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The Effect of Propolis and Sodium Metabisulfite as Postharvest Treatments on Pomegranate Arils Storage

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Abstract: During 2013 and 2014 seasons, the pomegranate arils of (cv. Wonderful) were immersed in ethanolic extracted propolis (EEP) (0.5% and 1%), sodium metabisulfite (SM) (0.5 and 1g/l) and mixed solution (0.5% EEP+0.5g/l SM and 1% EEP+1g/l SM) and in tap water as control. The arils were packed in rigid plastic trays and stored at 5±1°C and 85±90%RH for 25days. The obtained results showed that weight loss (%) and decay (%) of treated arils were significantly decreased by different postharvest treatments when comparing with the control arils during both seasons and highest effect at 25days was attributed to combined treatments. Application of 0.5% EEP+0.5g/l SM at 25 and 19 days of cold storage in 1st and 2nd seasons, respectively maintained firmness higher than remaining treatments with insignificant different with 1% EEP+1g/l SM. The lowest values of arils color hue (h°) at 25 days were scored by 1%EEP solely under storage conditions in both seasons. Mixed solution (low and high concentrations) at 25 days maintained a significant higher juice during 1st and 2nd seasons, respectively compared with control arils. All postharvest treatments resulted in significant decreases in TSS% of arils at 25days as compared with the initial readings in both seasons, since high levels of mixed solution had low value in the 1st season and 0.5g/l SM alone in the 2nd season. At 19days, arils dipped in high and low concentrations of mixed solution in the 1st and 2nd seasons, respectively exhibited the highest significant values of acidity (%) than untreated control arils. At 25days, dipping arils in 1% EEP solution solely in 1st season and combined with SM (1g/l) in the 2nd season appeared the highest values of TSS/acid ratio comparing with other treatments. The maximum values of anthocyanins content (%) were established through 19 days with arils treated by 0.5g/l SM in the 1st season and 1%EEP+1g/l SM during the 2nd season comparison with other treatments. All examined post-harvest treatments significantly succeeded in decreasing the respiration rate of Wonderful arils throughout both seasons compared with control arils, which exhibited the highest respiration rate. It can be concluded from the present investigation that 1g/l SM solely or combined with 1% EEP have potential to be used to maintain quality attributes of Wonderful arils treated up to 19 days during cold storage.

Key words: Wonderful arils · Propolis · Sodium metabisulfite · Quality attributes · Respiration rate · Cold storage

INTRODUCTION

Pomegranate is a fruit that is consumed mainly fresh or processed into fresh juice, however its consumption is still limited, whereas difficult extracting the arils from the fruit and the stimulation of phenolic metabolites during preparation of arils [1]. The edible part of the pomegranate fruit is called arils, it is made up of 80% juice and 20% seed [2]. Fresh arils are minimally processed and the "ready-to-eat", could be a good alternative for the national market. Pomegranate arils have health benefits, high value of nutritious [3]. However, maintaining the quality attributes of pomegranate arils is a major challenge, due to the deterioration of arils texture, color and overall quality as result of minimally processed [4, 1]. This is attributing to the active metabolic processes such

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as activity of endogenous enzymatic, enhancing respiration rates with increasing production of ethylene [5, 6].

Propolis is a natural waxy resinous substance collected by honeybees from different plant sources, it is consider a safe for human health and it is used in the pharmaceutical industry [7]. The presence of phenolic compounds, waxes, vitamins and essential oils could have the most significant biological action of propolis in inhibiting the microbial activity [7-10]. While, using propolis as a food additive is finite because it is soluble only in alcohol [11]. The application of ethanolic extracted propolis (EEP) as a fruit coating for avocado, grapefruit cv. Star Ruby, Navel orange**,** dragon fruit, papaya and bell pepper were evaluated [10, 12-14, 15, 16].

Decadence fruit product could be attributed to non-enzymatic browning and it can be treated enzymatically by adding suitable additives such as sodium metabisulphite or sulphur dioxide [17, 18]. Sodium metabisulfite ($Na_2S_2O_5$) is a compound that gradually releases SO_2 and in most cases it packed as a sheet in a wrapper bag or box that enables the gradual release of SO_2 to restrain the growth of pathogens and SO_2 treatments have also been used for controlling postharvest decay of litchi, figs and blueberries [19-21]. In addition, Sodium metabisulphite is also widely used to keeping quality grapes and dried mango slices [22, 23]. Different fresh cut fruits can be store at recommended temperature from 7 to 20 days and Wonderful pomegranate arils reached 16 days at 5°C with 20% gas composition of CO_2, while the arils with mechanical damage presented more susceptibility to the moulds after 12 days [24, 25].

To our knowledge, there have been no published reports about the use of ethanolic extracted propolis (EEP) and sodium metabisulfite (SM) solely or in combination as a technique method for maintaining quality attributes and enhancing the storage life of Wonderful pomegranate arils. Therefore, the objective of this investigation was to investigate the impact of ethanolic extracted propolis (EEP) and/or sodium metabisulfite (SM) on the physicochemical changes and respiration rate of Wonderful pomegranate arils during cold storage.

MATERIALS AND METHODS

During 2013 and 2014 seasons, pomegranate fruits (cv. Wonderful) were obtained during the commercial harvest date (mid-October) from a commercial orchard at 74km from Cairo, immediately transferred brought to laboratory of the agricultural development system (ADS) project, Faculty of Agriculture, Cairo University. The damaged fruits were discarded and the remaining fruits of uniform size were washed with tap water and left to dry. Husks were carefully cut with sharp knife and the arils were manually extracted. The extracted arils were collected in a tray and mixed to assure uniformity. Samples were dipped in a solution containing 1% (v/v) ethyl alcohol (95%) for 3-5 minutes as sanitizing agents for inhibiting micro-spoilage. Arils were subjected to the following treatments: (1) dipping in ethanolic extracted propolis (EEP) at 0.5%. (2) dipping in ethanolic extracted propolis (EEP) at 1%. (3) dipping in sodium metabisulfite (SM) at 0.5g/l. (4) dipping in sodium metabisulfite (SM) at 1g/l. (5) dipping in mixed solution of 0.5% EEP+0.5g/l SM (6) dipping in mixed solution of 1% EEP+1g/l SM (7) dipping in water (water control). One hundred and five of rigid plastic boxes trays (150 × 150 × 80 mm) previously sanitized with 1% (v/v) ethanol alcohol (95%) were used for packing treated arils after air drying (400g/box). Packaged samples then stored at 5±1°C and 85-90% relative humidity for 25days and sampling were carried out on 0, 6, 13, 19, 25days of storage. Each treatment compressed 3 replicates, each box was considered as a replicate.

Effect of the tested treatments on arils was evaluated throughout the following determinations:

Weight loss%: Weight loss% was calculated according to the following equation:

$$\frac{\text{Arils weight at the beginning} - \text{Arils weight at the sampling time}}{\text{Arils weight at the beginning of the storage}} \times 100$$

Decay Percentage: Microbial decay, observable shrivels and browning of arils were considered as decayed. The decayed arils of each treatment were separated, weighed and ascribed to whole weight of arils on each box.

Firmness (g/cm^2): was measured using lefra texture analyser (Mod.TA1000).

Color (h°): Was determined using a Konica Minolta Colorimeter (Chroma meter CR-400, Minolta, Japan). The hue angle was measured on surface of arils expressed in degrees (h°). Since, hue angle h°(0–360°), where 0° (red – purple), 90° (yellow), 180° (bluish-green) and 270° (blue) as described by McGuire [26].

Juice (%): A sample of 100g of arils were hand pressed using muslin cloth and the extracted juice was weighted.

Total Soluble Solids (TSS%): Fresh arils juice was used to measure total soluble solids (TSS) by using digital hand refractometer (Model Palette, PR-32, ATAGO).

Total Acidity (%): It was determined in arils juice by titration against 0.1 N NaOH using phenolphthalein as an indicator and expressed as citric acid content (%) [27].

Total Soluble Solids/ Total Acidity Ratio: It was calculated by dividing TSS value by total acidity value.

Anthocyanins Content (%): Total anthocyanins (%) in treated arils juice was determined as the method described by Wettstein [28].

Respiration rate (ml $CO_2kg^{-1}h^{-1}$): The respiration rate was measured by using Food Package analyser (Model 1450-Servomex 1400) and expressed as ml $CO_2kg^{-1}h^{-1}$ according to Croos [29].

Statistical Analysis: This experiment included two factors and was designed as a completely randomize. The means were compared by the least significant difference (LSD) at 5% level according to Snedecor and Cochran [30].

RESULTS AND DISCUSSION

Weight Loss%: On the average all treatments significantly decreased the weight loss% compared with control. Highest effect was attributed to both combined treatments with insignificant differences between them and the remaining treatments (Table 1). Weight loss% was significantly increased as storage period extended to reach 0.49 and 0.46% at the end of the storage period (25 days) for 2013 and 2014 seasons, respectively (Table 1). That on the last sampling data control arils attained significantly the highest weight loss percentage with insignificant differences from both propolis treated and the 0.5g/l sodium metabisulfite (SM) treated arils in first season only. Least reduction was attributed for the mixed treatment at (0.5% EEP+0.5g/l SM) but with insignificant differences from most treatments. Least effect on weight loss% was attributed to propolis at 1% with insignificant differences from the majority of conducted treatments.

Interaction data show the increment in weight loss in arils treated with the high concentration of EEP might be due to the heat generation it causes leading to the increase in anaerobic respiration and other senescence's related to the metabolic processes during the storage that lead to higher weight loss [31, 24]. These experimental results were confirmed by Zahid *et al.* [10] who reported that, dragon fruit treated with 0.50% EEP showed the most promising results, while fruit treated with 0.75 and 1.0% EEP showed some phytotoxic effects. Moreover, Ali *et al.* [32] on Chilli stated that weight loss was observed to gradually increase during the storage period and combined treatment of Brazilian green propolis extract (5%) and cinnamon oil (0.1%) was the most effective to reduce weight loss at the end of the storage period. On the contrary, El-Badawy *et al.* [14] on navel orange cleared that, by increasing, the used concentrations of ethanolic extracted propolis (EEP) (2 and 3%), weight loss was decreased. Moreover, Ali *et al.* [15] cleared that, combined application of 1.5% EEP and 10% gum delayed the reduction of papaya weight loss compared with 0.5, 1% of EEP and the control fruits.

Decay Percentage: Results in Table (1) clear that, undesirable arils were significantly increased gradually according to increase in storage period during both seasons. As a general trend, on the average all treatments decreased arils decay% and treatment with 1g/l sodium metabisulfite (SM) alone or combined with 1% EEP resulted in arils with a significant lower decay%, as compared to control arils during the first and second season. However, the arils treated with different concentrations of EEP showed significantly higher decay% than that of the other treatments except the untreated arils. A noticeable decrease in decay% was observed after 25 days in arils treated with 1g/l SM alone or combined with 1% EEP without significance differences between them. This trend was true in both seasons.

Different types of preservatives such as sulphur dioxide (SO_2), potassium metabisulphite and sodium metabisulphite are often mixed in fruit puree such as, guava and sapota for preservation and to reduce enzymatic browning and to remain stable for 2-3 months [17, 18].

Results of the current study are in parallel with Schutte *et al.* [33]; Duvenhage [34] and Liang *et al.* [35] who mentioned that, dipping litchi fruits in 60g/l sodium metabisulfit effectively delayed the browning reaction and

Table 1: Effect of proplis and sodium metabisulfite treatments on weight loss (%) and decay (%) of Wonderful arils throughout cold storage during 2013 and 2014 seasons

	Weight loss (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	0.00	0.11	0.18	0.33	0.56	0.23	0.00	0.09	0.21	0.34	0.47	0.22
1% EEP	0.00	0.10	0.27	0.40	0.59	0.27	0.00	0.20	0.31	0.39	0.51	0.28
0.5g /l SM**	0.00	0.05	0.14	0.24	0.53	0.19	0.00	0.11	0.18	0.33	0.40	0.21
1g /l SM	0.00	0.08	0.20	0.23	0.38	0.18	0.00	0.07	0.23	0.28	0.39	0.19
Mixed solution (0.5% EEP+0.5 g/l SM)	0.00	0.15	0.19	0.22	0.28	0.17	0.00	0.12	0.16	0.21	0.31	0.16
Mixed solution (1% EEP+1 g/l SM)	0.00	0.04	0.15	0.22	0.36	0.15	0.00	0.05	0.14	0.29	0.38	0.17
Control (water only)	0.00	0.22	0.38	0.56	0.69	0.37	0.00	0.23	0.34	0.57	0.76	0.38
Mean (B)	0.00	0.11	0.21	0.31	0.49	-	0.00	0.12	0.22	0.35	0.46	-
L.S.D at 5%	A= 0.07982		B= 0.06746		AB= 0.1785		A= 0.06517		B= 0.05508		AB= 0.1457	
	Decay (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	0.00	3.52	8.52	18.57	34.43	13.01	0.00	4.01	7.51	16.00	29.74	11.45
1% EEP	0.00	5.44	14.33	27.28	37.51	16.91	0.00	6.22	14.98	24.85	31.67	15.54
0.5g /l SM**	0.00	2.18	4.24	7.82	33.17	9.48	0.00	2.77	3.41	7.27	31.33	8.96
1g /l SM	0.00	2.15	2.08	4.35	14.43	4.60	0.00	2.15	2.77	5.60	15.51	5.21
Mixed solution (0.5% EEP+0.5 g/l SM)	0.00	2.71	4.40	9.97	19.68	7.35	0.00	3.03	5.70	8.39	19.06	7.24
Mixed solution (1% EEP+1 g/l SM)	0.00	2.22	3.08	3.87	16.79	5.19	0.00	2.50	3.76	4.18	17.96	5.68
Control (water only)	0.00	5.86	17.41	33.49	62.25	23.80	0.00	6.22	15.62	28.02	53.57	20.69
Mean (B)	0.00	3.44	7.72	15.05	31.18	-	0.00	3.84	7.68	13.47	28.41	-
L.S.D at 5%	A= 1.279		B= 1.081		AB= 2.859		A= 1.220		B= 1.031		AB= 2.728	

*EEP= Ethanolic Extracted Propolis **SM= Sodium metabisulfite

reduced decay, thereby extending the fruit storage life up to 18days compared with 30g/l of sodium metabisulfite (up to 9 days) and the control fruits (up to 12 days). Lower concentrations of sodium metabisulfite, if applied, change microflora population dynamics on the fruits surface, which increases the speed of pathogens growth, facilitating decay [36]. Çandir *et al.* [37] reported that the incidence of stem browning was increased significantly in cherries treated with EEP during 4weeks of storage. However, the 5% EEP treatment was effective in preventing fungal decay in grapefruits more than 10% EEP treatment. This might have been a result of the adverse effect of 10% EEP treatment [13]. On the contrary, El-Badawy *et al.* [14] demonstrated that, wax and propolis extract treatment at 3% showed to be the superior in reducing fruit decay (%) of Navel orange compared with 2% and control treatments. In the same line, combine application of 1.5% EEP and 10% arabic gum synergistically reduced the decays (%) of papaya fruits compared with 0.5, 1% of EEP+ 10% gum Arabic and control fruits [15].

Firmness (g/cm^2): Results presented in Table (2) clear that, on the average, Wonderful pomegranate arils treated by with mixed solution of ethanolic extracted propolis (EEP) and sodium metabisulfite (SM) at low concentrations recorded the highest non-significant when comparing with the other treatments under the study and control differ. Prolonging storage period resulted in non-significant decrease of arils firmness in both seasons. The interaction between different treatments and storage time cleared that, application of 0.5% EEP+0.5g/l SM in the 1st season maintained firmness at 25days of cold storage with a magnitude that was insignificant different from zero time. In the second, however all treatment expect 0.5% EEP maintain firmness at 19 days of storage with a magnitude that was insignificant different from zero days.

Table 2: Effect of proplis and sodium metabisulfite treatments on firmness (g/cm^2) and color (h°) of Wonderful arils throughout cold storage during2013 and 2014 seasons

	Firmness (g/cm^2)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	10.67	9.67	9.00	8.67	7.33	9.07	10.00	9.67	8.67	8.00	7.33	8.73
1% EEP	10.67	9.33	8.33	7.67	7.00	8.60	10.00	9.00	8.67	7.33	7.00	8.40
0.5g /l SM**	10.67	9.00	8.67	8.33	7.00	8.73	10.00	9.33	8.67	8.33	8.00	8.87
1g /l SM	10.67	10.33	9.33	9.00	8.00	9.47	10.00	9.67	9.00	8.33	8.00	9.00
Mixed solution (0.5% EEP+0.5 g/l SM)	10.67	10.00	9.67	9.00	8.67	9.60	10.00	9.67	9.33	8.67	7.67	9.07
Mixed solution (1% EEP+1 g/l SM)	10.67	9.33	9.00	8.67	8.33	9.20	10.00	9.33	9.00	8.67	7.67	8.93
Control (water only)	10.67	9.00	8.33	7.00	6.00	8.20	10.00	9.33	8.33	8.00	7.00	8.53
Mean (B)	10.67	9.52	8.90	8.33	7.48	-	10.00	9.43	8.81	8.19	7.52	-
L.S.D at 5%	A= 1.074		B= 0.9074		AB= 2.401		A= 0.7642		B= 0.6459		AB= 1.709	
	Color (h°)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	30.52	31.31	45.39	22.51	20.63	30.07	34.01	25.36	42.02	22.67	21.23	29.06
1% EEP	30.52	36.01	41.27	20.71	19.00	29.50	34.01	28.36	40.02	22.96	20.67	29.20
0.5g /l SM**	30.52	33.23	34.73	25.57	33.90	31.59	34.01	28.49	33.41	22.89	29.00	29.56
1g /l SM	30.52	31.54	30.96	34.96	24.96	30.59	34.01	29.21	34.32	22.79	21.90	28.45
Mixed solution (0.5% EEP+0.5 g/l SM)	30.52	33.51	36.72	25.39	27.59	30.75	34.01	28.67	35.21	22.79	24.34	29.00
Mixed solution (1% EEP+1 g/l SM)	30.52	35.20	29.56	37.36	34.70	33.47	34.01	29.08	35.66	24.07	28.80	30.32
Control (water only)	30.52	31.00	32.42	25.88	32.38	30.44	34.01	24.53	32.08	25.88	28.36	28.97
Mean (B)	30.52	33.11	35.86	27.48	27.59	-	34.01	27.67	36.10	23.44	24.90	-
L.S.D at 5%	A= 2.541		B= 2.148		AB= 5.683		A= 1.927		B= 1.629		AB= 4.309	

*EEP= Ethanolic Extracted Propolis **SM= Sodium metabisulfite

Firmness of pomegranate arils has been reported to decrease throughout the storage period [38]. An increase in softening of arils at higher concentrations of EEP might be due to the cohesion between EEP and arils which decreased at higher concentration as ethanol evaporates off leaving hydrophobic propolis and water, which separates and leaving an open matrix, for higher respiration, thus it could not change the atmosphere surrounding the arils and the higher concentrations of EEP might have negatively affected the mitotic cell division which results in the breakage of cell structure [10]. On Other side, maximum papaya fruit firmness was maintained by 10% GA+1.5% EEP, followed by 10% GA+ 0.5% EEP compared with 10% GA+1% EEP and control fruits [15]. While, Ali *et al.* [16] stated that no significant differences were observed for firmness of bell paper among the different treatments of EEP (1, 5, 10% and control) and even throughout the storage period".

Color (h°): No differences in the arils h° were observed between the control arils and the other treatments in both seasons on the average, expect the mixed solution (at high concentration) where arils attained significant higher level hue angle compared with control arils in the first season only (Table 2). Arils color hue (h°) value significantly increased up to day 13 then decreased till the end of the storage periods throughout the first season, however in the second season no clear trend was observed. Anyway, the lowest values of this parameter were scored by treated arils with high 1% EEP under cold storage at 25 days in both seasons. On the contrary, the highest values (37.36) of arils color were related to application of 1% EEP+1g/l SM at 19 days storage period in the 1st season. However, in the 2nd season, dipping arils on sodium metabisulfite (SM) (0.5g/l) alone exhibited highest value of color (29.00) at day 25.

Table 3: Effect of proplis and sodium metabisulfite treatments on juice (%) and total soluble solids (%) of Wonderful arils throughout cold storage during 2013 and 2014 seasons

	Juice (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	77.65	75.00	74.04	62.90	60.00	69.92	72.00	68.14	63.83	60.15	53.24	63.47
1% EEP	77.65	65.17	60.24	57.00	51.23	62.26	72.00	62.14	57.47	51.26	44.53	57.48
0.5g /l SM**	77.65	71.98	66.30	52.00	52.48	64.08	72.00	67.51	60.33	56.33	48.76	60.99
1g /l SM	77.65	74.41	74.00	66.30	62.09	70.89	72.00	69.44	66.30	60.61	55.24	64.72
Mixed solution (0.5% EEP+0.5 g/l SM)	77.65	74.37	73.57	66.90	64.94	71.49	72.00	69.75	66.73	60.98	57.21	65.33
Mixed solution (1% EEP+1 g/l SM)	77.65	75.25	70.59	65.90	62.08	70.29	72.00	69.12	63.97	61.93	57.83	64.97
Control (water only)	77.65	72.96	68.10	66.20	52.88	67.56	72.00	66.42	61.90	58.56	48.25	61.43
Mean (B)	77.65	72.74	69.55	62.46	57.96	-	72.00	67.51	62.93	58.55	52.15	-
L.S.D at 5%	A= 1.980		B= 1.674		AB= 4.428		A= 2.196		B= 1.856		AB= 4.910	
	Total soluble solids (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	17.03	16.13	14.57	13.83	12.40	14.79	17.60	15.47	14.33	13.90	11.20	14.50
1% EEP	17.03	14.90	14.47	14.13	13.47	14.80	17.60	16.03	14.37	13.77	12.53	14.86
0.5g /l SM**	17.03	15.03	14.20	13.83	12.80	14.58	17.60	15.50	14.10	14.93	10.90	14.61
1g /l SM	17.03	15.50	14.00	13.50	12.70	14.55	17.60	14.93	14.30	14.30	12.17	14.66
Mixed solution (0.5% EEP+0.5 g/l SM)	17.03	15.10	14.23	14.03	12.13	14.51	17.60	14.97	14.03	13.40	12.30	14.46
Mixed solution (1% EEP+1 g/l SM)	17.03	15.87	14.47	14.03	11.07	14.49	17.60	14.83	14.70	14.30	13.63	15.01
Control (water only)	17.03	15.77	15.10	14.17	12.20	14.85	17.60	15.27	14.93	14.83	13.87	15.30
Mean (B)	17.03	15.47	14.43	13.93	12.40	-	17.60	15.29	14.40	14.20	12.37	-
L.S.D at 5%	A= 0.2597		B= 0.2195		AB= 0.5806		A= 0.2524		B= 0.2133		AB= 0.5644	

*EEP= Ethanolic Extracted Propolis **SM= Sodium metabisulfite

On contrary, Çandir *et al.* [37] reported that, propolis treatment had a significant effect on the hue value of cherries skin color during storage. However, the current results are in harmony with that obtained by Özdemir *et al.* [13], who mentioned that hue angle values of Star Ruby grapefruit was increased during the storage (8°C and 85%-90% RH), as compared with the time of harvest and the treated fruits with 5% propolis were brighter in comparison to remaining treatments and appearance of the 10% EEP-treated fruits was very poor.

Juice (%): As shown in Table 3, on the average, 1% EEP treatment significantly recorded the lowest juice% of arils in both seasons, however 0.5% EEP+ 0.5g/l sodium metabisulfite (SM) treatment had higher values content of juice during both seasons. Juice content (%) was significantly decreased with prolonging postharvest storage periods in both seasons. At 25days, arils treated with mixed solution of EEP and sodium metabisulfite at low and high concentrations maintained significant higher juice (64.94 and 57.83%) during 1st and 2nd seasons, respectively compared with control arils (52.88 and 48.25%). Fruit juice content of Star Ruby grapefruit was decreased during the cold storage and the effects of EEP treatment on fruit juice content were not significant during 6 months of the storage [13].

Total Soluble Solids (TSS%): Apart from the physical quality attributes, the total soluble solids (TSS) are important factors when describing the quality of the fruit product [39]. The results pertaining the effect of different treatments on arils TSS values as shown in Table (3), report that, the highest significant value was observed with the control arils (14.85 and 15.30% for 1st and 2nd seasons, respectively) followed by arils treated by 1% EEP alone or combined with sodium metabisulfite (SM) (1g/l) (14.80 and 15.01%) in the first and second seasons, respectively on the average. Meanwhile, the lowest value

was occurred in the arils treated with mixed solution of EEP and sodium metabisulfite at high and low concentrations throughout the 1st and 2nd seasons, respectively compared with the other treatments. TSS% was significantly decreased by prolonging the storage period in both seasons.

As for the effect between the investigated post-harvest treatments and storage periods, data indicated that all treatments resulted in significant decreases in TSS% of arils at 25days as compared with the initial readings in both seasons. Since, high levels of mixed solution had the lowest values in the 1st season and 0.5g/l sodium metabisulfite alone in the 2nd season.

Our results exhibited, there were lower TSS levels in EEP-treated arils compared with the control arils, it might be due to the formation a semipermeable film around the arils which suppressed ethylene production and restored TSS content in the arils [40]. Similarly, significantly higher TSS value was recorded in the control fruit of dragon and bell pepper as compared to the fruit treated with EEP (concentration ranged from 0.25 to 10%) [10, 16]. Other results showed that propolis treatment had little effect on the TSS content of mandarin and cherries fruits during storage (4 months and 4 weeks) [41, 37]. Moreover, 1.5% EEP+10% Arabic gum treatment delayed the reduction of TSS content in papaya fruit as compared with 0.5, 1% and the control fruits [15]. Various studies have found that TSS of pomegranate arils were decreased with storage period [38, 42, 43].

Acidity (%): Concerning the effect of different treatments on acidity (%) (Table 4), arils dipped in mixed solution (1% EEP+1g/l SM) was significantly slight higher than untreated arils throughout 2013 season and that treated with 0.5% EEP solely in 2014 season. The storage period effect on increasing the arils acidity was significant after 13days in both seasons. Whereas, acidity (%) in treated arils was increased gradually in 1st season and with some fluctuated in the 2nd season. At 19days, the highest significant values of acidity (%) were noticed with arils treated by mixed solution (1% EEP+1g/l SM) in the 1st season and that with mixed solution (0.5% EEP+0.5g/l SM) in the 2nd season.

Propolis treatment had little effect on the titratable acidity content of mandarin and cherries fruits during storage (4 months and 4 weeks) [41, 37]. The current results of acidity percentage content as affected by storage period are in disharmony with findings mentioned by Zahid *et al.* [10]. They stated that there was a significant decrease in titratable acidity (TA) content of dragon control fruits followed by the fruits treated with 1, 0.25, 0.75 and 0.5% ethanolic extract of propolis.

Meanwhile, 1.5% EEP+10% Arabic gum delayed the reduction of titratable acidity in papaya fruits compared to 0.5 and 1% EEP in combined with 10% Arabic gum [15]. Insignificant differences were noticed between the different EEP treatments (1%, 5% and 10%), except for 10% EEP. This treatment maintained the highest titratable acidity content of bell pepper at days 7 and 21 [16].

Total Soluble Solids/Total Acidity Ratio: The effect of different treatments on TSS/acid ratio of Wonderful arils presented in Table (4). It is clearly disclose that, in the 1st season, TSS/acid ratio in control arils juice followed by 0.5% EEP treated arils attained the highest on the average with insignificant differences and the lowest TSS/acid ratio was noticed with arils treated by 1% EEP+1g/l SM. Meanwhile, in the 2nd season, high level of mixed solution then control arils had highest significant ratio of TSS/acid, while treatment of 0.5% EEP+ 0.5g/l SM exhibited significant lower value of TSS/acid ratio in compared to remaining treatments except 0.5% EEP, differences were insignificant. TSS/acid ratio of arils juice was significantly decreased with increasing storage period in both seasons. At 25days, dipping arils in 1% EEP solution solely in 1st season and combined with sodium metabisulfite (SM) (1g/l) in the 2nd season resulted in highest values of TSS/acid ratio comparing with other treatments and significant differences differ between them.

The results of the current investigation cleared that TSS/TA was decreased during cold storage it could be attributed to the decline in TSS and increased total acidity (%). Our findings are in accordance with the results of Ghasemnezhad *et al.* [44] that there was a gradual decrease in TSS/TA of uncoated pomegranate arils cv. Tarom during cold storage (4°C).

Anthocyanins Content (%): Anthocyanins are light-absorbing plant-based pigments and are responsible for the red color of pomegranate juice [38, 45, 46]. Our findings indicated that high significant anthocyanins content (%) on the average was observed with arils treated with 1% EEP+1g/l SM in the 1st season and that with sodium metabisulfite(SM) (0.5 or 1g/l) solely in the 2nd season in comparison with control arils that had the lowest content of anthocyanins (%) in both seasons

Table 4: Effect of proplis and sodium metabisulfite treatments on acidity (%) and total soluble solids/acidity ratio of Wonderful arils throughout cold storage during 2013 and 2014 seasons

	Acidity (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	1.21	1.24	1.27	1.30	1.30	1.26	1.02	1.05	1.03	1.09	1.12	1.06
1% EEP	1.21	1.25	1.27	1.31	1.34	1.28	1.02	1.03	1.01	0.99	1.13	1.04
0.5g /l SM**	1.21	1.22	1.27	1.29	1.35	1.27	1.02	0.99	1.00	1.02	0.95	1.00
1g /l SM	1.21	1.22	1.23	1.26	1.37	1.25	1.02	1.03	1.06	1.03	1.03	1.04
Mixed solution (0.5% EEP+0.5 g/l SM)	1.21	1.24	1.27	1.34	1.37	1.28	1.02	1.05	1.07	1.11	1.10	1.07
Mixed solution (1% EEP+1 g/l SM)	1.21	1.27	1.27	1.37	1.38	1.30	1.02	1.03	0.96	0.94	1.02	1.00
Control (water only)	1.21	1.24	1.25	1.26	1.31	1.25	1.02	0.99	1.01	1.05	1.09	1.03
Mean (B)	1.21	1.24	1.26	1.30	1.35	-	1.02	1.03	1.02	1.03	1.06	-
L.S.D at 5%	A= 0.03991		B= 0.03373		AB= 0.08924		A= 0.02304		B= 0.01947		AB= 0.05152	
	Total soluble solids/acidity ratio											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	14.18	13.04	11.48	10.63	9.54	11.77	17.24	14.80	13.86	12.78	10.02	13.74
1% EEP	14.18	11.95	11.46	10.78	10.03	11.68	17.24	15.51	14.20	13.93	11.11	14.40
0.5g /l SM**	14.18	12.41	11.26	10.72	9.45	11.60	17.24	15.66	14.07	14.62	11.48	14.61
1g /l SM	14.18	12.78	11.45	10.74	9.30	11.69	17.24	14.44	13.55	13.85	11.77	14.17
Mixed solution (0.5% EEP+0.5 g/l SM)	14.18	12.25	11.22	10.47	8.89	11.40	17.24	14.32	13.16	12.11	11.20	13.61
Mixed solution (1% EEP+1 g/l SM)	14.18	12.51	11.41	10.29	8.04	11.29	17.24	14.35	15.31	15.31	13.32	15.11
Control (water only)	14.18	12.84	12.12	11.44	9.32	11.98	17.24	15.43	14.76	14.19	12.76	14.88
Mean (B)	14.18	12.54	11.48	10.72	9.23	-	17.24	14.93	14.13	13.83	11.67	-
L.S.D at 5%	A= 0.4562		B 0.3856		AB= 1.020		A= 0.5462		B= 0.4617		AB= 1.221	

*EEP= Ethanolic Extracted Propolis **SM= Sodium metabisulfite

(Table 5). Anthocyanins content was increased as the storage period progresses up to 13 days then decreased till the end of storage period. Moreover, the storage period has a significant effect on arils anthocyanins content (%) till 13days, while after 13days till the end of storage period, differences were not significant during the two seasons. Concerning the interaction, the maximum values of anthocyanins content (%) were established through 19 days with arils treated by SM (0.5g/l) in the 1st season with significant differences with remaining treatments and 1% EEP+1g/l SM during 2nd season with insignificant differences in comparison with the other treatments expect 0.5% EEP and 0.5%EEP+0.5g/l sodium metabisulfite (SM) differences were significant.

The decrease in anthocyanins (%) in control arils and the arils treated with higher concentration of EEP as single treatment could be due to the higher rate of respiration or the change of enzyme activities and decrease in the antioxidant capacity resulting to degradation of certain phenolic compounds [47, 48]. While the retention of anthocyanins (%) with sodium metabisulfite treatments and 0.5% EEP-treated arils could be due to slower respiration rates as compared to the arils treated with higher concentration of EEP as single treatment. Anthocyanins (%) that increased up to 13 days may be related to increase in biosynthesis and continued accumulation of anthocyanins at lower temperatures, then declined till the end of storage, this may be related to the breakdown of phenolic compounds as a result for oxidation and enzymatic activity occurring during the storage [49-51].

Respiration Rate (ml $CO_2kg^{-1}h^{-1}$): Respiration rate of fresh produce can either be expressed as the rate of O_2 consumption and/or the rate of CO_2 production. Pomegranate is classified as a non-climacteric fruit and that has a relatively low respiration rate, which declines with postharvest storage to reach a stable state [52]. It is

Table 5: Effect of proplis and sodium metabisulfite treatments on anthocyanins content (%) and respiration rate (ml $CO_2kg^{-1}h^{-1}$) of Wonderful arils throughout cold storage during 2013 and 2014 seasons

	Anthocyanins content (%)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	0.34	0.47	0.51	0.50	0.42	0.45	0.29	0.37	0.45	0.41	0.36	0.38
1% EEP	0.34	0.40	0.58	0.48	0.42	0.44	0.29	0.33	0.47	0.42	0.32	0.36
0.5g /l SM**	0.34	0.43	0.60	0.59	0.55	0.50	0.29	0.43	0.49	0.42	0.37	0.40
1g /l SM	0.34	0.41	0.54	0.51	0.49	0.46	0.29	0.40	0.48	0.45	0.39	0.40
Mixed solution (0.5% EEP+0.5 g/l SM)	0.34	0.48	0.57	0.54	0.52	0.49	0.29	0.38	0.40	0.40	0.37	0.37
Mixed solution (1% EEP+1 g/l SM)	0.34	0.48	0.60	0.55	0.56	0.51	0.29	0.39	0.44	0.49	0.35	0.39
Control (water only)	0.34	0.43	0.55	0.33	0.47	0.42	0.29	0.34	0.41	0.42	0.31	0.35
Mean (B)	0.34	0.44	0.57	0.50	0.49	-	0.29	0.38	0.45	0.43	0.35	-
L.S.D at 5%	A= 0.03991		B= 0.03373		AB= 0.08924		A= 0.03259		B= 0.02754		AB= 0.07286	
	Respiration rate (ml $CO_2kg^{-1}h^{-1}$)											
	2013 Season						2014 Season					
	Storage period (days) (B)						Storage period (days) (B)					
Treatments (A)	0	6	13	19	25	Mean (A)	0	6	13	19	25	Mean (A)
0.5% EEP*	0.00	1.87	0.97	0.69	2.14	1.13	0.00	1.76	1.46	1.18	1.60	1.20
1% EEP	0.00	1.87	1.60	1.86	0.59	1.18	0.00	1.92	1.23	1.36	1.90	1.28
0.5g /l SM**	0.00	1.40	0.66	1.30	0.49	0.77	0.00	1.92	0.99	0.95	1.55	1.08
1g /l SM	0.00	1.07	0.82	0.73	1.33	0.79	0.00	1.58	1.05	1.11	1.39	1.03
Mixed solution (0.5% EEP+0.5 g/l SM)	0.00	1.12	1.44	1.16	0.56	0.86	0.00	1.10	1.08	1.02	1.38	0.92
Mixed solution (1% EEP+1 g/l SM)	0.00	1.30	0.59	0.43	0.70	0.60	0.00	1.41	1.22	0.97	1.62	1.04
Control (water only)	0.00	1.94	1.76	1.45	1.73	1.38	0.00	2.06	1.85	1.43	2.16	1.50
Mean (B)	0.00	1.51	1.12	1.09	1.08	-	0.00	1.68	1.27	1.15	1.66	-
L.S.D at 5%	A= 0.1004		B= 0.08488		AB= 0.2246		A= 0.06096		B= 0.05152		AB= 0.1363	

*EEP= Ethanolic Extracted Propolis **SM= Sodium metabisulfite

evident from Table (5) that that all examined post-harvest treatments significantly succeeded in decreasing the respiration rate of Wonderful arils throughout both seasons compared with control arils, which exhibited the highest respiration rate. Storage period had a significant effect on respiration rate of treated arils in both seasons. High values were observed at 6 days then decreased till the end of the storage period during 2013 season. While in 2014 season respiration rate decreased up to 19 days then increased at day 25 in the 2nd season. Treatment of 1% EEP+1g/l sodium metabisulfite (SM) decrease respiration of treated arils up to 19 days with lowest respiration rate (0.43 ml $CO_2kg^{-1}h^{-1}$) in the 2013 season followed by 0.5g/l sodium metabisulfite treatment (SM) (0.95 ml $CO_2kg^{-1}h^{-1}$) throughout 2014 season.

The high respiration rate of Wonderful arils at 6 days might be attributed to peeling and due to an increase in the surface area exposed, which induces a high diffusion rate of oxygen into the internal cells of the arils and consequently increasing the metabolic processes of these injured cells [55, 56]. The respiration rate decreased till the end of storage periods and at 19days in the 1st and 2nd seasons, respectively could be due to effect of lower temperature (5°C) in reducing respiration rate of arils [57]. While respiration rate of Wonderful arils that increased after 19 days in the 2nd season may be due to anaerobic respiration that occurred and the growth of pathogens on the arils surfaces, resulting in tissue deterioration and production of off-flavours and off-odours [47, 58-60].

The respiration rate of the pomegranate arils differs, depending on the storage condition as well as on the cultivar. In this sphere, Lopez-Rubira *et al.* [42] reported a minimum respiration rate of Mollar arils about 1.15 ml CO_2 $kg^{-1}h^{-1}$ when stored at 5°C, while Ersan *et al.* [53] reported that respiration rate of Hicaz arils about 0.52 ml CO_2 $kg^{-1}h^{-1}$ under a storage condition of 2% O_2 with 10% CO_2 at 4°C. Furthermore, results from the study conducted by Caleb *et al.* [54] indicated the arils (cv. 'Acco' and

'Herskawitz') had respiration rate of about 2.72 CO_2 ml CO_2 $kg^{-1}h^{-1}$, when stored at 5°C under ambient air condition.

CONCLUSION

From the above results, it can be summarize that application of higher concentration of ethanolic extract of propolis (EEP) as a single treatment showed negative effects. While, the most effective treatments in maintaining quality attributes of Wonderful arils during cold storage was Sodium metabisulfite (1g/l) solely and combined with EEP (1%), which successfully extended the storage life of arils up to 19 days during cold storage with minimal reduction in quality attributes.

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