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INFLUENCE OF PROPOLIS EXTRACT AND OXALIC ACID ON PRESERVING QUALITY OF GUAVA FRUITS DURING POSTHARVEST COLD STORAGE

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ABSTRACT

In this investigation, effects of post harvest oxalic acid and propolis extract applications on quality and storability of "Maamoura" guava fruits were studied. Fruits were harvested at maturity stage (yellowish green) and transported to laboratory of Sabahiya Horticulture Research Station, Alexandria, Egypt, immediately. Guava fruits at the same stage were washed with 0.01% sodium hypochlorite water solution for 2 minutes and then air dried at room temperature. Fruits were dipped in the following treatments: distilled water used for untreated fruits (control treatment), oxalic acid at (3 and 6) mM/L, propolis extract at (2 and 4)%for five minutes in five liter of aqueous solutions containing Tween-80 at a concentration of 0.05% (v/v). After dipping treatments, the fruits were allowed to dry for 30 minutes at room temperature by electric fan and then were stored at 7±1˚C and 90±5% R.H. for 21 days and shelf life period at room temperature under conditions (25±2˚C and 65±5% R.H.).

Results showed that, oxalic acid and propolis extract treatments significantly decreased weight loss and decay percentage during cold storage period and shelf life as compared to the control. Also, increased fruit firmness, soluble solid content, SSC/acid ratio, ascorbic acid content and decreased titrable acidity during cold storage period and shelf life in comparison with control. It could be concluded that post harvest applications of oxalic acid at 6 mM/L and propolis extract at 4%gave the highest efficacy on the treated fruits during cold storage and shelf life periods of "Maamoura"guava fruits compared with other treatments.

Keywords: "Maamoura" guava fruits, oxalic acid, propolis extract, storage life.

Introduction

Guava (*Psidium guajava*, L.) is an important fruit crop of tropical and subtropical countries, fruits are an excellent source of vitamin C and have high levels of sugars and nutrients. Guava a climacteric fruit are highly perishable and have limited storage and shelf life. Fruits have the low of PH and this lowest makes them vulnerable to fungal decaying (Singh and Sharma, 2007). Many storage techniques have been developed to extend the useful marketing distances and holding periods for fresh horticultural commodities after harvest. One method of extending post harvest shelf-life is the use of edible coatings, such as propolis extract and oxalic acid.

Propolis and its extracts possess antimicrobial action and include some hydrophobic compounds able to improve a few properties of biodegradable coatings on fruits (Ali *et al.,* 2015; Ali *et al.,* 2014 and Zahid *et al.,* 2013). Ali *et al.,* 2015 and Zahid *et al.* (2013) founded that, in bell pepper and in dragon fruit respectively, propolis coating given excellent antifungal properties, providing an effective barrier to limit mycelial growth and germination of *Colletotrichum capsici* spores (the fungus responsible for anthracnose). Furthermore, Ali *et al.* (2014) found that propolis extract, when additive with cinnamon oil, acts as an efficient bio-fungicide against *C. capsici*, and slowing changes in weight, flesh firmness, peel color, and concentration of soluble solids in peppers. Several studies have reported the efficiency of propolis on gram-positive bacteria, however, having a limited activity towards gram-negative ones (Torlak and Sert, 2013; Uzel *et al.,* 2005). In addition, Daiuto *et al.* (2012) observed less weight loss and CO_2 production in avocados in application of propolis extract in amalgamation with vegetable wax.

Oxalic acid is a natural organic acid, has been reported to play an important function in systemic fight and restraint to environment (Zheng *et al.,* 2012 and Jin *et al.,* 2014). Oxalic acid application is a secure and hopeful post harvest handling technology for keeping quality and extending storage life of fruit (Zheng and Tian, 2006). Oxalic acid (OA) has shown some antioxidant activities and could play a serious function in systemic strength, programmed cell death, redo homeostasis in plants and an anti-senescence effectiveness in harvested fruits (Ding *et al.,* 2007, Zheng *et al.,* 2007a and Wu *et al.,* 2011). Also, OA decrease PPO activity (Yoruk *et al.,* 2002).

Pre-storage application with OA promoted the antioxidant capacities of banana and pomegranate fruits (Huang *et al*., 2013 a,b and Sayyari *et al*., 2010). Moreover, oxalic acid induce systemic fighting versus diseases caused by microbes in trees and crops (Mucharromah & Kuc, 1991; Toal & Jones, 1999). Furthermore, post harvest application of OA can suppress postharvest disorders and prolong the shelf life of fruits, this due to the a combination of physiological effects associated with retardant the ripening procedure and direct effects including low pH, reduced decay incidence and extended post harvest shelf and storage life of mangoes (Zheng *et al*., 2007b,c and Zheng *et al*., 2012).

Postharvest treatment with OA, also decrease fruit softening and actions of exo-PG enzyme besides enhancing the activities of antioxidative enzymes (superoxide dismutase, catalase and Peroxidase). Moreover, the SSC and SSC: TA ratio had been lowered, while, TA and ascorbic acid contents were higher in treated fruits as comparable with untreated fruits (Razzaq *et al.,* 2015). In addition, OA maintained peel appearance and prolonged the green shelf life of banana fruit during storage at ambient temperature and displayed the occasion for commercial application to store the bananas at ambient temperature (Huang *et al.,* 2013a,b).

Therefore, the present investigation aimed to study the influence of postharvest application of propolis extract and oxalic acid on preserving quality of "Maamoura" guava fruits during cold storage and shelf life.

Materials and Methods

Fruit material

The present study was carried out during 2018 and 2019 seasons at laboratory of Sabahiya Horticulture Research Station, Alexandria, Egypt. "Maamoura" guava trees are grown in Kafr El-Dawar, El-Behera Governorate, Egypt. Guava trees were about 20 years of age, planted at a spacing of 5 × 5 meters apart in a loamy clay soil under flooding irrigation and subjected to standard agriculture practices recommended by ministry of agriculture and land reclamation. Guava fruits were picked from a private orchard at maturity stage (yellowish green) in the second week of August according to Mercado-Silva *et al.* (1998) from almost similar trees and guavas apparently uniform in size and free of visible symptoms of infection. In addition, ethanolic extract of propolis was prepared according to Ali *et al.,* 2014.

Postharvest treatments and storage

Samples free of defects were collected randomly after harvest during both seasons, and then transferred quickly to the laboratory to the Horticulture laboratory in plastic boxes (15 kg capacity).

The sound fruits at the same maturity stage were washed with 0.01% sodium hypochlorite water solution for 2 minutes to clean the surface of fruits and air dried at room temperature until visible moisture on fruit surfaces disappeared completely. A total of 750 clean sound fruits were selected and randomly divided into five treatments with three replicates. Guava fruits were subjected to the following treatments: (1) distilled water used for untreated fruits (control treatment), (2) Oxalic acid at 3 mM/L, (3) Oxalic acid at 6 mM/L, (4) Propolis extract at 2% and (5) Propolis extract at 4%.

Postharvest treatments were performed by dipping fruits in the previous treatments for five minutes in five liter of aqueous solutions containing Tween-80 at a concentration of 0.05% (v/v) to improve wett ability and adherence to guavas surface. After dipping treatments, the fruits were placed to dry for 30 minutes at room conditions by electric fan. After that, the fruits in each treatment were packed in foam plates covered with perforated polyethylene sheets with a thickness of 0.04 mm and then packaged in cardboard boxes with dimensions of 45×35×10 cm. All experiential boxes were stored at 7±1˚C and 90±5% R.H. for 21 days. Fruit physical and chemical characteristics were examined at harvest time and then every seven days intervals of cold storage period and after shelf life at home temperature.

Assessments performed

Fruit physical characteristics

Weight loss % was calculated by the following formula: [(fruit weight before storage - fruit weight after each period of cold storage) / fruit weight before storage] × 100.

Decay percentage was recorded every seven days of cold storage by counting the number of decayed fruits consequent to fungus or any microorganism's infection and studied as a percentage of the initial number of stored fruits using the following equation: (number of decayed fruits at specified storage period / initial number of stored fruit) × 100.

Visual appearance score was measured by a rating system, fruit scored: very good = 9, good = 7, acceptable = 5, unacceptable = 3 and poor = 1.

Firmness was measured in three guava fruits per replicate at two equatorial sites to determine the penetration force by using a hand-held fruit firmness tester (FT-327, Italy) equipped with an 8 mm cylindrical stainless steel plunger tip (Watkins and Harman, 1981). Two readings were taken on the flesh of each fruit after peeling. The firmness value was expressed in terms of kilogram force (kgf) and data was calculated as Newton (N) by the following formula (1 N = 0.1 kgf).

Fruit chemical characteristics

After each of cold storage period, fifteen guava fruits from each treatment (three replicates) were extracted by crushing the pulp of fruits, then the juice strained through a muslin cloth and used for measuring internal fruit quality as follow:

Fruit ascorbic acid analysis was estimated according to A.O.A.C. (2005). Samples of fruit juice were used, oxalic acid solution was added to each sample and titrated with 2,6-dichlorophenol-indophenol dye solution and expressed as a milligram of ascorbic acid and was calculated as mg/100 ml of the juice.

Fruit TSS content was measured using a hand refractometer, 0-32 scale (ATAGO N-1E, Japan) and expressed in Brix° after making the temperature rectification at 20°C according to A.O.A.C. (2005).

Fruit titrable acidity (TA) was assayed based on the method of adopting the procedure described by A.O.A.C. (2005). Aliquot of fruit juice was taken and titrated against 0.1 N NaOH in the presence of phenolphthalein as an indicator to the end point and expressed as a percentage of citric acid.

Fruit TSS/TA ratio was calculated from the values recorded for fruit juice TSS and TA percentages determined.

Total sugars percentage was determined by using the methods of Smith *et al.* (1956) and the concentration was calculated as gm glucose per 100 gm. fresh weight.

Marketable period (in days)

After 21 days of cold storage at 7±1˚C a guava fruit sample from each replicates was taken out and placed at ambient conditions (25±2˚C and 65±5% R.H.) till bad appearance or rotting occurs. Then, the number of days was recorded which was considered as shelf life period for guava fruits.

Experimental design and statistical analysis

All obtained data of the measured parameters were subjected to statistically analyzed as a factorial RCBD by analysis of variance (ANOVA) computer program SAS according to Gomez and Gomez (1984) and means of treatments were compared using LSD at 0.05 level of possibility according to Snedecor and Cochran (1980).

Results and Discussion

Weight loss percentage

Data of studying the effect of postharvest applications of oxalic acid and propolis extract during cold storage on weight lossof "Maamoura" guava fruits was recorded in Table (1). It is clear that, increased storage periods caused a significant increase in fruit weight loss percentages. Also, the differences between all storage periods were significant compared with the initial date in both seasons. The loss of fruit weight during cold storage is caused by water exchange between the internal and external atmosphere, the transpiration rate being accelerated by cellular breakdown (Woods, 1990). The increases in physiological loss of weight and decay incidence as well as a decrease in marketable of guavas with the progress of cold storage are attributing to the increase in transpiration rate, ethylene production and cellular breakdown of fruits (Barman *et al.,* 2011 and Razzaq *et al.,* 2014).

Table 1: Effect of postharvest applications of propolis extract and oxalic acid on weight loss percentage of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	7	14	21	Means
	Season 2018				
Control	0.00	6.65	6.95	18.12	9.73
Oxalic Acid (3mM/L)	0.00	5.18	5.85	10.18	5.58
Oxalic Acid (6mM/L)	0.00	4.08	5.85	9.38	4.83
Propolis Extract (2%)	0.00	5.55	7.12	10.30	5.74
Propolis Extract (4%)	0.00	4.88	6.80	9.83	5.38
Means	0.00	5.27	8.17	11.56	
LSD at $_{0.05}$	(T): 0.26 (D): 0.23 (T×D): 0.51				
	Season 2019				
Control	0.00	6.49	13.53	17.20	9.30
Oxalic Acid (3mM/L)	0.00	4.90	7.05	10.02	5.19
Oxalic Acid (6mM/L)	0.00	4.15	6.13	9.25	4.88
Propolis Extract (2%)	0.00	5.42	6.97	10.22	5.65
Propolis Extract (4%)	0.00	4.72	6.34	9.87	5.23
Means	0.00	5.13	8.00	11.31	
LSD at $_{0.05}$	(T): 0.23 (D): 0.20 (T×D): 0.45				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Furthermore, oxalic acid and propolis extract treatments at all concentrations significantly reduced the percentage of fruit weight loss as compared to the control. Moreover, oxalic acid at 6 mM/L and propolis extract at 4 % treatment were more effective than other treatments on reducing fruit weight loss. These results may be due to making a thin film of propolis (wax) surrounding the fruit peel, which contact as a semi permeable barrier against oxygen, carbon dioxide, moisture and soluble movements. Hence they can reduce the rates of the respiration, water loss and oxidation reaction (Baldwin *et al.,* 1999). The loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and weight loss. Surface coatings have been used widely in fruits to reduce dehydration in fruits, reduce water loss and thereby delay the decline in fruit quality.

Oxalic acid treatments decreased fruit weight loss because of reduced the respiration rate, transpiration through skin, various metabolic activities and inhibited the ethylene production in plums (Singh *et al.,* 2009 and Wu *et al.,* 2011), mangoes (Zheng *et al.,* 2007b, c and Zaharah & Singh, 2011) and banana fruits (Huang *et al.,* 2013a). In addition, the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance and shelf life of harvested late Valencia orange fruits were examined by Mohamed *et al.* (2016). Results showed that weight loss percentage of Valencia orange fruits increased gradually and significantly with prolonging of cold storage period at 8˚C in the two seasons in this investigation. Data also cleared that, postharvest treatment with 10 mM OA gave the least percentage of fruit weight loss compared with untreated fruits.

In harmony with these results are those obtained by Passos *et al.* (2016) evaluated the effects of coating orange with propolis extract on the physicochemical characteristics of the "Pera" orange during storage under ambient temperature. Results showed that the propolis extract coatings showed lower permeability to water evaporation between the fruit and the medium until the 18th day of storage, thereby decreasing the weight loss of oranges. Also, only the postharvest “refrigerated” treatment showed significant difference, with least loss of weight during the 25 days of storage. As at low temperatures, the metabolic respiration processes gets reduced, and consequently, the weight loss of the fruit is also decreased (Chitarra and Chitarra, 2005). In addition, the effects of postharvest oxalic acid (OA) treatments on storage life and quality of apricot cv. 'Aprikoz' were investigated by Koyuncu *et al.* (2018). Results showed that weight loss, one of the most important factors limiting the storage life of the products, has increased continuously during storage. But this increase was found to be lower in OA treatments than in control groups.

Decay percentage

Data in Tables (2) introduced the influence of postharvest applications of oxalic acid and propolis extract during cold storage on decay percentage of "Maamoura" guava fruits in 2018 and 2019 seasons.

Results revealed that, increasing storage periods caused a significant increase in fruit decay and the differences through all periods were significant compared with the initial time in the two seasons of study. In addition, oxalic acid and propolis extract treatments at all concentrations significantly decreased fruit decay percentages during cold storage periods as compared to the control.

Furthermore, decreasing the percentage of fruit decay during cold storage periods was noticed with treatments of oxalic acid at 6 mM/L and proplois extract at 4% when compared with other treatments. These results are in agreement with those obtained by (Zheng *et al*., 2012 and Zheng *et al*., 2007b,c) on mangoes, (Zheng *et al*., 2007a) on peach fruits, (Zheng and Tian, 2006) on litchi fruits and (Bayoumi, 2008) on pepper fruits, they reported that, the application of postharvest treatments with oxalic acid reduced decay incidence of stored fruits. Also, the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance and storage life of harvested late Valencia orange fruits were examined by Mohamed *et al.* (2016). Results showed that fruit decay percentage of Valencia orange increased gradually and significantly with prolonging of cold storage period at 8˚C in the two seasons in this investigation. Data also cleared that, postharvest treatment with 10 mM OA significantly decreased the fruit decay percentage compared with untreated fruits (control).

Table 2: Effect of postharvest applications of propolis extract and oxalic acid on decay percentage of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	7	14	21	Means
	Season 2018				
Control	0.00	15.22	30.48	52.48	24.55
Oxalic Acid (3mM/L)	0.00	1.85	2.58	5.50	2.48
Oxalic Acid (6mM/L)	0.00	0.00	0.50	3.42	0.98
Propolis Extract (2%)	0.00	0.67	1.00	4.52	1.55
Propolis Extract (4%)	0.00	0.00	0.08	3.00	0.77
Means	0.00	3.55	6.93	13.78	
LSD at $_{0.05}$	(T): 0.60 (D): 0.53 (T×D): 1.18				
	Season 2019				
Control	0.00	14.85	30.00	51.8	24.06
Oxalic Acid (3mM/L)	0.00	1.92	2.67	7.02	2.90
Oxalic Acid (6mM/L)	0.00	0.17	0.92	4.60	1.42
Propolis Extract (2%)	0.00	1.08	1.33	5.15	1.89
Propolis Extract (4%)	0.00	0.00	0.17	3.52	0.92
Means	0.00	3.60	7.02	14.33	
LSD at $_{0.05}$	(T): 0.57 (D): 0.51 (T×D): 1.13				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Visual appearance

Fruit visual appearance changes during cold storage period at 7±1˚C and 90±5% R.H. of "Maamoura" guava fruits are shown in Table (3). Data indicate that, gradual and significant decrease in fruit visual appearance values were observed with the advancement of cold storage period at 7±1˚C in both seasons. These results indicated that, the minimum visual appearance score (6.47 and 6.07) in the first and second seasons, respectively were recorded at the end of cold storage period.

Our results reveal that, postharvest applications of oxalic acid at 6 mM/L of "Maamoura" guava fruits significantly induced higher visual appearance score values as compared to untreated fruits (control). In addition, dipped "Maamoura" guava fruits in 6 mM of oxalic acid and 4% of propolis extract for five minutes were more effective in retarding the reduction in fruit visual appearance than individual applications and untreated fruits (control) in the two seasons.

The effects of postharvest oxalic acid (OA) treatments on storage life and quality of apricot cv. 'Aprikoz' were investigated by Koyuncu *et al.* (2018). Results showed that storage period and treatments affected significantly the external appearance, taste scores and internal browning of apricots during storage ($p<0.05$). OA treated apricots kept their external appearance and taste values better than control fruit. The average highest external appearance (8.79) and taste (4.83) scores were obtained from 1 mM OA treatment during storage. Control fruit gave the lowest external appearance (8.12) and taste (4.42) scores. Internal browning of fruit increased compared to the initial values at the end of cold storage regardless of treatment, but the lowest value was determined in 1 mM OA treatment. The OA treatments limited internal browning incidence of apricots. Furthermore, (Koyuncu *et al.,* 2010), reported that, internal browning is the important and limiting factor for marketable quality of apricots.

Table 3: Effect of postharvest applications of propolis extract and oxalic acid on visual appearance of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	**7**	**14**	**21**	**Means**
	Season 2018				
Control	9.00	8.33	6.33	4.33	7.00
Oxalic Acid (3mM/L)	9.00	9.00	8.33	7.00	8.33
Oxalic Acid (6mM/L)	9.00	9.00	9.00	7.67	8.67
Propolis Extract (2%)	9.00	9.00	7.67	6.33	7.83
Propolis Extract (4%)	9.00	9.00	8.33	7.00	8.17
Means	9.00	8.73	7.80	6.47	
LSD at $_{0.05}$	(T): 0.77 (D): 0.69 (T×D): 1.52				
	Season 2019				
Control	9.00	6.33	5.00	3.00	5.83
Oxalic Acid (3mM/L)	9.00	9.00	7.67	7.00	8.17
Oxalic Acid (6mM/L)	9.00	9.00	8.33	7.67	8.50
Propolis Extract (2%)	9.00	9.00	7.00	5.67	7.67
Propolis Extract (4%)	9.00	9.00	7.67	7.00	8.17
Means	9.00	8.47	7.13	6.07	
LSD at $_{0.05}$	(T): 0.60 (D): 0.54 (T×D): 1.19				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Firmness

Data obtained regarding fruit firmness for seasons of 2018 and 2019 are presented in Table (4) it is clear that firmness decreased with progress of storage periods in the two seasons, Yaman and Bayoindirli (2002) indicated that, the retention of firmness which occurred during storage could be illustrated by retarded degradation of insoluble protopectins to the more soluble pectic acid and pectin. During fruit ripening depolymerization or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalactronase activities.

All treatments, also increased the firmness than control fruits with significant differences among all treatments in both seasons.

Moreover, oxalic acid at 6 mM/L and proplois extract at 4%gave the greatest fruit firmness during cold storage periods compared with other treatments. Generally, fruit firmness reduces due to softening of fruits by dissolving middle lamella of the cell wall (Wills *et al*., 1980). When fruits ripen, hemicelluloses become more soluble and therefore the cell wall is disrupted and loosened (Arvanitoyannis *et al*., 2005). Higher firmness was shown by treatments due to delaying of ripening. Fruit softening, also is associated with changes in cell wall mechanical strength (Valero and Serrano, 2010). In addition, severe decrease in firmness of untreated "Maamoura" guava fruits (control) was accompanied with the increases in activities of cell wall hydrolysis enzymes and the degradation in cellular structures because of the high rates of ethylene production, respiration and other metabolic activities (Mondal, 2005, Barman *et al.,* 2011 and Razzaq *et al.,* 2014).

Table 4: Effect of postharvest applications of propolis extract and oxalic acid on firmness (Newton) of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	**7**	**14**	**21**	**Means**
	Season 2018				
Control	65.54	20.55	9.84	3.05	24.74
Oxalic Acid (3mM/L)	65.54	60.44	47.72	37.12	52.70
Oxalic Acid (6mM/L)	65.54	63.72	53.89	40.55	55.80
Propolis Extract (2%)	65.54	59.25	46.72	35.71	51.80
Propolis Extract (4%)	65.54	61.55	51.05	39.18	54.33
Means	65.54	53.10	41.84	31.12	
LSD at $_{0.05}$	(T): 0.49 (D): 0.44 (T×D): 0.97				
	Season 2019				
Control	59.45	19.68	9.42	2.03	22.64
Oxalic Acid (3mM/L)	59.45	55.45	46.42	36.16	49.37
Oxalic Acid (6mM/L)	59.45	57.17	51.38	39.22	51.80
Propolis Extract (2%)	59.45	53.38	45.48	34.98	48.32
Propolis Extract (4%)	59.45	54.72	49.42	37.95	50.38
Means	59.45	48.08	40.42	30.07	
LSD at $_{0.05}$	(T): 0.52 (D): 0.46 (T×D): 1.02				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

These results are in harmony with those obtained by Wu *et al.* (2011) on plums, Zheng *et al.* (2012) and Razzaq *et al.* (2015) on mangoes and Li *et al.* (2014) on papaya fruits. They reported that, oxalic acid reduced cell wall hydrolytic enzymes and consequently decreased loss of firmness of fruits during storage. Furthermore, Mohamed *et al.* (2016) examined the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits. Results shown that, fruit firmness decreased gradually with prolonging of cold storage period in both seasons in this investigation. Data also cleared that, postharvest treatment with 10 mM OA significantly increased the fruit firmness compared with untreated fruits (control). On the other hand, Passos *et al.* (2016) evaluated the effects of coating orange with propolis extract on the physicochemical characteristics of the "Pera" orange during storage under ambient temperature. Results showed that an increase in the firmness value was noted during the storage period for the postharvest "2.5% propolis" and "5% propolis" treatments, as appeared by the adjusted linear models. The orange fruit exposed to postharvest treatment "refrigerated" showed a relatively constant firmness value during the 25 days of storage.

In addition, the effects of postharvest oxalic acid (OA) treatments on storage life and quality of apricot cv. 'Aprikoz' were investigated by Koyuncu *et al.* (2018). Results showed that the oxalic acid treatments had positive effects on fruit firmness. The flesh firmness in treated fruit was maintained compared with the control, thus fruit softening rate was delayed by oxalic acid during storage.

Vitamin C

With respect to the effect of various applied treatments on vitamin C contents of "Maamoura" guava fruits, in both experimental seasons, the data demonstrated in Table (5) declared that, fruit vitamin C contents significantly decreased as the storage period extended till the end of storage period 23 days. The loss of ascorbic acid content of guavas during cold storage period might be due to a fast transformation of L-ascorbic acid into dehydroascorbic acid in the presence of oxidizing enzymes like ascorbic acid oxidase and ascorbate peroxidase (Davey *et al.,* 2000).

Table 5: Effect of postharvest applications of propolis extract and oxalic acid on vitamin C (mg/100 ml juice) of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	7	14	21	Means
	Season 2018				
Control	112.65	84.31	60.45	46.88	76.07
Oxalic Acid (3mM/L)	112.65	100.90	88.35	84.15	96.51
Oxalic Acid (6mM/L)	112.65	106.82	94.42	90.88	101.19
Propolis Extract (2%)	112.65	94.05	85.58	80.65	93.23
Propolis Extract (4%)	112.65	96.02	90.02	85.08	95.94
Means	112.65	96.42	83.76	77.53	
LSD at $_{0.05}$	(T): 0.89 (D): 0.80 (T×D): 1.76				
	Season 2019				
Control	106.85	80.72	58.44	41.68	71.92
Oxalic Acid (3mM/L)	106.85	94.44	82.44	78.52	90.56
Oxalic Acid (6mM/L)	106.85	97.55	86.61	81.90	93.22
Propolis Extract (2%)	106.85	86.21	77.35	66.95	84.34
Propolis Extract (4%)	106.85	90.54	81.27	76.38	88.76
Means	106.85	89.89	77.22	69.08	
LSD at $_{0.05}$	(T): 0.63 (D): 0.57 (T×D): 1.25				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Statistical analysis of the present data also, indicated that, oxalic acid at 6 mM/L and propolis extract at 4% treatments were more effective on increasing vitamin C contents compared with other treatments. These results are agreed with those obtained by Badawy (2016) studied the effect of ethanol extracted propolis (EEP) at 2, 3 and 5% on fruit quality and storability of Balady orange fruits during cold storage. Propolis was applied once or twice pre and post harvest then the fruits were stored at 5-7˚C with 90±5 R.H. for ten weeks. Result showed that vitamin C content decreased in propolis extract treatments and untreated one (control) during the two studied seasons. On the other hand, in contrast with our results these showed that, propolis treatments failed to show any significant effects on fruit vitamin C content compared to control.

Moreover, Mohamed *et al.* (2016) examined the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits. Results shown that, juice contents of AsA in Valencia orange fruits declined during storage at 8˚C as compared with initial time. Data also cleared that, postharvest treatment with 10 mM OA significantly increased the fruit vitamin C contents compared with untreated fruits (control). This trend was cleared during the two seasons in this work.

Total soluble solids

Data tabulated in Table (6) show that all postharvest applications of oxalic acid and propolis extract during cold storage on total soluble solids content of "Maamoura" guava fruits in 2018 and 2019 seasons. These results indicate that there was significant increase in fruit TSS contents as the storage period prolonged compared with the initial time. Excessive increase in TSS observed in control fruits indicates quality deterioration, may be attributed to the utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits or due to breakdown of complex polymer into simple sugars by hydrolytic enzymes which might be further metabolized during respiration and level decreased during subsequent storage.

On the other hand, the increase in guavas content in TSS with prolonging of storage period could be due to the hydrolysis of starch into sugars and an increase in water soluble galacturonic acids from the degradation of pectic substances by hydrolytic enzymes (Jain *et al.,* 2003). Whereas, slight decline of fruits content in TSS at the end of storage period might be due to utilization of soluble solids in respiratory processes (Jain *et al.,* 2003).

Table 6: Effect of postharvest applications of propolis extract and oxalic acid on total soluble solids content (Brix°) of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	7	14	21	Means
	Season 2018				
Control	6.65	8.94	10.45	9.35	8.85
Oxalic Acid (3mM/L)	6.65	9.27	9.94	89.82	8.92
Oxalic Acid (6mM/L)	6.65	9.80	10.62	10.38	9.36
Propolis Extract (2%)	6.65	9.19	9.58	9.33	8.69
Propolis Extract (4%)	6.65	9.68	10.35	10.12	9.20
Means	6.65	9.38	10.19	9.80	
LSD at $_{0.05}$	(T): 0.13 (D): 0.11 (T×D): 0.25				
	Season 2019				
Control	6.24	8.28	9.97	9.21	8.42
Oxalic Acid (3mM/L)	6.24	9.11	9.85	9.71	8.73
Oxalic Acid (6mM/L)	6.24	9.68	10.42	10.24	9.14
Propolis Extract (2%)	6.24	8.98	9.48	9.24	8.49
Propolis Extract (4%)	6.24	9.45	10.12	9.95	8.94
Means	6.24	9.10	9.97	9.67	
LSD at $_{0.05}$	(T): 0.15 (D): 0.13 (T×D): 0.29				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

In addition, results, generally, showed that the fruit TSS contents did not show a constant or regular trend in both seasons. Even that, it showed a significant increase compared with control for all treatments, except for oxalic acid at 3 mM/L in 2018 and propolis extract at 2% in 2019 where the differences were not big enough to be significant. Where, in 2018 season, results also, showed that a non-significant decrease compared with control for propolis extract at 2%.

In agreement with these results are those obtained by Badawy (2016) studied the effect of ethanol extracted propolis (EEP) at 2, 3 and 5% on fruit quality and storability of Baladyorange fruits during cold storage. Propolis was applied once or twice pre and post harvest then the fruits were stored at 5-7˚C with 90±5 R.H. for ten weeks. Result noticed that prolonging cold storage at 5-7˚C for ten weeks slightly increased total soluble solids. On the other hand, in contrast with our results these showed that, propolis treatments failed to show any significant effects on fruit TSS content compared to control. Furthermore, Mohamed *et al.* (2016) examined the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits. Results shown that, juice contents of SSC in Valencia orange fruits increased during storage at 8˚C as compared with control. This trend was cleared during the two seasons in this work. Furthermore, Kaur *et al.* (2019) worked on Litchi fruits to study the effects of oxalic acid (5%) and oxalic acid (10%) on fruit total sugars under cold storage conditions at 1st, 3rd, 5th, 7th, 9th, 11th, 13th, 15th days after post harvest treatment. Results showed that, the range of TSS varied from 18.27 to 20.60 Brix°. The maximum value for TSS was 20.60 Brix° recoded for (oxalic acid 5%). The minimum value for TSS was 18.27 Brix° recorded for T0 (Control). As compared to control, oxalic acid showed 12.75% increase in TSS. It is obvious that the TSS content of fruits increase with increase in duration of storage, reaches its peak, and then decline gradually thereafter. However in Trial I, it was observed that TSS level of fruits starts increasing right from the first day which proceed up to the end of the 6 days storage period.

Titrable acidity

Results in Table (7) show the effect of post-harvest treatments of oxalic acid and propolis extract on titrable acidity content of guava cv. "Maamoura" fruits under cold storage conditions during 2018 and 2019 seasons.Data indicated that fruit titrable acidity percentage was decreased gradually during storage period. The obtained results agreed partially with those reported by Siddiqui *et al.* (1991) and Alana *et al.* (2015), they noted that acidity increased progressively according to the length of storage period in all postures of guava fruits. Moreover, TA is directly related to the concentration of organic acids present in the fruit. Citric acid is the major organic acid in guava fruits, which is an important parameter in maintaining the quality of fruits and rapid reduction in acidity hastens senescence of fruits (Jain *et al.,* 2003), furthermore, the progressive decline of guavas content in TA with the advancement of storage period might be due to utilization of organic acids in respiration process and conversion of acids into salts and sugars by the enzymes.

Table 7: Effect of postharvest applications of propolis extract and oxalic acid on titrable Acidity percentage of "Maamoura" guava fruits during cold storageat (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	**7**	**14**	**21**	**Means**
	Season 2018				
Control	1.09	0.80	0.71	0.61	0.80
Oxalic Acid (3mM/L)	1.09	0.71	0.65	0.56	0.75
Oxalic Acid (6mM/L)	1.09	0.66	0.61	0.51	0.72
Propolis Extract (2%)	1.09	0.76	0.69	0.59	0.78
Propolis Extract (4%)	1.09	0.71	0.65	0.54	0.74
Means	1.09	0.73	0.66	0.56	
LSD at $_{0.05}$	(T): 0.01 (D): 0.01 (T×D): 0.02				
	Season 2019				
Control	1.16	0.81	0.75	0.64	0.84
Oxalic Acid (3mM/L)	1.16	0.75	0.68	0.58	0.79
Oxalic Acid (6mM/L)	1.16	0.70	0.64	0.55	0.76
Propolis Extract (2%)	1.16	0.79	0.76	0.61	0.83
Propolis Extract (4%)	1.16	0.75	0.69	0.58	0.79
Means	1.16	0.76	0.70	0.59	
LSD at $_{0.05}$	(T): 0.01 (D): 0.01 (T×D): 0.03				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Statistical analysis of the present data also, showed that, all treatments decreased significantly titrable acidity compared with untreated fruits during both seasons of this study except for, propolis extract at 2% in second season, where the difference was not big enough to be significant. Furthermore, oxalic acid at 6 mM/L and propolis extract at 4% treatments were more effective in decreasing fruit titrable acidity contents compared with other treatments.In agreement with these results are those obtained by Badawy (2016) studied the effect of ethanol extracted propolis (EEP) at 2, 3 and 5% on fruit quality and storability of Balady orange fruits during cold storage. Propolis was applied once or twice pre and post harvest then the fruits were stored at 5-7˚C with 90±5 R.H. for ten weeks. Result showed that total acidity decreased in propolis extract treatments and untreated fruits (control) during the two studied seasons. This result may be due to loosing amount of fruit moisture and organic acids in metabolism activities. On the other hand, in contrast with our results these showed that, propolis treatments failed to show any significant effects on fruit total acidity compared to control.

Furthermore, Mohamed *et al.* (2016) examined the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits. Results shown that, juice contents of titrable acidity in Valencia orange fruits declined during storage at 8˚C as compared with control. This trend was cleared during the two seasons in this work. Moreover, the effects of postharvest oxalic acid (OA) treatments on storage life and quality of apricot cv. 'Aprikoz' were investigated by Koyuncu *et al.* (2018). Results showed that the TA contents of fruit gradually decreased over the storage period regardless of treatments.

TSS/Acid ratio

Data tabulated in Table (8) declared the effect of some post-harvest treatments on TSS/Acid ratio of "Maamoura" guava fruits stored at 7±1ºC and 90±5% R.H., during 2018 and 2019 seasons. It is clear that, all used treatments significantly increased fruit TSS/Acid ratio than the control fruits, except for propolis extract at 2% in 2019 season. However, TSS/Acid ratio increased with prolonging cold storage period as a compared with initial time in two seasons of study.

Table 8: Effect of postharvest applications of propolis extract and oxalic acid on TSS/Acid ratio of "Maamoura" guava fruits during cold storage at (7±1°C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	**7**	**14**	**21**	**Means**
	Season 2018				
Control	6.10	11.23	14.65	15.27	11.81
Oxalic Acid (3mM/L)	6.10	13.12	15.30	17.70	13.05
Oxalic Acid (6mM/L)	6.10	14.86	17.31	20.38	14.66
Propolis Extract (2%)	6.10	12.09	13.82	15.75	11.94
Propolis Extract (4%)	6.10	13.64	26.01	18.88	13.66
Means	6.10	12.99	15.42	17.60	
LSD at $_{0.05}$	(T): 0.45 (D): 0.40 (T×D): 0.89				
	Season 2019				
Control	5.38	10.18	13.29	14.47	10.83
Oxalic Acid (3mM/L)	5.38	11.80	14.49	16.88	12.14
Oxalic Acid (6mM/L)	5.38	13.90	16.28	18.52	13.52

Propolis Extract (2%)	5.38	11.33	12.42	16.41	11.38
Propolis Extract (4%)	5.38	12.66	14.61	17.26	12.47
Means	5.38	11.97	14.42	16.71	
LSD at $_{0.05}$	(T): 0.52 (D): 0.46 (T×D): 1.03				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

In harmony with these results are those obtained by Badawy (2016) studied the effect of ethanol extracted propolis (EEP) at 2, 3 and 5% on fruit quality and storability of Balady orange fruits during cold storage. Propolis was applied once or twice pre and post harvest then the fruits were stored at 5-7˚C with 90±5 R.H. for ten weeks. Result noticed that prolonging cold storage at 5-7˚C for ten weeks slightly increased TSS/acid ratio. On the other hand, in contrast with our results these showed that, propolis treatments failed to show any significant effects on fruit TSS content compared to control. Moreover, Mohamed *et al.* (2016) examined the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits. Results shown that, juice contents of SSC/Acid ratio in Valencia orange fruits increased during storage at 8˚C as compared with control. This trend was cleared during the two seasons in this work.

Total sugars

The response of total sugars of "Maamoura" guava fruits stored at 7±1˚C and 90±5% % R.H. to postharvest spraying of oxalic acid and propolis extraction 2018 and 2019 seasons was reported in Table (9).Data in demonstrated that total sugars percentage increased gradually with progress of storage periods in the two seasons. The highest total sugars percentage was obtained by oxalic acid at (6mM/L) treatment (7.76% and7.70%), while the least value in the first season was recorded by fruits untreated (control) (7.16% and 7.20%) in the first and second seasons, respectively.

Table 9: Effect of postharvest applications of propolis extract and oxalic acid on total sugars percentage of "Maamoura" guava fruits during cold storage at (7±1˚C and 90±5% R.H.) in 2018 and 2019 seasons.

Treatments	Storage Periods (Days)				
	0	7	14	21	Means
	Season 2018				
Control	5.82	6.40	7.57	8.86	7.16
Oxalic Acid (3mM/L)	5.82	6.74	8.27	9.23	7.51
Oxalic Acid (6mM/L)	5.82	7.06	8.63	9.55	7.76
Propolis Extract (2%)	5.82	6.57	8.12	9.08	7.40
Propolis Extract (4%)	5.82	6.87	8.28	9.26	7.56
Means	5.82	6.73	8.17	9.20	
LSD at $_{0.05}$	(T): 0.25 (D): 0.23 (T×D): 0.50				
	Season 2019				
Control	5.59	6.30	7.93	9.05	7.21
Oxalic Acid (3mM/L)	5.59	6.63	8.56	9.47	7.56
Oxalic Acid (6mM/L)	5.59	6.98	8.70	9.54	7.70
Propolis Extract (2%)	5.59	6.59	8.33	9.20	7.43
Propolis Extract (4%)	5.59	6.85	8.65	9.26	7.59
Means	5.59	6.67	8.43	9.30	
LSD at $_{0.05}$	(T): 0.11 (D): 0.12 (T×D): 0.23				
T: Treatments D: Storage Periods (Days) T×D: Interaction					

Furthermore, oxalic acid and propolis extract treatments at all concentrations significantly increased fruit total sugars percentage during cold storage periods as compared to the control. Moreover, oxalic acid at 6 mM/L was more effective on increasing fruit total sugar contents as compared with other treatments. These results are conformed with those obtained by Kaur *et al.* (2019) worked on Litchi fruits to study the effects of oxalic acid (5%) and oxalic acid (10%) on fruit total sugars under cold storage conditions at 1st, 3rd, 5th, 7th, 9th, 11th, 13th, 15th days after post harvest treatment. Results showed that, the range of total sugar varied from 10.40 to 12.50%. The maximum value for total sugar was 12.50% recorded for (oxalic acid 10%) followed by (oxalic acid 5%) i.e. 12.41%, moreover, total sugar content of litchi fruits in the trail increased and continued up to the last. The increase in total sugar during storage might be because of an increase in reducing sugars and non-reducing sugars resulting conversion of starch into simple sugar and later on reduction in conversion rate was due to utilization of sugar in the process of respiration. Improvement in sugar percent may be because of converting some cell wall material like hemicelluloses to reducing content under long storing conditions (Stahi and Camp, 1971). These results are in close similarity with the results of Parihar and Kumar (2007) because they found, total sugars were improved along with the higher storing period in guava.

Marketing life

Data presented in Table (10) show that all postharvest applications of "Maamoura" guavas prolonged shelf life period at ambient conditions (25±2˚C and 65±5% R.H.) as compared to untreated fruits (control). These results indicated that the longest shelf life period was attained by guavas treated with propolis extract at 4% (8.35 and 8.16 days) incorporated with oxalic acid at 6 mM/L (8.00 and 7.77 days) in 2018 and 2019 seasons, respectively followed by fruits treated with propolis extract at 2% (7.14 and 7.09 days) incorporated with oxalic acid at 3 mM/L (6.84 and 6.67 days) in the first and second seasons, respectively. On contrary, the shortest shelf life period (1.75 and 2.25 days) in 2018 and 2019 seasons, respectively were recorded for untreated fruits (control).

In anther studies, the effectiveness of postharvest oxalic acid (OA) treatments on the quality maintenance of harvested late Valencia orange fruits were examined by Mohamed *et al.* (2016). Results showed that weight loss percentage, decay percentage, SCC and SSC/Acid increased gradually and significantly, while it caused a significantly decline in fruit firmness titrable acidity and ascorbic acidof Valencia orange fruits at one week as a shelf life at 18-23˚C in the two seasons in this investigation. Data also cleared that, postharvest treatment with 10 mM OA significantly decreased the fruit weight loss and decay percentages, while it caused a significant increase in fruit firmness, SSC and SSC/Acid compared with untreated fruits (control).

In addition, Kaur *et al.* (2018) studied the effect of post harvest treatments of oxalic acid at 5% and 10% for enhancing shelf life of Litchi fruits at room temperature and they observed that there was significant effect of oxalic acid treatments on chemical parameters like TSS, ascorbic acid, total sugar compared with the control. The highest TSS was recorded from the fruits treated with oxalic acid 5%.

Table 10: Effect of postharvest applications of propolis extract and oxalic acid on shelf life period (Days) of "Maamoura" guava fruits at ambient conditions (25±2˚C and 65±5% R.H.) in 2018 and 2019 seasons.

Treatments	Season 2018	Season 2019
Control	2.25	1.75
Oxalic Acid (3mM/L)	6.84	6.67
Oxalic Acid (6mM/L)	8.00	7.77
Propolis Extract (2%)	7.14	7.09
Propolis Extract (4%)	8.35	8.16
$LSD_{at\ 0.05}$	0.46	0.48

Conclusion

In this study, it could be concluded that oxalic acid at 6 mM/L and propolis extract at 4% postharvest applications had a pronounce effect in reducing weight loss, decay percentages and maintaining "Maamoura" guava fruits quality during cold storage period and shelf life. Moreover, postharvest applications of oxalic acid at 6 mM/L and propolis extract at 4% could be suggested for improving the storability of "Maamoura" guava fruits and maintaining their quality characteristics during cold storage conditions and shelf life.

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