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EFFECT OF SAFE POST-HARVEST ALTERNATIVES ON QUALITY AND STORAGE LIFE OF "BARHI" DATE PALM

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Abstract

The current investigation was carried out to study the influence of 1.5 % chitosan, *Aloe Vera* gel, propolis extract, 4% calcium chloride, each alone and combination of them to maintain quality attributes of "Barhi" date palm. The treated fruits stored at 0°C up to 90 days. Results showed that weight loss and total sugars content were increased with increasing storage period. Whereas firmness, total phenols and total tannins decreased by increasing storage period. 1.5% chitosan + 4% ethanol-extracted propolis followed by 1.5% chitosan + *Aloe Vera* gel gave the lowest weight loss, the highest firmness and slow down compositional changes in total phenols, total sugars and total tannins. Thus, Chitosan + Propolis extract or chitosan + *Aloe Vera* gel were the best treatment to maintain quality of "Barhi" date palm during cold storage at 0°C. The study suggests that these treatments might be a promising alternative to maintain date palm quality and to get a safe and healthy product during cold storage and extending post-harvest life of date palm fruits.

Key words: Date palm, post-harvest, calcium chloride, Propolis extract, Chitosan, *Aleo Vera* gel, quality and cold storage.

Introduction

Date palm (*Phoenix dactyllifera* L.) is one of the oldest fruit trees in the world. It is known as "Tree of life" because of its long term productivity and its multiple purpose qualities. Date palm is a common fruit tree in Arabian countries and Middle East (Chao and Krueger, 2007). Date palm is a climacteric fruit and ripens rapidly after harvest, which limits the storage, handling and transport potential. "Barhi" cultivar is the most important soft cultivar grown in Egypt and consumed at the full mature stage of development (Khalal) (Iqbal *et al.*, 2004). However, its economic value decreases sharply when it ripens (Al-Redhaiman, 2004). Thus, it is important to slow down ripening of "Barhi" date. The major goal of post-harvest technology is to use safe and effective methods to maintain fruit quality during handling, transport and storage. Edible coatings with semipermeable film can prolong post-harvest fruit life through reducing moisture loss, respiration rate, and oxidative reaction rates (Petriccione *et al.*, 2015). Chitosan is a natural antimicrobial compound, widely used as edible coating materials (Jiang *et al*., 2014). Previous studies showed that using chitosan in different fruit crops was very effective in improving quality. Zhang *et al*., (2011) found that chitosan maintained post-harvest quality of citrus fruit after 56 days of storage at 15°C. Chitosan reduce ethylene production, respiration rate, decay percentage and weight loss (Velickova *et al*., 2013). Also, Shiri *et al*., (2013) who reported that coated table grapes with 0.5% or 1% chitosan and then stored at 0°C for 60 days showed less weight loss, decay and gave the higher levels of titratable acidity. El-Wahab *et al*., (2014) reported that post-harvest application of 1% chitosan + 4% calcium chloride decreased weight loss and maintained quality parameters of Crimson seedless grape during storage periods compared with control. Recently, the use of *Aloe Vera* gel as an edible coating has been reported to be biologically safe and prolong the shelf life, delay senescence, prevent moisture loss and control respiration rate, in sweet cherries and papaya fruits (Misir *et al*., 2014, Martinez-Romero *et al*., 2006, Marpudi *et al*., 2011). *Aloe Vera* gel improved post-harvest life by reduces weight loss, maintained firmness and total soluble solids of mango fruit (Sophia *et al*., 2015). Propolis extract is natural glue produced by honey bees with main constituents being resins, waxes and essential

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oils (Zahid *et al*., 2013). Coating orange or grapefruit fruit with propolis extract reduced weight loss, remained fruit firmer during cold storage (Ozdemir *et al*., 2010, Passos *et al*., 2016). Post-harvest treatment with $CaCl_2$ delay ripening, reduces decay and reduced the rate of senescence of different fruits and vegetables (El-Gamal *et al*., 2007 and Mahajan and Dhatt, 2004). Dipping in Calcium chloride at 2.5% and 3.5% significantly improved maintenance of fruit firmness, decreased weight loss of papaya fruits (Mahmud *et al*., 2008). Calcium chloride played a significant role in reducing damage of fruit by retardation of firmness loss (Oms-Oliu *et al*., 2010). The aim of this research was to investigate effects of chitosan, *Aloe Vera* gel and Propolis extract and calcium chloride each alone or in combination as safe post-harvest treatments to maintain quality of "Barhi" date palm fruits during storage.

Materials and methods

Fruit material

"Barhi" date palm, 10 years old palm trees grown on a private farm at Masr-Alexandria desert road, Egypt. Palm trees treated with standard cultural practices were selected. The fruits were harvested at Khalal stage when fruits attained full color (bright yellow) according to (Iqbal *et al*., 2004) in mid-September during 2015 and 2016 seasons. Fruits were transported to the laboratory of Agriculture Development Systems (ADS) project in the Faculty of Agriculture, Cairo University. Fruits without signs of mechanical damage and deterioration were selected and standardized showing homogeneous size, color and form, then randomly distributed into 8 groups before treatment.

Preparation of coating solutions

1. **Aloe Vera:** *Aloe Vera* leaves were washed with water, the base and tips of the leaves along with its spikes were removed, the skin was carefully separated from parenchyma to obtain *Aloe Vera* flesh. The flesh was then washed and blanched in hot water at 100°C for 4 minutes. The pH of the gel was adjusted to 3 by the addition of citric acid to stabilize and prevent browning. The process was then continued with pasteurization at 85°C for 1 minute and then the gel was quickly cooled to 5°C. Finally, the gel was filled into sterilized, glass bottles for storage at 5°C. Accordingly, coating of *Aloe Vera* gel solution was made in 1:3 ratio with water (Ramachandra and Rao, 2008).
2. **Chitosan:** 15g Chitosan was dispersed separately to make 1.5% solution in an aqueous solution of glacial acetic acid (1% v/v) at 40°C. The pH value of the chitosan solution was then adjusted to 5.6 using 0.1M NaOH (Sophia *et al*., 2015).
3. **Propolis extract:** Crude propolis was first subjected to pr- cleaning and dried under an air circulation for 10h., it was packed and freeze stored at -5°C for 12h. Then a 100g aliquot was ground in a blender, packaged into amber glass bottles and the volume was made to 1L with 70% ethanol (1st dilution). The suspension was allowed to stand for 5 days at room temperature, afterwards, it was filtered through quantitative filter paper, lastly, the propolis extract was diluted in 70% ethanol (2nd dilution). The solution was used as stock solution for preparation of 4% as ethanolic propolis extract (EEP) (Ali *et al*., 2014).
4. **Calcium chloride:** Calcium chloride 4% (w/v) solution was prepared by dissolving 4 grams of $CaCl_2$ in 100mL of distilled water. The solution was agitated constantly using a magnetic stirrer for 30 minutes and 0.2mL of Tween 20 was added to the solution.

The used post-harvest treatments including (4% $CaCl_2$, 4% Ethanol-extracted propolis (EEP), *Aloe Vera* gel (1:3), 1.5% Chitosan, 1.5% Chitosan + 4% $CaCl_2$, 1.5% Chitosan + 4% ethanol-extracted propolis (EEP), 1.5% Chitosan + *Aloe Vera* gel (1:3) and Control). The fruits were divided into different lots and dipped in these solutions for five minute and dried at 25-28°C before storage.

Storage fruits

Fruits from each treatment were packed in performing carton boxes and stored at cold temperature 0°C with 90-95% RH, each box contained 2 kg of fruits and each was replicated three times and the experiment was done during two seasons (2015 and 2016). During the storage period all the physical characteristics (weight loss and firmness) and chemical characteristics (Total phenol, Total sugars and total Tannins) were determined in fruits sample every 15 days.

Physical Characteristics

Weight loss percentage: Fruits were periodically weighed and the loss in weight was recorded for each replicate. Data were calculated as percentage of the initial weight.

Weight loss% = Initial weight - Weight at specific interval / The initial weight of the fruits (g.) × 100

Firmness (g/cm²): Firmness was recorded by Lifra texture analyzer instrument using a penetrating cylinder of 1 mm of diameter to a constant distance (3 mm) inside the pulp of fruits.

Chemical Characteristics

Total phenols (mg/100g F.W): Total phenols were

determined according to Swain and Hillis (1959). 0.5ml of Folin-Ciocalteu was added to 1ml of ethanol extract in the test tube and immediately followed by addition of 4ml of 2.5 sodium carbonate, tubes were shacked and left 2 min. at room temperature. The absorbance was read at weave length 725nm using spectrophotometer. The amount of total phenols was calculated from standard curve using gallic acid and expressed as mg fresh weight of dates.

Total Sugars %: Total sugars were determined by using the phenol-sulphuric acids methods (Dubois *et al*., 1956) as follows: One ml of ethanol sugars extracted was mixed with 0.5ml phenol (5%) followed by the addition of 5 ml of concentrated sulfuric acid then the mixture was left to cool. The absorbance of developed yellow-orange color was measured at 490 nm using spectrophotometer. A standard curve was carried out using pure glucose. The amount of total sugars was calculated and expressed as percentage.

Total tannins (mg/100g F.W): Soluble tannins were measured according to (Linskens and Jackson, 1995). 1ml sample solution was mixed with 6ml distilled water and 0.5ml Folin Denis reagent (previously diluted 10-fold with distilled water). After exactly 3 min, 1ml of saturated sodium carbonate was added, then 1.5ml distilled water was added and mixed well (total, 10ml) and left for 1h. at ambient temperature before measuring absorbance at 750nm using a spectrophotometer. Soluble tannins were quantified from a standard curve obtained using gallic acid.

Statistical Analysis

The treatments were arranged in factorial experiment in a completely randomized design with three replicates for each treatment. The obtained data were subjected to variance analysis (Snedecor and Cochron, 1991) and means were compared according to Duncan's multiple range tests at 1% level (Duncan, 1955).

Results and Discussion

Effect of safe post-harvest treatments on fruit quality parameters

Weight loss: tables 1 and 2, shows that loss in fruit weight was increased significantly as storage period advanced in all treatments in both seasons. The statistical analysis emphasizes that all safe post-harvest treatment recorded the lowest significant percentage of fruit weight loss in both seasons as compared with the control which gave the highest significant percentage of weight loss. As for the effect of interaction between the tested safe post-harvest treatments and storage periods, the lowest value for weight loss in "Barhi" date palm fruits at different sampling time *i.e.* 15, 30, 45, 60 up to 90 days of storage was connected with dipping the fruits with 1.5% chitosan combined with 4% ethanol-extracted propolis or with *Aloe Vera* gel 1:3 ratio in water compared with control in both seasons.

Firmness: As shown in tables 3 and 4, it is clear that the average values decreased as the storage period increased reaching its lowest values of fruit firmness at the end of storage period 90 days in all post-harvest treatments. The highest significant values of "Barhi" date palm firmness obtained from 1.5% chitosan + 4% $CaCl_2$ followed by 1.5% chitosan + 4% ethanol-extracted propolis followed by 1.5% chitosan + *Aloe Vera* gel 1:3 ratio in water and then 4% $CaCl_2$ in descending order as compared with the control treatment in both seasons. In addition, chitosan combined with $CaCl_2$ reflected the highest firmness for "Barhi" date palm fruits and untreated fruits gave the lowest fruit firmness in this respect with regard to the effect of the interaction during the different periods of storage in two seasons of study.

Table 1: Effect of safe post-harvest treatments on weight loss of "Barhi" date palm fruits during cold storage at 0ºC in season 2015.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.000 t	1.00 p-t	2.50 h-p	3.10 f-m	3.25 f-l	3.65 f-i	4.50 ef	2.57 B
EEP	0.000 t	0.85 q-t	1.95 j-r	2.65 h-o	2.97 g-n	3.25 f-l	3.64 f-i	2.18 B
A.V	0.000 t	0.95 q-t	1.76 l-s	2.73 g-n	3.00 f-n	3.36 f-k	3.66 f-i	2.21 B
Chitosan	0.000 t	0.75 q-t	1.88 k-r	2.50 h-p	2.90 g-n	3.15 f-l	3.45 f-j	2.09 B
Ch + Ca	0.000 t	0.98 p-t	2.20 i-q	2.95 g-n	3.15 f-l	3.45 f-j	3.95 e-h	2.38 B
Ch + EEP	0.000 t	0.30 st	0.92 q-t	1.20 o-t	1.50n-t	2.10 j-q	2.15 i-q	1.16 B
Ch + A.v	0.000 t	0.50 rst	1.60 m-s	1.90 k-r	2.10 j-q	2.25 i-q	2.60 h-o	1.56 B
Control	0.000 t	4.20 efg	5.30 de	6.40 cd	7.80 bc	9.20 b	11.30 a	6.31 A
MEAN (B)	0.000 T	1.19 E	2.26 D	2.92 C	3.33 BC	3.80 B	4.40 A	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Table 2: Effect of safe post-harvest treatments on weight loss of "Barhi" date palm fruits during cold storage at 0ºC in season 2016.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.00 z	1.09 vw	2.65 m-p	3.25 jk	3.30 ijk	3.70 hi	4.60 f	2.65 B
EEP	0.00 z	0.88 wx	1.99 rst	2.78 lmn	2.99 klm	3.35 ijk	3.70 hi	2.24 BC
A.V	0.00 z	0.99 vwx	2.13 qrs	2.80 lmn	3.15 jkl	3.42 ijk	3.85 gh	2.33 BC
Chitosan	0.00 z	0.79 wxy	1.95 rst	2.55 n-q	2.99 klm	3.26 jk	3.52 hij	2.15 C
Ch + Ca	0.00 z	1.00 vwx	2.29 o-r	2.98 klm	3.20 jkl	3.56 hij	4.20 g	2.46 BC
Ch + EEP	0.00z	0.45 y	1.00 vwx	1.35 uv	1.60 tu	2.30 o-r	2.45 n-q	1.30 D
Ch + A.v	0.00 z	0.65 xy	1.75 stu	2.00 rst	2.22 pqr	2.34 o-r	2.68 mno	1.66 D
Control	0.00 z	4.90 f	6.00 e	7.10 d	8.00 c	9.30 b	13.10 a	6.91 A
MEAN (B)	0.00 G	1.34 F	2.47 E	3.101 D	3.43 C	3.90 B	4.76 A	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Total phenols: Results illustrated in tables 5 and 6, showed that there was significant decrease in total phenols content as the storage period prolonged. Similar result was obtained by Davarynejad *et al*., (2013). Moreover, the present data reveals that the highest values of total phenols were recorded for "Barhi'' date palm fruits treated with safe post-harvest treatments chitosan + ethanol-extracted proplis, chitosan + *Aloe Vera*, chitosan or ethanol-extracted proplis alone in descending order compared with untreated "Barhi" fruits which had the lowest significant means of total phenols at the end of storage period in both seasons of study. Concerning the effect of the interaction between the tested post-harvest treatments and storage period, the lowest values for total phenols was rapidly decreased in control compared with treated fruits.

Total sugars: The effect of different post-harvest treatments on total soluble sugars content of stored "Barhi" date palm fruits are presented in tables 7 and 8. It clearly show that total soluble sugars increased gradually and significantly with extending of storage period as previously detected by Davarynejad *et al*., (2013). However, control treatment resulted in higher and faster increase in total soluble sugars during cold storage than that occurred in fruits treated with post-harvest treatments at the two seasons of this study. In this respect chitosan + ethanol-extracted propolis followed by chitosan + *Aloe Vera* gel followed by chitosan treatment alone and then Ethanol-extracted propolis treatments in descending order gave the lowest values of total sugars as compared with the control treatment for both investigate seasons. Moreover, the effect of interaction revealed that at the end of storage period (90 days), fruits treated with chitosan + ethanol-extracted propolis, chitosan + *Aloe Vera* gel showed the lowest values of total sugars than untreated fruits in the first and second seasons.

Total tannins: The effects of the post-harvest treatments on "Barhi'' date palm total tannins content were found to be statistically significant ($p<0.01$). At the end of the 90 days storage period, the total tannins content of fruits decreased in both seasons. However, decline was much higher in control. All post-harvest coating treatments inhibited the decline of total tannins specially

Table 3: Effect of safe post-harvest treatments on firmness (g/cm^2) of "Barhi" date palm fruits during cold storage at 0ºC in 2015.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	6.500 a	6.100 e	6.000 f	5.700 i	5.500 k	5.200 n	4.900 q	5.700 D
EEP	6.50 a	6.10 e	5.90 g	5.401	5.10 o	4.80 r	4.50 u	5.47 F
A.V	6.50 a	6.00 f	5.60 j	5.20 n	4.90 q	4.60 t	4.20 v	5.28 G
Chitosan	6.50 a	6.20 d	5.80 h	5.60 j	5.30 m	5.00 p	4.70 s	5.58 E
Ch + Ca	6.50 a	6.40 b	6.30 c	6.10 e	6.00 f	5.80 h	5.60 j	6.10 A
Ch + EEP	6.50 a	6.30 c	6.20 d	6.00 f	5.70 i	5.50 k	5.20 n	5.91 B
Ch +A.v	6.50 a	6.20 c	6.10 e	5.80 h	5.60 j	5.401	5.00 p	5.80 C
Control	6.50 a	4.70 s	4.20 v	3.50 w	3.20 x	2.80 y	2.40 z	3.90 H
MEAN (B)	6.50 A	6.00 B	5.76 C	5.41 D	5.16 E	4.88 F	4.56 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Table 4: Effect of safe post-harvest treatments on firmness (g/cm^2) of "Barhi" date palm fruits during cold storage at 0ºC in 2016.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	6.30 a	6.00 e	5.80 g	5.40 l	5.20 n	5.00 p	4.70 r	5.48 E
EEP	6.30 a	5.90 f	5.60 i	5.30 m	5.00 p	4.60 s	4.30 t	5.28 F
A.V	6.30 a	5.70 h	5.45 k	5.20 n	4.90 q	4.60 s	4.10 v	5.17 G
Chitosan	6.30 a	6.10 d	6.00 e	5.80 g	5.60 i	5.40 l	5.20 n	5.77 B
Ch + Ca	6.30 a	6.20 b	6.10 d	5.90 f	5.60 i	5.40 l	5.10 o	5.80 A
Ch + EEP	6.30 a	6.15 c	6.00 e	5.70 h	5.50 j	5.20 n	5.00 p	5.69 C
Ch + A.v	6.30 a	6.10 d	5.90 f	5.60 i	5.40 l	5.30 m	4.90 q	5.64 D
Control	6.30 a	4.20 u	3.80 w	3.10 x	2.70 y	2.30 z	2.00 z	3.48 H
Mean (B)	6.30 A	5.79 B	5.58 C	5.25 D	4.98 E	4.72 F	4.41 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

chitosan + extracted propolis treatment they had higher ability in maintaining the decrease in the total tannins content of fruits and maintaining significantly higher levels of tannins. The interaction data shows significant differences between various treatments and storage period and the highest total tannins content was obtained from "Barhi" date palm fruits coated with chitosan + ethanol-extracted propolis followed by chitosan + *Aloe vera* treatments compared to control fruits.

Discussion

Post-harvest losses of date palm fruits is a serious problem mainly because of rapid deterioration during handling, transport and storage. Berhi dates, fruits at the khalal stage are often preferred and considered as a premium product because they are physiologically mature, hard, crisp and have bright yellow color (Ismail *et al*., 2006). This clearly indicates the positive effect of safe post-harvest coating treatments in retarding the fruit ripening process, maintaining fruit quality and extend cold storage period of "Barhi" date plam. The reduction in weight loss percentage in coated fruit may be due to the fact that chitosan, propolis or *Aleo vera* gel blocked the transpiration from fruit skin and reduce respiratory exchange and consequently reduced the loss in weight. The chitosan enabled epidermal tissues to control water loss and reduce respiratory exchange in grapes (Shiri *et al*., 2013), *Aloe vera* gel effect may be due to the hygroscopic properties that enable the formation of a barrier to the diffusion of gasses and water vapour between fruit and environment (Borah *et al*., 2016). Propolis extract contributed to gases and water vapor permeability properties (Ali *et al*., 2015). Meanwhile, Calcium chloride might conserve the qualities of fruits with prevented physiological disorders and reduced rate of respiration and reduced weight loss (Mahmud *et al*., 2008). Similar results have been reported in Chitosan coated grapes and orange (Shiri *et al*., 2013 and Mahmoud *et al*., 2017), chitosan + calcium chloride coated grape (El wahab *et al*., 2014), propolis coated orange (Passos *et al*., 2016) and *Aloe vera* coated grape and mango (Chauhan *et al*., 2011 and Sophia *et al*., 2015). The highest firmness values were obtained by chitosan combined with calcium chloride followed by propolis or

Table 5: Effect of safe post-harvest treatments on total tannins (mg/100g F.W) of "Barhi" date palm fruits during cold storage at 0ºC in season 2015.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.280 a	0.205 k-n	0.190 no	0.173pq	0.162qr	0.153rs	0.140 st	0.186 E
EEP	0.280 a	0.237fg	0.230 ghi	0.225 g-j	0.219 h-k	0.210 j-m	0.192 no	0.228 C
A.V	0.280 a	0.230ghi	0.225 g-j	0.215 i-l	0.210 j-m	0.200 l-o	0.185 op	0.221 C
Chitosan	0.280 a	0.250 c-f	0.240 d-g	0.238 e-g	0.227ghi	0.220 h-k	0.200 l-o	0.236 B
Ch + Ca	0.280 a	0.210 j-m	0.200 l-o	0.195mno	0.184 op	0.170 pq	0.160 qr	0.200 D
Ch + EEP	0.280 a	0.270 ab	0.261bc	0.254 b-e	0.247 c-f	0.235fgh	0.225 g-j	0.253 A
Ch + A.v	0.280 a	0.260bc	0.255bcd	0.248 c-f	0.240 d-g	0.229ghi	0.210 j-m	0.246 A
Control	0.280 a	0.126 t	0.098 u	0.080 v	0.066 v	0.045 w	0.039 w	0.105 F
Mean (B)	0.280 A	0.224 B	0.212 C	0.204 D	0.194 E	0.183 F	0.169 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Table 6: Effect of safe post-harvest treatments on total tannins (mg/100g F.W) of "Barhi" date palm fruits during cold storage at 0ºC in season 2016.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.273 a	0.195ijk	0.182klm	0.163nop	0.152pq	0.143qr	0.130rs	0.177 E
EEP	0.273 a	0.230ef	0.215fgh	0.210ghi	0.200hij	0.189jkl	0.175lmn	0.213 C
A.V	0.273 a	0.220fg	0.210ghi	0.200hij	0.195ijk	0.180klm	0.170mno	0.207 C
Chitosan	0.273 a	0.240 de	0.230ef	0.220fg	0.215fgh	0.200hij	0.190jkl	0.224 B
Ch + Ca	0.273 a	0.209ghi	0.200hij	0.185 j-m	0.176lmn	0.162nop	0.154opq	0.194 D
Ch + EEP	0.273 a	0.263ab	0.252bcd	0.245cde	0.237 de	0.220fg	0.215fgh	0.244 A
Ch + A.v	0.273 a	0.257abc	0.250bcd	0.240 de	0.230ef	0.2100 ghi	0.200hij	0.237 A
Control	0.273 a	0.116 s	0.085 t	0.076tu	0.060 u	0.040 v	0.035 v	0.0979 F
Mean (B)	0.273 A	0.216 B	0.203 C	0.192 D	0.183 E	0.168 F	0.159 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Aloe Vera, this is may be due to the maintaining of cell wall carbohydrate metabolism during storage, chitosan treatment significantly inhibited the softening of "Barhi" date palm fruits resulting from the degradation of the middle lamella of the cell wall (Perkins-Veazie, 1995). Calcium is a major component of pectin and has a role in strengthening cell wall and membrane structure (Agar *et al*.,1999) and it plays a significant role in retarding of firmness loss (Mahmud *et al*., 2008 and Oms-Oliu *et al*., 2010). In addition, the effect of *Aloe Vera* gel and Propolis extract as coating can be given to the insolubility pectic material, which inhibits the degradation of pectin by pectin methylesterase (PME) and polygalacturonase (PG). The present results agree with those reported by (Nunan *et al*., 1998, Zahid *et al*., 2013 and Passos *et al*., 2016) on dargon orange fruits, (Martinez-Romero *et al*., 2006 and Marpudi *et al*., 2011 and Hong *et al*., 2012) on sweet cherries, papaya and guava (Shiri *et al*., 2013 and Hernandez-Munoz *et al*., 2008 and Elwahab *et al*., 2014) on grape. During storage, the decrease level of total phenols might be due to the breakdown of cell structure at senescence stage (Ghasemnezhad *et al*., 2010). It was assumed that the effect of chitosan + proplis, chitosan + *Aloe Vera* treatments on maintaining of total phenol content could be attributed to the delay in senescence process. Higher Polyphenol peroxidase activity can be involved in the oxidation of phenolic compounds and formation of dark brown pigments (Mortazavi *et al*., 2015). The reduction in total phenolic due to the decomposition of natural phenolics during "Barhi" date fruit development occur from Khalal mature stage to ripening stage (Rutab) (El-Rayes, 2009). It is evident that all post-harvest treatments gave the lowest decrease in total phenols compared with the control fruits. The maximum retention in phenolic compounds could be inferred by the reduced respiration. Furthermore, post-harvest treatments especially chitosan, proplis or *Aloe vera* treatments decreased losses in total phenols that may be due to delay oxidation of phenol substances through Polyphenol oxidase (PPO) activity (Yamaguchi *et al*., 2003) this could be attributed to its ability to decrease oxidative stress (ripening) as total phenols in date palm

Table 7: Effect of safe post-harvest treatments on total phenols (mg/100g F.W) of "Barhi" date palm fruits during cold storage at 0ºC in season 2015.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.250 a	0.165 g-j	0.149 j-m	0.129 nop	0.120 opq	0.110 qr	0.095 rs	0.145 E
EEP	0.250 a	0.190 ef	0.180 fg	0.160 hij	0.150 j-m	0.135 mno	0.084 s	0.164 C
A.V	0.250 a	0.180 fg	0.160 hij	0.140 k-n	0.130 nop	0.120 opq	0.115 pq	0.156 D
Chitosan	0.250 a	0.210 cd	0.190 ef	0.175 fgh	0.165 g-j	0.150 j-m	0.130 nop	0.181 B
Ch + Ca	0.250 a	0.176 fgh	0.152 jkl	0.138 lmn	0.126 n-q	0.116 pq	0.110 qr	0.153 DE
Ch + EEP	0.250 a	0.230 b	0.210 cd	0.200 de	0.180 fg	0.176 fgh	0.170 ghi	0.202 A
Ch + A.v	0.250 a	0.220 bc	0.200 de	0.170 ghi	0.160 hij	0.155 ijk	0.150 j-m	0.187 B
Control	0.250 a	0.150 j-m	0.116 pq	0.080 st	0.065 tu	0.055 uv	0.040 v	0.108 F
Mean (B)	0.250 A	0.190 B	0.170 C	0.149 D	0.137 E	0.127 F	0.112 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

Table 8: Effect of safe post-harvest treatments on total phenols (mg/100g F.W) of "Barhi" date palm fruits during cold storage at 0ºC in season 2016.

Treatments	Storage period (days)							Mean (A)
	0	15	30	45	60	75	90	
$Cacl_2$	0.230 a	0.150 j-n	0.145 k-o	0.120 qrs	0.115 rst	0.100 tu	0.090 u	0.136 E
EEP	0.230 a	0.180 efg	0.176 e-h	0.153 j-m	0.142 l-o	0.130 o-r	0.110 st	0.160 C
A.V	0.230 a	0.175 e-h	0.155 i-l	0.135 n-q	0.120 qrs	0.110 st	0.100 tu	0.146 D
Chitosan	0.230 a	0.200 cd	0.180 efg	0.165 g-j	0.150 j-n	0.138 m-p	0.125 p-s	0.170 B
Ch + Ca	0.230 a	0.160 h-k	0.145 k-o	0.135 n-q	0.120 qrs	0.110 st	0.090 u	0.141 DE
Ch + EEP	0.230 a	0.220 ab	0.200 cd	0.190 de	0.170 f-i	0.165 g-j	0.155 i-l	0.190 A
Ch + A.v	0.230 a	0.210 bc	0.185 def	0.165 g-j	0.150 j-n	0.140 l-p	0.130 o-r	0.173 B
Control	0.230 a	0.135 n-q	0.110 st	0.070 v	0.050 w	0.040 w	0.035 w	0.096 F
Mean (B)	0.230 A	0.179 B	0.162 C	0.142 D	0.127 E	0.117 F	0.104 G	

EEP= ethanol-extracted propolis, A.v= *Aleo vera* Ch= Chitosan, Ca= $Cacl_2$, Means followed by the same letter within each column are not significantly different at 1% level.

fruits play important role in antioxidant activities (Kosanic *et al*., 2011) and then leading to improve storability and market life of "Barhi" date palm fruits. These results are in harmony with those obtained by (Martinez-Romero *et al*., 2006, Marpudi *et al*., 2011) as *Aloe Vera* gel coating caused delay oxidative browning and prolong the shelf life in grapes (Shiri *et al.,* 2013). The inhibition of PPO activity by chitosan coating has been observed with longan fruit stored at low temperature (Jiang *et al*., 2005). Generally, edible coatings can prolong post-harvest fruit life through reducing respiration and oxidative reaction rates (Petriccione *et al.*, 2015). Increase in total soluble sugars may be due to the increasing hydrolysis of starch and polysaccharides during cold storage. It is evident that all post-harvest treatments decline increases in total soluble sugars, whereas, the control gave the highest content of total sugars in both seasons. This may be due to of the high respiration rate in control fruits. The increase in sugars content of fruits could be due to the ripening process that led to the transformation of some carbohydrates components as starch to sugars by the enzymatic activities (Karemera and Habimana, 2014). The higher total sugar content as "Barhi" date palm fruits passed from the Khalal to Rutab (full ripen fruits or softening) stage (El-Rayes, 2009). *Aloe Vera* gel reduces α-galactosidase and polygalacturonase activities in the fruit (Nunan *et al*., 1998) and so *Aloe Vera* gel post-harvest coating delayed the quick entry in rutab stage and then leading to extend the storability life of "Barhi" date palm fruits. Similar results have been reported in coating with chitosan alone or chitosan combined calcium chloride of grape (El-wahab *et al.*, 2014). Propolis of grapes, sweet cherries and citrus (Candir *et al*., 2006) and *Aloe Vera* gel of sweet cherry and papaya and mango (Martinez-Romero *et al*., 2006, Marpudi *et al*., 2011 and Sophia *et al.*, 2015). Minimum decrease of total tannins during storage has been noticed from different post-harvest edible coatings of "Barhi" date palm fruits especially with chitosan + propolis extract or chitosan + *Aloe vera*. This could be due slow tannin degradation by reducing the respiration rate and created a modified atmosphere inside the fruit (Guilbert *et al*., 1996) as extend the khalal stage and delayed the entrance in rutab stage so, helped to delay ripening and preserved quality of "Barhi" date palm fruits. Al-Redhaiman (2004) reported that total tannins content decreased as "Barhi" dates matured from the Khalal stage to the ripe stage (rutab). Tannin compounds are present as a layer below the skin of the date and consist mainly of polyphenols and flavones, which are broken down during maturation and converted to insoluble compounds that have no astringency (Tafti and Fooladi, 2005). The present results provided supporting evidence that Chitosan alone or combined with calcium chloride coated grape (El-wahab *et al*., 2014), *Aloe Vera* coated sweet cherry and Papaya (Martinez-Romero *et al*., 2006, Marpudi *et al.*, 2011) and Propolis extract coated sweet cherries (Candir *et al.*, 2009) as these safe post harvest treatments helped to delay ripening, preserve fruit quality and prolong the shelf life.

Conclusion

The results presented in our study indicated that all safe postharvest coating of "Barhi" date palm with chitosan, *Aloe Vera* gel, Propolis extract, calcium chloride, each alone and combination of them were more effective in controlling post-harvest compositional changes by delaying changed such as total weight loss, firmness, total phenols, total sugars and total tannins slowing down respiration rate with a minimum quality loss and prolong storage and market life. So, using Chitosan + Propolis extract or chitosan + *Aloe Vera* gel might give better results. They are new tools that could be included in integrated management programs especially suitable for

modern packing houses, fruit intended for long distance shipping for export.

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