods at 5% = 0.70						

statistical analysis of data in Table (7) indicates that all studied treatments failed to induce a remarkable effect on reduction antioxidant activity. However, the relative lower values of antioxidant activity were generally coupled by control and Pergrina moringa oil at 1000 ppm treated fruits oil in both seasons. Meanwhile, other investigated treatments were in between the previously mentioned two extends with a complete absence of significance in the two seasons. The obtained data during both seasons, as shown in Table (7) pointed out that each investigated treatment reflected its specific effect. The combination of fifteen days storage period generally recorded the lowest antioxidant activity values without significant difference with 30 days storage period. Meanwhile, as the cold storage period advanced, the differences became more pronounced and were significant, particularly when comparing antioxidant activity values of seven combinations after 15 days storage to either of 45 or 60 days cold storage during two seasons. In other words, the rate of reduction in antioxidant activity values became more acute after 45 days cold storage, whereas differences between seven combinations of such period (45 days) were significant with comparing to the fourteen combinations of the two earlier dates (15 and 30 days) regardless of postharvest treatments applied during both seasons.

These results are in agreement with those found by Miguel *et al*. [35]. Who pointed out that the main key to reduce chilling injury via its effect on antioxidant activity and changes in enzymes activity such as ascorbic acid oxidase, polyphenoloxidase, peroxidase, catalase, which may be related to membrane integrity and electrolyte leakage [36].

Total Anthocyanin Content (mg/100 g): It is evident from Table (8) that the reduction in total anthocyanin content of Wonderful pomegranate fruits is in proportionate with the advancement of storage period. Thus, sixty days of cold stored fruits scored the lowest values of fruit total anthocyanin content. On the contrary, the freshly harvested fruits (zero day storage) scored the highest values in this respect. Other values of cold storage periods occupied an intermediate position between the previously mentioned two categories. The differences among the studied storage periods were significant. The statistical analysis of the data in Table (8) indicate that differences among all studied treatments on fruit total anthocyanin content were insignificant. However, the relatively lower value of total anthocyanin content was generally coupled by control and Stinopetala moringa oil at 500 ppm- treated fruits in both seasons.

Table 9: The impact of using different concentrations and type of moringa oils and algae oil on pectinase (U/g pulp) Wonderful pomegranate fruits under cold storage

	First season					
	Storage periods (days)					
Treatments	0	15	30	45	60	Mean
Control	1.602	7.413	9.861	12.56	14.63	9.21 A
Pergrina moringa oil at 500 ppm	1.602	2.263	4.423	6.408	6.106	4.16 CD
Pergrina moringa oil at 1000 ppm	1.602	3.795	6.752	8.293	10.93	6.27 B
Stinopetala moringa oil at 500 ppm	1.602	4.544	5.906	7.879	10.55	6.09 BC
Stinopetala moringa oil at 1000 ppm	1.602	3.715	4.247	6.455	9.253	5.05 BC
Algae oil at 500 ppm	1.602	1.709	2.714	3.021	5.306	2.87 D
Algae oil at 1000 ppm	1.602	2.942	5.464	7.841	10.58	5.68 BC
Mean	1.602 D	3.76 C	5.62 BC	7.49 B	9.62 A	
LSD for the interaction effect between treatments and storage periods at 5% = 1.98						
Treatment	Second season					Mean
Control	1.67	7.41	8.43	11.41	13.40	8.46 A
Pergrina moringa oil at 500 ppm	1.70	2.07	3.91	5.73	8.32	4.35 F
Pergrina moringa oil at 1000 ppm	1.57	3.33	6.22	8.00	10.53	5.93 B
Stinopetala moringa oil at 500 ppm	1.64	4.20	5.69	7.08	9.47	5.62 C
Stinopetala moringa oil at 1000 ppm	1.65	3.69	4.24	6.25	8.56	4.88 E
Algae oil at 500 ppm	1.69	1.81	2.69	2.59	4. 90	2.74 G
Algae oil at 1000 ppm	1.58	2.88	5.10	6.24	9.69	5.10 D
Mean	1.64 E	3.63 D	5.18 C	6.76 B	9.27 A	
LSD for the interaction effect between treatments and storage periods at 5% = 0.39						

As shown in Table (8) the obtained data during both seasons, pointed out that each investigated treatment reflected its specific effect. Thereupon, seven combinations of fifteen days storage period stored generally the highest total anthocyanin content, however, the differences were insignificant compared to the analogous ones of 30 days storage. Meanwhile, as the cold storage periods extended, the differences became more pronounced and significant, particularly when comparing the total anthocyanin content of seven combinations after 15 days storage with either those of 45 or 60 days cold storage during two seasons. In other words, the reduction rate in total anthocyanin content became more acute after 45 days cold storage, whereas differences between seven combinations of such date (45 days) were significant compared to the sixteen combinations of the two earlier dates (15 and 30 days) regardless of postharvest treatments applied during both seasons. The severe reduction was also continued until the last storage date (after 60 days). The increase in anthocyanin concentration at cold storage may be attributed to the increase in biosynthesis and accumulation of anthocyanin, which induced in pomegranates at lower temperatures because of enzymes activity of the anthocyanin biosynthetic pathway. The abovementioned results are in agreement with those obtained by [5, 16, 34, 35].

Total Pectinase Content (U/g pulp): It is clear from the results in Table (9) that all examined postharvest treatments succeeded in decreasing the pectinase content of Wonderful pomegranate fruits in both seasons. However, the highest pectinase content of Wonderful pomegranate fruits was recorded by untreated fruits followed by Pergrina moringa oil at 1000 ppm -treated fruits, whereas the lowest values of this parameter were scored by Algae oil at 500 ppm treated fruits during both seasons of study. Referring to the effect of storage periods, Table (9) indicate that, regardless the initial reading, the pectinase content of Wonderful pomegranate fruits was progressively increased as the cold storage period increased from 15 to 60 days. However, stored Wonderful pomegranate fruits for 60 days scored the highest values as compared with storage periods for 15 days in both seasons. Regarding the interaction effect between the tested postharvest treatments and storage periods, data in Table (9) demonstrate that, irrespective of the initial data (zero storage period) the lowest values of pectinase content were recorded by the combination of 15 days storage periods, especially Algae oil at 500 ppm treated fruits. On the contrary, the highest values of this parameter were recorded by the combination of 60 days storage periods, particularly those of the untreated fruits in both seasons. Such a trend was actual during both seasons.

The aforementioned results are in parallel with those obtained by Patricia [37] they recorded that the function of edible coating showed inhibitory effect on pectinase and cellulase enzymes and in delay in ripening. pectinase activity was increased and the lowest activity values for pectinase and cellulase enzymes were recorded by moringa treatment [29].

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