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Effect of Edible Coating on Storability and Quality of Apricot Fruits

[1]M.A.A Mohamed,., [1]Gehan Ahmed Mahmoud and [2]Rania Ahmed Mahmoud

[1]Fruit handling Research Department, Horticulture Research Institute,
Agricultural Research Center, Giza, Egypt
[2]Deciduous Fruit Research Department, Horticulture Research Institute,
Agricultural Research Center, Egypt

Abstract: Apricot is a fragile and climacteric fruit that ripens very quickly after harvest resulting in very short storage life. Thus, the objective of this experiment was to enhance quality of apricot fruits cv. 'Canino' during cold storage by postharvest application with edible coating treatments. Fruits were immersed in either 0.05 or 0.1 % of Propolis, 0.05 or 0.025 % of Chitosan, 0.05 or 0.1 % of Oxalic acid and 0.05 or 0.1 % of Salicylic acid or water (control treatment). Chitosan and propolis were the most effective applications for keeping quality and prolonging storage life of fruits in terms of decreasing the decay incidence, weight loss and fruit firmness deterioration rate as well as inhibition of polyphenol oxidase (PPO) and peroxidase (POX) enzymes activity. Salicylic acid and chitosan significantly decreased the total phenolic contents deterioration incidence of apricots during cold storage. While, salicylic acid and propolis were the best treatments in regards to decreasing the antioxidant activity deterioration rate of apricots during cold storage. All treatments significantly increased TSS, VC and sugar contents of fruits during storage in comparison with control fruits during the two seasons.

Key words: Apricot · Propolis · Chitosan · Oxalic acid · Salicylic acid · Storage

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is one of the most important and popular fruit species nationally and internationally because of their high nutritional value, antioxidant effect and aroma content [1]. In Egypt, the total apricot planted area reached 15389 feddans, with a fruiting area that reached 13391 feddans produced nearly 91055 tons [2]. Apricot is a climacteric fruit that produces large amounts of ethylene at ripening [3]. It starts to lose its physical and chemical qualities directly after harvest and throughout the storage period [4]. Fruit ripening and senescence may be considered as an oxidative process involving marked alterations in fruit metabolism and the activity of some enzymatic systems including those related to the regulation of reactive oxidative species and the deleterious effects of ethylene have been linked with reactive oxygen species detoxifying enzymes[5].

Salicylic acid (SA) is a natural, safe simple phenolic compound recognized as a plant growth regulator that regulates many processes in plants. It is an important component in the signal transduction pathway [6]. Salicylic acid treatments counteract the negative effects of reactive oxygen species by increasing antioxidant enzymes activity [7-10]. Salicylic acid treatment has also been reported to delay ripening of different climacteric fruits by inhibiting ethylene biosynthesis and maintaining postharvest quality of horticultural crops [11]. Postharvest application of SA prolonged the storage life and preserved the valuable marketing characteristics of apricots and peach [7-15]. Furthermore, treatment with salicylic acid prolonged the storage life by maintaining nutritional attributes and showing good results in controlling fungal disease, stimulating antioxidant enzymes and delayed ripening and senescence mechanisms during postharvest storage of sweet cherries [16]. Moreover, salicylic acid treatment was found to delay banana fruits ripening process by decreasing the activities of cell wall degrading enzymes [17].

Oxalic acid (OA) is a natural organic acid which has been reported to play an important function in systemic fight [18, 19]. Oxalic acid application is a secure and hopeful postharvest handling technology for keeping quality and prolonging storage life of fruits [20].

Corresponding Author: M.A.A. Mohamed, Fruit handling Research Department, Horticulture Research Institute, ARC, Giza, Egypt.

Oxalic acid 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 [21-23]. Also, OA decrease polyphenol oxidase (PPO) activity [24]. Pre-storage application with OA enhanced the antioxidant capacities of banana and pomegranate fruits [25-27]. Moreover, OA and oxalate induce systemic fighting against diseases caused by microbes in trees and crops [28, 29].

Propolis is a natural glue produced by honey bees with main constituents being resins (flavonoids, phenolics and their esters), waxes, vitamins and essential oils [30]. Propolis inhibit the aflatoxigenic fungi and also decreases conidial growth in *Aspergillus flavus* [31]. The mechanism of anti-oxidant property of propolis is due to phenolic compounds which donate hydrogen ions to free radicals to protect cell from oxidation reactions and also stored food from oxidation and poisoning. Propolis had the capability to remove free radicals, which are the primary cause of lipids, nucleic acids and proteins oxidation [32, 33].

Chitosan edible coating was used to prolong the shelf life of apricots stored at 2 °C. Apricots were coated with two different coating formulations of soybean. Chitosan coating, significantly decreased the weight loss of apricots. Meanwhile, this treatment prevented the decrease in firmness [34]. Moreover, many scientists reported that chitosan had a positive effect on the shelf life of blueberries stored at 4°C and 75% relative humidity, decreased weight loss incidence and reduced fruit firmness deterioration [35]. Simonaitiene *et al*. [36] reported that whey proteins-chitosan films with quince and cranberry juice inhibited the growth of *Penicillium expansum* on apples.

It has been illustrated that, weight loss, decay percentage and total soluble solids content of 'Canino' apricot fruits generally increased significantly while fruit firmness showed gradual and significant reduction with prolonging of storage period [37-39].

Apricot is a perishable climacteric fruit that ripens very quickly after harvest. The objective of this experiment to assess the companionable impact of various edible coating treatments on quality stability and shelf life of apricot fruits cv. 'Canino' during the two seasons 2017 and 2018.

MATERIALS AND METHODS

Fruit Materials and Treatments: The present investigation was conducted for two successive seasons 2017 and 2018 at fruit handling department, Horticulture Research Institute, ARC, Giza, Egypt. Apricot _ cv. 'Canino' trees were 10 years old and planted at a spacing of 5 m x 6 m apart in a sandy soil under drip irrigation system. Fruits were picked at maturity stage (yellowish green) according to Dragovic-Uzelac *et al*. [40] during the 2nd week of June in both experimental seasons. Fruits were cleaned with 0.01% sodium hypochlorite water solution for 2 min and completely air dried at room temperature, sorted, graded and the detective fruits including wounded and other disorders were excluded. Apricot fruits were randomly selected and divided into seven equal groups. These groups were immersed in either 0.05 or 0.1 % of Propolis, 0.05 or 0.025 % of Chitosan, 0.05 or 0.1 % of Oxalic acid and 0.05 or 0.1 % of Salicylic acid or water (control treatment) all solutions containing Tween-80 0.05% (v/v). After immersing for 2 min in treatments, fruits were air dried for half hour at room temperature. Each treatment consisted of 15 bags with three replicates and each replicate contained of 15 fruits. All treatments packed in corrugated cartons and experimental boxes were stored at 0±1°C and 90±5% RH. Data was recorded on physical and chemical characteristics at the picking date (zero time of cold storage) and repeated at weekly intervals during cold storage period.

Measurement of Fruit Physical Properties: Weight Loss percentage was calculated every week as the following equation:

Weight Loss percentage = Weight loss value at the time of sampling/ initial apricot weight ×100

Decay percentage was determined according to the following equation:

Decay percentage = Decayed fruits weight at the time of sampling/ initial fruits weight ×100

Fruit firmness was expressed as the resistance force to the penetrating tester in units of pressure Lb/inch^2 as described by Watkins and Harman [41].

Measurement of Fruit Chemical Properties: Total soluble solids (TSS%) content was measured using a hand refractometer according to AOAC [42].

Titratable acidity (TA%) was assayed based on the method of adopting the procedure described by AOAC [42] and was calculated as grams of citric acid per 100 g FW.

Vitamin C (mg/100g FW.) value was estimated according to AOAC [42].

Total soluble sugars were determined calorimetrically and expressed as glucose according to Dubois *et al.* [43]. Total phenolic compounds were analyzed spectrophotometrically using the method described by Swain and Hillis [44]. Results were expressed as g gallic acid /100 g FW.

Antioxidant activities (%DPPHsc): The antioxidant activity was evaluated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging method according to the procedure of Chen *et al.* [45].

Measurement of Enzymes Specific Activities (Polyphenol oxidase (PPO) and Peroxidase (POX)): Polyphenol oxidase (PPO) activity was measured as mentioned by Fernandes *et al*. [46], while Peroxidase (POX) activities were determined according to Pine *et al.*[47] and the activities were expressed as units per gram fresh weight.

Experimental Design and Statistical Data Analysis: This experiment was arranged in a completely randomized factorial design. Obtained data were statistically analyzed according to Snedecor and Cochran [48] and significant difference was determined using L.S.D. values at $P = 0.05$.

RESULTS AND DISCUSSION

Effect of Edible Coating on Fruit Weight Loss; Decay Percentages and Firmness: Data shown in Tables 1, 2 and 3 demonstrated that, weight loss and decay percentages of 'Canino' apricots fruits increased while fruit firmness decreased gradually and significantly with cold storage period progress during the two seasons under this investigation.

These results are in similarity with the findings of weight loss percentage decay incidence increased gradually and significantly while fruit firmness decreased with the increasing of cold storage period on apricot fruits [37-39].

Data also revealed that, dipping of 'Canino' apricots fruits in either Salicylic Acid or Oxalic Acid and Propolis at 0.5% or 1 % or Chitosan at 0.025% or 0.05% concentration significantly decreased fruit weight loss and decay percentage incidence during cold storage. Moreover, these treatments significantly increased flesh firmness in comparison with control fruits during the two seasons in this study. Data also cleared that, Chitosan and Propolis significantly were the most effective in decreasing the decay incidence and weight loss of apricots during cold storage at 0°C in both seasons under this study. Also, these treatments decreased fruit firmness deterioration rate during the two seasons in this work in

Table 1: Effect of some postharvest treatments on weight loss percentage of Apricot fruit during storage in 2017 and 2018 seasons.

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		0.00	2.72	5.10	7.69	17.01	6.51
Propolis 0.1%		0.00	1.26	3.51	4.90	7.31	3.40
Propolis 0.05%		0.00	1.69	3.63	5.55	7.64	3.70
Chitosan 0.05%		0.00	1.62	3.39	4.47	6.71	3.24
Chitosan 0.025%		0.00	1.92	3.43	4.94	6.99	3.46
Oxalic Acid 0.1%		0.00	2.89	5.36	7.94	12.36	5.71
Oxalic Acid 0.05%		0.00	2.84	5.36	8.40	14.59	6.24
Salicylic Acid 0.1%		0.00	2.91	4.18	5.73	9.48	4.46
Salicylic Acid 0.05%		0.00	2.55	4.38	6.19	10.90	4.80
Means (B)		0.00	2.27	4.26	6.20	10.33	---
				Second Season			
Control		0.00	3.37	5.57	8.63	17.21	6.96
Propolis 0.1%		0.00	1.43	3.76	4.51	7.46	3.43
Propolis 0.05%		0.00	1.86	3.98	5.11	7.78	3.74
Chitosan 0.05%		0.00	1.81	3.62	4.11	6.79	3.27
Chitosan 0.025%		0.00	2.23	3.71	4.55	7.11	3.52
Oxalic Acid 0.1%		0.00	3.46	5.57	7.30	12.50	5.77
Oxalic Acid 0.05%		0.00	2.97	5.48	7.73	14.57	6.15
Salicylic Acid 0.1%		0.00	3.53	4.52	5.27	9.63	4.59
Salicylic Acid 0.05%		0.00	3.10	4.72	5.70	11.04	4.91
Means (B)		0.00	2.64	4.55	5.88	10.45	---
L.S.D value at 0.05 level	First Season		A= 0.479	B= 0.357	A×B=1.071		
	Second Season		A= 0.428	B= 0.319	A×B=0.956		

Table 2: Effect of some postharvest treatments on decay percentage of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		0.00	10.90	23.89	37.12	46.85	23.75
Propolis 0.1%		0.00	0.00	3.20	7.25	20.14	6.12
Propolis 0.05%		0.00	0.00	7.00	10.20	23.96	8.23
Chitosan 0.05%		0.00	0.00	3.58	6.84	24.53	6.99
Chitosan 0.025%		0.00	0.00	6.73	11.02	30.44	9.64
Oxalic Acid 0.1%		0.00	3.26	6.49	16.82	33.76	12.07
Oxalic Acid 0.05%		0.00	6.91	7.43	19.98	36.88	14.24
Salicylic Acid 0.1%		0.00	3.26	3.88	14.48	37.70	11.87
Salicylic Acid 0.05%		0.00	6.91	10.37	24.36	33.18	14.96
Means (B)		0.00	3.47	8.06	16.45	31.94	---
				Second Season			
Control		0.00	9.34	23.33	36.67	46.67	23.20
Propolis 0.1%		0.00	0.00	4.44	6.67	20.00	6.22
Propolis 0.05%		0.00	0.00	5.56	7.33	23.33	7.24
Chitosan 0.05%		0.00	0.00	3.33	6.67	24.00	6.80
Chitosan 0.025%		0.00	3.33	5.56	10.67	30.00	9.91
Oxalic Acid 0.1%		0.00	3.33	6.67	16.67	33.33	12.00
Oxalic Acid 0.05%		0.00	4.44	7.33	20.00	33.33	13.02
Salicylic Acid 0.1%		0.00	3.33	6.67	10.67	36.67	11.47
Salicylic Acid 0.05%		0.00	6.67	8.22	24.00	37.33	15.24
Means (B)		0.00	3.38	7.90	15.48	31.63	---
L.S.D value at 0.05 level	First Season		A=0.223	B=0.166	A×B=0.499		
	Second Season		A=0.514	B=0.383	A×B=1.149		

Table 3: Effect of some postharvest treatments on firmness (Lb/inch^2) of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		7.23	6.74	5.93	4.96	4.39	5.85
Propolis 0.1%		7.23	6.64	6.61	5.88	5.40	6.35
Propolis 0.05%		7.23	6.53	6.39	5.79	5.72	6.33
Chitosan 0.05%		7.23	6.54	6.42	5.81	5.77	6.35
Chitosan 0.025%		7.23	6.32	6.38	5.68	5.70	6.26
Oxalic Acid 0.1%		7.23	6.34	6.01	5.08	5.18	5.97
Oxalic Acid 0.05%		7.23	6.35	6.09	5.43	5.12	6.04
Salicylic Acid 0.1%		7.23	6.68	6.25	5.21	4.79	6.03
Salicylic Acid 0.05%		7.23	6.36	6.20	4.96	4.44	5.84
Means (B)		7.23	6.50	6.25	5.42	5.17	---
				Second Season			
Control		7.55	6.75	5.88	4.99	4.69	5.97
Propolis 0.1%		7.55	6.69	6.53	6.31	6.02	6.62
Propolis 0.05%		7.55	6.82	6.74	6.00	5.70	6.56
Chitosan 0.05%		7.55	6.71	6.61	6.37	6.07	6.66
Chitosan 0.025%		7.55	6.65	6.51	6.30	6.00	6.60
Oxalic Acid 0.1%		7.55	6.22	6.10	5.78	5.48	6.23
Oxalic Acid 0.05%		7.55	6.50	5.98	5.72	5.42	6.24
Salicylic Acid 0.1%		7.55	6.65	6.35	5.39	5.09	6.21
Salicylic Acid 0.05%		7.55	6.37	6.21	5.04	4.74	5.98
Means (B)		7.55	6.50	6.25	5.42	5.17	---
L.S.D value at 0.05 level	First Season		A= 0.209	B= 0.157	A×B=0.469		
	Second Season		A= 0.161	B= 0.120	A×B=0.360		

comparison with the other treatments. Canino apricot fruits treated with Chitosan at 0.05% had a weight loss % that reached the mean values of (3.24 & 3.27 %) and decay percentage (6.99 & 6.80 %) during the first and the second seasons, respectively. On the other side Canino apricot fruits treated with Propolis at 0.1% had a weight loss % recorded that, the values of (3.4 & 3.43 %) and decay percentage (6.12 & 6.22 %) during the first and the second seasons, respectively. On contrary, untreated fruits (control treatment) had weight loss (6.51 & 6.96 %) and decay percentage (23.75 & 23.20 %) during the first and the second seasons, respectively.

Moreover, Canino apricot fruits treated with Chitosan attained the highest flesh firmness during storage as compared to all the other treatments. Fruits treated with Chitosan at 0.05% had flesh firmness (6.35 & 6.66 Lb/inch^2) during the first and the second seasons, respectively. While those treated with Propolis at 0.1% recorded the values of (6.35 & 6.62 Lb/inch^2) during the first and the second seasons, respectively.

On contrary, untreated fruits (control treatment) showed the lowest flesh firmness during storage (5.85 & 5.97 Lb/inch^2) in the first and the second seasons, respectively.

The interaction effect between postharvest treatments and storage periods were significantly different for weight loss, decay and percentages and flesh firmness of 'Canino' apricots during the two seasons under this work.

These results are in agreement with the previous studies of Ezzat [10]; Hajilou and Fakhimrezaei [12]; Moradinezhad and Jahani [13]; Ali *et al.* [14] on apricots; Wang *et al.* [7]; Tareen *et al.*[8]; Tareen *et al.* [15] on peaches and Mohamed *et al.* [49] on 'Valencia' oranges. They demonstrated that SA postharvest treatment reduced weight loss percentage, decay incidence and maintained fruit firmness values as compared with control during cold storage. Furthermore, OA treatment increased storage life of Horticultural fruits [19-21, 23].

Postharvest chitosan application controlling decay, maintaining quality and increasing the shelf life of fruits [34]. Moreover, chitosan coating can provide an alternative to the modified atmospheric storage through a reduction in quality changes as well in and quantity losses through modification and control of the internal atmosphere of each individual fruits [50]. Also, propolis is a promising postharvest treatment for the management of fruits postharvest diseases. These treatments may be used as treatment for controlling anthracnose, maintaining quality and increasing the fruit shelf life [51-53].

Also, the obtained results are in harmony with those reported by Razzaq *et al.* [54] on mango fruits. They obtained that, postharvest treatment with OA decreased mango fruit softening during storage as comparable with untreated fruits.

Effect of Edible Coating on Total Soluble Solids (TSS %), Titratable Acidity (TA), Ascorbic Acid (AsA) and Sugar Contents: Data shown in Tables 4, 5, 6 and 7 demonstrated that, total soluble solids (TSS%) and sugar contents of fruits increased while total acidity (TA) and VC contents decreased gradually and significantly with prolonging of storage period during the two seasons under this investigation.

These results are in line with those reported by El-Abbasy *et al.* [37] and Liu *et al.* [38], they mentioned that, total soluble solids contents of fruits significantly increased while ascorbic acid and titratable acidity contents declined continuously and significantly with the progress of cold storage periods.

Data also revealed that, postharvest of apricots fruits treatments with either Salicylic acid or Oxalic acid or Propolis at 0.1% or 0.5 % or Chitosan at 0.025% or 0.05% concentration significantly increased TSS, VC and Sugar contents of fruits during storage in comparison with control fruits during the two seasons in this study. On the other hand, concerning the effect of these treatments on total acidity during storage, Propolis at 0.5% or 1 % and Chitosan at 0.025% or 0.05% concentration significantly increased total acidity contents of apricot fruits. In contrast, Salicylic acid or Oxalic acid at 0.5% or 1 % concentration significantly decreased total acidity contents of fruits during storage in comparison with control fruits during the two seasons in this study.

Data also cleared that, propolis and chitosan significantly were the most effective treatments in increasing Apricot fruits contents of TSS and sugar during storage. On the other side, Salicylic acid and Oxalic acid were the most effective treatments in maintaining fruits contents of total acidity and VC during storage in comparison with control fruits and all other treatments during the two seasons in this study.

Fruits dipped in propolis at 0.1% attained a juice TSS% of 13.51 and 13.74 % during the first and the second season respectively on the average. On the other side fruits treated with chitosan at 0.05 attained a juice TSS% of 13.44 and 13.68 % for the first and the second season respectively on the average. On the contrary, Apricot fruits untreated (control treatment) showed TSS% of 12.61 and 12.65 % for the first and the second season respectively on the average.

Table 4: Effect of some postharvest treatments on TSS% contents of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		11.39	11.40	12.81	13.13	14.32	12.61
Propolis 0.1%		11.39	12.57	13.29	14.49	15.80	13.51
Propolis 0.05%		11.39	12.14	13.07	15.06	15.94	13.52
Chitosan 0.05%		11.39	12.53	13.08	14.29	15.91	13.44
Chitosan 0.025%		11.39	12.13	12.96	14.98	15.66	13.42
Oxalic Acid 0.1%		11.39	11.43	12.15	14.10	15.14	12.84
Oxalic Acid 0.05%		11.39	11.57	12.71	13.58	14.67	12.78
Salicylic Acid 0.1%		11.39	11.87	13.36	13.35	14.66	12.92
Salicylic Acid 0.05%		11.39	11.78	12.85	13.20	14.91	12.83
Means (B)		11.39	11.93	12.92	14.02	15.22	---
Second Season							
Control		11.61	11.33	12.70	13.20	14.41	12.65
Propolis 0.1%		11.61	12.68	13.38	15.13	15.90	13.74
Propolis 0.05%		11.61	12.25	13.16	14.56	15.90	13.50
Chitosan 0.05%		11.61	12.64	13.17	15.05	15.93	13.68
Chitosan 0.025%		11.61	12.24	13.06	14.37	15.65	13.38
Oxalic Acid 0.1%		11.61	11.29	12.01	14.20	15.27	12.87
Oxalic Acid 0.05%		11.61	11.43	12.57	13.68	14.80	12.82
Salicylic Acid 0.1%		11.61	11.73	13.23	13.45	15.04	13.01
Salicylic Acid 0.05%		11.61	11.64	12.65	13.20	14.86	12.79
Means (B)		11.61	11.91	12.88	14.09	15.31	---
L.S.D value at 0.05 level	First Season		A= 0.314	B= 0.234	A×B=0.702		
	Second Season		A= 0.306	B= 0.228	A×B=0.683		

Table 5: Effect of some postharvest treatments on total acidity% contents of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		1.14	1.04	0.94	0.69	0.57	0.88
Propolis 0.1%		1.14	0.97	0.89	0.64	0.59	0.85
Propolis 0.05%		1.14	1.01	0.78	0.72	0.52	0.83
Chitosan 0.05%		1.14	1.01	0.81	0.73	0.56	0.85
Chitosan 0.025%		1.14	0.98	0.73	0.61	0.58	0.81
Oxalic Acid 0.1%		1.14	1.08	0.88	0.79	0.65	0.91
Oxalic Acid 0.05%		1.14	1.05	0.98	0.78	0.64	0.92
Salicylic Acid 0.1%		1.14	1.02	0.97	0.87	0.79	0.96
Salicylic Acid 0.05%		1.14	1.10	0.91	0.80	0.73	0.94
Means (B)		1.14	1.03	0.88	0.74	0.63	---
				Second Season			
Control		1.17	1.09	0.99	0.71	0.58	0.91
Propolis 0.1%		1.17	0.97	0.86	0.76	0.57	0.87
Propolis 0.05%		1.17	0.94	0.82	0.72	0.66	0.86
Chitosan 0.05%		1.17	1.01	0.90	0.80	0.59	0.89
Chitosan 0.025%		1.17	0.95	0.87	0.78	0.56	0.87
Oxalic Acid 0.1%		1.17	1.03	0.94	0.75	0.60	0.90
Oxalic Acid 0.05%		1.17	1.02	0.91	0.74	0.62	0.89
Salicylic Acid 0.1%		1.17	1.08	0.91	0.81	0.68	0.93
Salicylic Acid 0.05%		1.17	1.04	0.78	0.75	0.64	0.89
Means (B)		1.17	1.01	0.90	0.76	0.61	---
L.S.D value at 0.05 level	First Season		A= 0.059	B= 0.044	A×B=0.131		
	Second Season		A= 0.045	B= 0.033	A×B=0.100		

Table 6: Effect of some postharvest treatments on sugar contents g/100 g FW. of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		7.03	7.50	8.37	8.42	8.76	8.02
Propolis 0.1%		7.03	8.27	8.68	9.29	9.66	8.59
Propolis 0.05%		7.03	7.99	8.54	9.38	10.04	8.59
Chitosan 0.05%		7.03	8.25	8.55	9.36	9.53	8.54
Chitosan 0.025%		7.03	7.98	8.47	9.21	9.99	8.54
Oxalic Acid 0.1%		7.03	7.52	7.94	8.90	9.40	8.16
Oxalic Acid 0.05%		7.03	7.61	8.31	8.63	9.06	8.13
Salicylic Acid 0.1%		7.03	7.81	8.74	8.62	8.90	8.22
Salicylic Acid 0.05%		7.03	7.75	8.40	8.77	8.80	8.15
Means (B)		7.03	7.85	8.44	8.95	9.35	---
				Second Season			
Control		6.99	7.82	8.40	8.39	8.86	8.09
Propolis 0.1%		6.99	8.09	8.82	9.39	9.78	8.61
Propolis 0.05%		6.99	7.79	8.71	9.18	9.86	8.51
Chitosan 0.05%		6.99	8.50	8.65	9.57	10.01	8.74
Chitosan 0.025%		6.99	8.05	8.86	9.15	9.61	8.53
Oxalic Acid 0.1%		6.99	7.59	8.21	9.08	9.53	8.28
Oxalic Acid 0.05%		6.99	7.96	8.60	8.56	9.17	8.26
Salicylic Acid 0.1%		6.99	8.04	8.67	8.79	9.04	8.31
Salicylic Acid 0.05%		6.99	7.92	8.33	8.66	8.63	8.11
Means (B)		6.99	7.97	8.58	8.97	9.39	---
L.S.D value at 0.05 level	First Season		A= 0.202	B=0.151	A×B=0.453		
	Second Season		A= 0.171	B= 0.127	A×B=0.382		

Table 7: Effect of some postharvest treatments on VC contents (mg/100g FW.) of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		15.06	12.94	10.73	10.62	7.88	11.45
Propolis 0.1%		15.06	12.59	11.11	10.84	9.20	11.76
Propolis 0.05%		15.06	11.82	10.79	10.29	9.46	11.48
Chitosan 0.05%		15.06	12.70	10.54	9.91	9.17	11.48
Chitosan 0.025%		15.06	12.27	11.45	10.29	9.66	11.75
Oxalic Acid 0.1%		15.06	14.47	13.08	11.62	10.19	12.88
Oxalic Acid 0.05%		15.06	14.78	11.32	10.31	9.80	12.26
Salicylic Acid 0.1%		15.06	15.39	13.33	11.22	8.18	12.64
Salicylic Acid 0.05%		15.06	14.79	12.68	10.49	9.18	12.44
Means (B)		15.06	13.97	11.67	10.62	9.19	---
				Second Season			
Control		14.69	11.91	11.47	10.52	7.64	11.25
Propolis 0.1%		14.69	13.9	11.71	10.51	8.95	11.95
Propolis 0.05%		14.69	13.93	11.11	10.29	9.22	11.85
Chitosan 0.05%		14.69	13.9	11.7	9.91	8.92	11.82
Chitosan 0.025%		14.69	13.6	11.11	10.91	9.42	11.95
Oxalic Acid 0.1%		14.69	14.32	12.54	11.55	9.95	12.61
Oxalic Acid 0.05%		14.69	13.94	11.13	10.31	9.56	11.93
Salicylic Acid 0.1%		14.69	14.58	12.32	11.5	9.94	12.61
Salicylic Acid 0.05%		14.69	14.29	12.11	11.01	8.94	12.21
Means (B)		14.7	13.8	11.7	10.7	9.2	---
L.S.D value at 0.05 level	First Season		A=0.641	B= 0.487	A×B=1.434		
	Second Season		A= 0.568	B= 0.423	A×B=1.269		

Fruits treated with Salicylic acid 0.1 had TA% of 0.96 and 0.93 % during the first and the second season respectively on the average. On the other hand fruits treated with Oxalic acid 0.5% had a TA% of 0.91 and 0.90 % during the first and the second season respectively on the average. Whereas, untreated fruits (control treatment) had a TA% of 0.88 and 0.91 % for the first and the second season respectively, on the average.

Apricot fruits treated with propolis 0.1% had a sugar content of 8.59 and 8.61% during the first and the second season respectively on the average. On the other side fruits treated with chitosan 0.05% had Sugar contents reached the values of 8.54 and 8.74 % during the first and the second season respectively. While untreated fruits had sugar contents reached the values of 8.02 and 8.09 % during the first and the second season respectively.

Apricot fruits treated with SA 0.1% had VC contents reached the values of 12.64 and 12.61 % during the first and the second season respectively. On the other side, fruits treated with Oxalic Acid 0.1 had VC contents reached the values of 12.88 and 12.61 % during the first and the second season respectively. Whereas, untreated fruits had VC contents reached the values of 11.45 and 11.25 % during the first and the second season respectively.

The interaction effect between pre-storage treatments and storage periods showed significant differences ($p \leq 0.05$) for TSS, TA, Sugar and VC of 'Canino' apricot fruits.

These results may be due to that salicylic acid treatment delayed ripening of different climacteric fruits by inhibiting ethylene biosynthesis and maintained postharvest quality of horticultural crops. Moreover these applications prolonged apricot fruits storage life and maintained fruit quality during cold storage [11-13]. Also, Oxalic acid application is a safe postharvest handling treatment for keeping quality and prolonging storage life of horticultural fruits. These results may be due to that OA can retard the ripening procedure, lower SSC and SSC/TA ratio, increase TA and ascorbic acid contents of fruits [18-23].

These results are in partial agreement with those reported by Zahid *et al.* [53] on dragon fruits. They demonstrated that, propolis postharvest treatment significantly increased fruit acidity contents and reduced TSS fruit contents during cold storage.

Effect of Edible Coating on Fruit Total Phenolic Contents and Antioxidants Activity: Data shown in Tables 8 and 9 demonstrated that all treatments increased total phenolic contents and antioxidants activity compared to control.

Table 8: Effect of some postharvest treatments on total phenolic contents (as g gallic acid /100 g FW) of Apricot fruit during storage in 2017 and 2018 seasons

	Storage period (days)					
Postharvest Treatments	0	7	14	21	28	Means (A)
			First Season			
Control	0.453	0.360	0.318	0.268	0.169	0.314
Propolis 0.1%	0.453	0.354	0.316	0.274	0.218	0.323
Propolis 0.05%	0.453	0.344	0.315	0.275	0.212	0.320
Chitosan 0.05%	0.453	0.437	0.320	0.300	0.228	0.348
Chitosan 0.025%	0.453	0.358	0.318	0.274	0.203	0.321
Oxalic Acid 0.1%	0.453	0.415	0.323	0.269	0.215	0.335
Oxalic Acid 0.05%	0.453	0.397	0.323	0.277	0.210	0.332
Salicylic Acid 0.1%	0.453	0.443	0.326	0.294	0.211	0.345
Salicylic Acid 0.05%	0.453	0.440	0.323	0.297	0.213	0.345
Means (B)	0.453	0.394	0.320	0.281	0.209	---
			Second Season			
Control	0.497	0.427	0.404	0.377	0.197	0.380
Propolis 0.1%	0.497	0.431	0.421	0.382	0.257	0.398
Propolis 0.05%	0.497	0.415	0.411	0.379	0.260	0.392
Chitosan 0.05%	0.497	0.507	0.485	0.403	0.281	0.435
Chitosan 0.025%	0.497	0.423	0.420	0.383	0.258	0.396
Oxalic Acid 0.1%	0.497	0.449	0.441	0.389	0.264	0.408
Oxalic Acid 0.05%	0.497	0.444	0.446	0.385	0.263	0.407
Salicylic Acid 0.1%	0.497	0.451	0.450	0.388	0.266	0.410
Salicylic Acid 0.05%	0.497	0.448	0.427	0.385	0.263	0.404
Means (B)	0.497	0.444	0.434	0.386	0.256	---
L.S.D value at 0.05 level First Season		A=0.002	B=0.002	A×B=0.005		
Second Season		A= 0.008	B= 0.006	A×B=0.017		

Table 9: Effect of some postharvest treatments on antioxidant activity (DPPH) (%) contents of Apricot fruit during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		61.7	56.8	49.5	46.8	41.4	51.3
Propolis 0.1%		61.7	60.5	56.9	51.0	54.4	56.9
Propolis 0.05%		61.7	56.6	52.6	50.6	45.5	53.4
Chitosan 0.05%		61.7	55.3	50.1	48.5	44.2	51.9
Chitosan 0.025%		61.7	56.6	52.7	48.0	48.9	53.6
Oxalic Acid 0.1%		61.7	55.5	52.0	47.1	51.6	53.6
Oxalic Acid 0.05%		61.7	57.1	48.0	44.8	50.6	52.4
Salicylic Acid 0.1%		61.7	61.7	57.7	52.9	51.1	57.0
Salicylic Acid 0.05%		61.7	61.1	58.2	47.8	50.6	55.9
Means (B)		61.7	57.9	53.1	48.6	48.7	---
				Second Season			
Control		60.8	55.1	47.6	43.1	37.1	48.7
Propolis 0.1%		60.8	58.3	55.6	52.0	50.1	55.4
Propolis 0.05%		60.8	55.0	50.7	47.6	40.2	50.9
Chitosan 0.05%		60.8	54.4	45.7	41.2	40.3	48.5
Chitosan 0.025%		60.8	55.6	50.7	46.6	44.6	51.7
Oxalic Acid 0.1%		60.8	54.6	49.8	40.8	47.3	50.7
Oxalic Acid 0.05%		60.8	56.2	48.4	43.8	46.4	51.1
Salicylic Acid 0.1%		60.8	60.3	55.3	50.3	47.1	54.8
Salicylic Acid 0.05%		60.8	60.0	56.2	44.8	46.6	53.7
Means (B)		60.8	56.6	51.1	45.6	44.4	---
L.S.D value at 0.05 level	First Season		A=1.94	B=1.44	A×B=4.33		
	Second Season		A=1.21	B= 0.90	A×B=2.71		

Table 10: Effect of some postharvest treatments on POX activity of Apricot fruit during storage U /g F W. in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		0.223	0.299	0.301	0.324	0.414	0.312
Propolis 0.1%		0.223	0.219	0.229	0.239	0.324	0.247
Propolis 0.05%		0.223	0.219	0.235	0.288	0.324	0.258
Chitosan 0.05%		0.223	0.221	0.235	0.272	0.325	0.255
Chitosan 0.025%		0.223	0.225	0.257	0.282	0.325	0.262
Oxalic Acid 0.1%		0.223	0.270	0.278	0.293	0.359	0.284
Oxalic Acid 0.05%		0.223	0.240	0.269	0.309	0.358	0.280
Salicylic Acid 0.1%		0.223	0.251	0.271	0.289	0.360	0.279
Salicylic Acid 0.05%		0.223	0.273	0.285	0.296	0.359	0.287
Means (B)		0.223	0.246	0.262	0.288	0.350	---
				Second Season			
Control		0.210	0.248	0.277	0.389	0.435	0.312
Propolis 0.1%		0.210	0.224	0.239	0.329	0.352	0.271
Propolis 0.05%		0.210	0.227	0.244	0.340	0.376	0.280
Chitosan 0.05%		0.210	0.222	0.235	0.338	0.363	0.274
Chitosan 0.025%		0.210	0.228	0.243	0.334	0.379	0.279
Oxalic Acid 0.1%		0.210	0.234	0.254	0.351	0.392	0.288
Oxalic Acid 0.05%		0.210	0.230	0.257	0.348	0.390	0.287
Salicylic Acid 0.1%		0.210	0.233	0.259	0.353	0.391	0.289
Salicylic Acid 0.05%		0.210	0.230	0.247	0.351	0.388	0.285
Means (B)		0.210	0.231	0.251	0.348	0.385	---
L.S.D value at 0.05 level	First Season		A= 0.0039	B= 0.0029	A×B=0.0089		
	Second Season		A= 0.004	B= 0.003	A×B=0.0093		

Table 11: Effect of some postharvest treatments on PPO activity of Apricot fruit U /g F W. during storage in 2017 and 2018 seasons

		Storage period (days)					
Postharvest Treatments		0	7	14	21	28	Means (A)
				First Season			
Control		0.151	0.222	0.241	0.289	0.373	0.255
Propolis 0.1%		0.151	0.162	0.183	0.201	0.280	0.195
Propolis 0.05%		0.151	0.163	0.188	0.242	0.291	0.207
Chitosan 0.05%		0.151	0.164	0.188	0.229	0.290	0.204
Chitosan 0.025%		0.151	0.166	0.205	0.237	0.290	0.210
Oxalic Acid 0.1%		0.151	0.200	0.222	0.246	0.320	0.228
Oxalic Acid 0.05%		0.151	0.178	0.216	0.260	0.320	0.225
Salicylic Acid 0.1%		0.151	0.186	0.217	0.243	0.321	0.223
Salicylic Acid 0.05%		0.151	0.202	0.228	0.249	0.320	0.230
Means (B)		0.151	0.182	0.210	0.244	0.312	---
				Second Season			
Control		0.144	0.188	0.223	0.283	0.329	0.233
Propolis 0.1%		0.144	0.169	0.192	0.239	0.266	0.202
Propolis 0.05%		0.144	0.172	0.196	0.247	0.285	0.209
Chitosan 0.05%		0.144	0.168	0.189	0.245	0.275	0.204
Chitosan 0.025%		0.144	0.173	0.196	0.243	0.287	0.208
Oxalic Acid 0.1%		0.144	0.177	0.204	0.255	0.297	0.215
Oxalic Acid 0.05%		0.144	0.174	0.207	0.253	0.295	0.215
Salicylic Acid 0.1%		0.144	0.176	0.208	0.256	0.296	0.216
Salicylic Acid 0.05%		0.144	0.174	0.199	0.255	0.294	0.213
Means (B)		0.144	0.174	0.202	0.253	0.292	---
L.S.D value at 0.05 level	First Season		A= 0.0035	B= 0.0026	A×B=0.0078		
	Second Season		A=0.003	B= 0.002	A×B=0.007		

Apricot fruits treated with chitosan 0.05% had highest total phenolic contents (0.348 and 0.435 %) during the first and the second season respectively on the average. On the contrary, untreated fruits showed the lowest total phenolic contents (0.314 and 0.380 %) during the first and the second season respectively on the average.

Fruits treated with salicylic acid 0.1% recorded the highest antioxidant activity (57.0 and 54.8 %) followed by propolis 0.1% (56.9 and 55.4 %) during the first and the second season respectively on the average. Whereas, untreated fruits had lowest antioxidant activity (51.3 and 48.7%) during the first and the second season respectively.

Effect of edible coating on POX and PPO Enzymes Activities: Enzymes activities of POX and PPO increased gradually with prolonging for storage period during the two seasons. Data also revealed that, dipping of apricots fruits in either salicylic acid or Oxalic acid and propolis at 0.5% or 1 % or Chitosan at 0.025% or 0.05% concentration significantly reduced the POX and PPO enzymes activities in comparison with control during the two seasons. Moreover, data also indicated that, Propolis and chitosan were the most effective treatments in decreasing POX and PPO enzymes activities of apricots fruits during cold storage in comparison with the other treatments. Fruits treated with chitosan 0.05% had POX activity (0.255 and 0.274) followed by propolis 0.05% (0.247 and 0.271 %) during the first and the second season respectively on the average. On the contrary, untreated fruits had POX activity reached the values of 0.312 and 0.312 % during the first and the second season respectively (Tables, 10 and 11).

Apricot fruits treated with propolis 0.05% had lowest PPO activity (0.195 and 0.202 %) followed by chitosan 0.05% (0.204 and 0.204 %) during the first and the second season respectively. On the other hand, control treatment showed high PPO activity reached the values of 0.255 and 0.230 % during the first and the second season respectively.

These results are in similarity with the findings of SA postharvest treatment increased antioxidant enzymes activity of fruits during cold storage [7-10].

Postharvest oxidative stress occurs during fruit storage, causing an imbalance between the production and removal of reactive oxygen species (ROS), such as H2O2, O2- and hydroxyl radicals, from the tissues. The protection of fruit cells from oxidative injury depends on the level of antioxidant enzymes, such as peroxidase,

which scavenge ROS and prevent harmful effects [55, 56]. Furthermore, OA has shown some antioxidant activities and could play a role as an anti-senescence effectiveness in harvested fruits [21-23]. Moreover, these results are in accordance with the findings of OA decrease PPO activity and enhanced the antioxidant capacities of banana, pomegranate and Mango fruits [24, 25-27, 54].

Generally, the application of edible coatings is one of the most innovative methods to extend the commercial shelf-life of fruits. Edible coatings on fresh fruit can provide an alternative to modified atmospheric storage by reducing quality changes and slowing down of quantity losses through modification and control of the internal atmosphere of the individual fruits [57]. Chitosan is a naturally compound this molecule was shown to be extend storage life and reduce some several forms of decay caused by fungi during storage [58]. Salicylic Acid (SA) and oxalic acid (OA) are natural identical antibrowning agents. Anti-browning agent possessing have different inhibitory mechanism such as PPO isozymes and phenolic substrates [59]. Salicylic acid treatment counteracted the negative effects of reactive oxygen species by increasing antioxidant enzymes activity [7]. Acidulants, such as oxalic acid retard browning by lowering the pH of the product to minimize the activity of PPO. Successful browning inhibition by reducing agents, such as ascorbic acid, is attributed to the reduction of quinones back to diphenols or the reduction of Cu^{2+} to mononuclear copper (Cu^{+}) at the PPO active site [60-63]. Propolis is a natural glue constituents being resins (flavonoids, phenolics and their esters), waxes, vitamins and essential oils and it has antimicrobial activity [30].

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