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Effectiveness of Some Edible Coatings on Storage Ability of Zaghloul Date Palm Fruits

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ABSTRACT

Effectiveness of edible coatings such as Jojoba oil (JO) at 5%, Arabic gum (AG) at 10% and Paraffin oil (PA) at 7.5% as solely or in combination on physical and chemical characteristics of Zaghloul date palm fruits stored at 0±1°C and R.H. 85-90 % for 6 weeks were investigated during two successive seasons (2018 and 2019). The achieved data registered that all tested treatments prolonged the cold storage period of Zaghloul date palm fruits as compared to the control (Tap water). Fruits treated with JO at 5% combined with AG at 10% significantly recorded the highest responses, where it significantly mitigated the rise in decay incidence and reduced weight loss, and maintained high firmness, total phenol content, total flavonoids, total tannins, total sugars and antioxidant activity. Also, the result of ion leakage detected that this treatment protected the cell membrane integrity. According to these results, Jojoba oil (JO) at 5% combined with Arabic gum (AG) at 10% application could be suggested to maintain the storability during cold storage of Zaghloul date palm fruits.

Keywords: Edible coatings; Jojoba oil; Arabic gum; Ion leakage; Antioxidant activity

INTRODUCTION

Date palm is considered one of the most important and oldest fruit trees in Egypt, its cultivations spread from north to south and from east to west with different cultivars. In recent years, an expansion in its cultivation was noticed in the new lands. Furthermore, it is one of the early domesticated fruit trees in the world, mainly in the Middle East countries, and its fruits perform an essential function in many people's nutritional model (Krueger ,1998). The whole production of date fruits in Egypt amounted to 1,562,171 tons/year from 49184 ha (Food and Organization, 2019). In Egypt, many cultivars such as Zaghloul, Samani, Halaway and Hayany are grown in different regions. They are the earliest ripening species of soft date produced in Egypt. Zaghloul date is the most relevant investment cultivar in Egypt and highly expected in the Arab markets (Kassem *et al*., 2011). The process of storing date palm fruits may be inevitable, since the marketing of dates according to market requirements and for a period as longer as than the period of normal season, also achieving a good return (Omaima *et al*., 2012). The optimal condition for store the date fruits is temperature of 0 – 4 ºC and relative humidity 85-90 % (Al-Redhaiman ,2004) for saving the fruits about a month depending on the cultivar. The improvement and use of alternative postharvest control requirements including natural plant extracts have grow to be important, since it is perceived as being environmentally more secure and more perfect to the overall public treatments (Janisiewicz and Korsten,2002). The storage life of most fruits remains prolong if they're cooled speedy after harvest. The temperature has a direct impact on the respiration rate of fruits and on the decay percentage as a result of the activity of organisms. The respiration rate is an indication of the rate at which the fruit is using up its resources of sugars and several metabolites and consequently, an index of the loss in shelf life. The application of fruit coating is considered to be one of several treatments more advanced to reduce post-harvest losses and to extend the storage life of fruits. External coating has been used as a defense method for many fruits and vegetables. The principal goals of applying fruit coatings are to reduce water evaporation from the fruit and thereby reduce its weight loss by up to 50% and maintain the quality of the fruits (Baldwin *et al*., 1999). Many previous reports have been focused on waxes coating on different fruits (El-Anany *et al.*, 2009). Edible coatings can be obtained from several sources of consumables, but the commonly used ones are made from polysaccharides. However, due to their hygroscopic characteristics, confirmed determination or disadvantages have been observed, especially for those made from starch and pectin (Moraes *et al*., 2012) . There are various trials were recently conducted to investigate the effect of Jojoba oil, Arabic gum and Paraffin oil to prolong the storage period and the marketing life of some fruits. Some trials used jojoba oil as an emulsifiable natural product for coating the fruits before cold storage. Jojoba oil is the liquid wax composed in the seed of jojoba plant. This oil looks as a bright golden liquid at room temperature with a lightly fatty smell. Jojoba oil presents all-day moisturization, which does not dissolve like water based moisturizers, very permanent and does not become contaminated or lose antioxidants even after long periods of storage flows and absorbs well (Abd-Allah *et al.*, 2012). Jojoba oil is ordinarily known as liquid, colorless and odorless with

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individual physical and chemical properties (Naqvi and Ting, 1990). In study of Eman and Magda (2006) investigated the effect of different edible coating materials and reported that coating Washington navel orange fruits with jojoba oil and orange oil were the most useful in decreasing decay, water loss and enhancing fruits storage life . The main source of Arabic gum is the acacia plant from its branches and stems. It is considered the least gelatinous material and has the capacity to dissolve in hydrocolloid. It is characterized by means of emulsifying , forming and encapsulating properties , so it's miles widely used in industrial purposes, used commercially as a safe nutrition addition because has perfect film - forming characteristics (Motlagh *et al*., 2006). Application of Arabic gum as a natural coating film has been reported to influence the conservation of antioxidant activity and total phenols in bananas , fruits (Alali *et al*., 2018) and guavas (Etemadipoor *et al.*, 2019). It also supports maintain firmness, ascorbic acid, total phenol, and chlorophyll content in guava fruits at room temperature (Gurjar et al., 2018). Arabic gum can decrease the browning in mango during cold storage (Khaliq *et al*., 2015).

The purpose of the existing investigation was to extend the cold storage period of Zaghloul date palm fruits by using edible coating treatments, i.e., Jojoba oil, Arabic gum and Paraffin oil as a separate treatment and also their combinations under cold storage.

MATERIALS AND METHODS

This experiment carried out during two successive seasons (2018 and 2019) on Zaghloul fruits of 15-years-old date palm (*phoenix dactylifera* L.) planted in a private orchard in the Egyptian governorate, Dakhlia. The fruits were harvested in the colored stage (Khlal) and transferred directly to the horticultural laboratory of the Agricultural Faculty of Damietta University. Uniform fruits, apparently free from any physical damage and disease were selected, washed with chlorine water for 3-5 minutes as sanitizing agents for inhibiting micro-spoilage (Sapers, 2014) then washed with tap water only, cleaned with a muslin cloth and air-dried. The selected fruits were divided into eight groups and each one of them was immersed for 5 min into one of the following coating solutions:

T1- Control (tap water only), T2- Jojoba oil at 5 %, T3- Arabic gum at 10%, T4- Paraffin oil at 7.5% , T5- Jojoba oil at 5 %+ Arabic gum at 10% (mix of 1:1 v/v), T6- Jojoba oil at 5 % + Paraffin oil at 7.5%, T7- Arabic gum at10% + Paraffin oil at 7.5% and T8- Jojoba oil at 5 % + Arabic gum at10% + Paraffin oil at 7.5% (mix of 1:1:1 volumes). In all treatments, 0.1 ml/L of Tween 80 was added as emulsified material.

Preparing of the used emulsions

Jojoba oil at 5% was prepared by mixing 5ml of Jojoba oil with tween 80 in 100ml of water (Ju *et al*., 2000). Arabic gum at 10% was prepared by dissolving 100 g of Arabic gum powder in 1.0 L distilled water with stirring at low heat 40Cº for 30 min using a hotplate magnetic stirrer (El-Sharony *et al*., 2015). Paraffin oil emulsion at 7.5% was made by combining paraffin oil with tween 80 in water.

The immersed fruits samples per each treatment were parted into 2 groups, the first to determine chemical properties and the other to determine physical properties. Fruits of each group were carried out as 3 replicates (about 1 Kg each) in one layer inside carton box and cold stored at 0ºC and 85-90 % relative humidity for 6 weeks. Changes in fruits samples properties were determined at 2weeks intervals.

Physical characteristics

Fruits weight loss percentage

The tested fruits of each replicate per treatment was weighted separately before storage to get the initial weight, then reweighted after the storage period. The fruit weight losses % was calculated by using the following equation:

$$[(Wa - Wb) / Wa] \times 100$$

where,

Wa = initial weight before storage period; Wb = weight at the end of storage period.

Decay percentage

Date fruits which had bad change in their color, shrink or pathogenic symptoms are decayed fruits. Decayed fruits % was calculated according to the following equation :(decayed fruits number / Initial number of stored fruits) x 100.

Fruit Firmness (lb\inch^2)

Fruit firmness was determined before and after storage period as lb /inch^2 using fruit pressure tester model. FT327 (3-27Lbs).

Chemical characteristics

Total phenolic contents

Total phenolic contents in fruit juice of the tested samples were determined by using Folin-Ciocalteu reagent (FCR) or Folin's phenol reagent method according to Lin and Tang (2007). For quantitatively determination a standard curve of gallic acid (0-200 mg/l) was prepared in the same manner. Total phenol contents were expressed as milligram gallic acid equivalent (GAE)/g based on dry weight.

Total flavonoid contents

Total flavonoid contents of samples were determined colorimetrically using aluminum chloride as described by Chang *et al*. (2002). The samples were prepared in distilled water at a definite concentration. Resulting solution (100 µl) of the sample was mixed with 4.0 ml of distilled water and 0.3 ml sodium nitrite (5%). After 5 min, 0.3 ml of aluminum chloride solution (10%) "prepared freshly in ethyl alcohol 95% (10 g $AlCl_3$/ 100 ml EtOH)" was added and the mixture was left for 1 min. Then, 2 ml of sodium hydroxide solution (1 M) was added to the mixture and the volume of the mixture was completed to 10 ml by distilled water. The test was run at room temperature and the absorbance of the samples was measured using a spectrophotometer at λ= 510 nm. A blank sample was prepared by the previous steps without adding the tested sample and the final volume was completed to 10 ml by distilled water. Catechin was selected as the standard for flavonoids for creating the regular curve (0–50 mg / l). The amount of the total content of flavonoids was manifested as milligrams of catechin equivalent (QE) / g on a dry weight basis.

Tannins

Was prepared by taken 1ml of the date palm juice sample and diluted with distilled water to a definite concentration. Five ml of vanillin hydrochloride reagent (8% HCl in methanol and 4% vanillin in methanol 1:1 v / v) were added to 1 ml of the date palm juice, and then the visible density of the resulting color was estimated at 500 nm after 20 minutes. The standard curve was prepared using 0-100 µg tannic acid. (Khawas *et al*.,2014)

Total Sugars (g /100 g fresh weight):

Total Sugars were determined in stored date fruits by the method described by AOAC (2000).

Antioxidant capacity (DPPH) radical

The DPPH free radical scavenging activity of Asteraceae (Family composite) samples at different concentrations were measured from bleaching of the purple colour of (2.2 Diphenyl-1-picryl hydrazyl) assay was based on the method of Pratap *et al.*(2013). A serial dilution of each sample was prepared in methanol. Exactly 1 ml solution of different concentration of sample was added to 1 ml of DPPH and kept in dark for 30 min. The absorbance (A) was measured at 517 nm, using a Spekol 11 (CarlZeiss-Jena) Spectrophotometer and the inhibition percentage was calculated from the following equation.

Percentage of inhibition = (Blank A –Test A) / Blank A) × 100.

Ion leakage (IL%)

5 g of skin tissue was cut into discs. The disks were washed 3 times using demineralized water and placed in 20 ml of mannitol (0.4M) in demineralized water for 3 hours at 24 ° C (Hakim *et al.*,1999). The electrical conductivity of the aqueous phase was measured using a conductivity meter and the tissue samples were sacrificed by heating them in a water bath at 100 ° C for 20 min. The cooking process makes it possible to measure the conductivity again and to calculate the relative electrolyte leakage from the uncooked peel samples as follows:

IL (%) = Conductivity after 3 hr / Conductivity after boiling × 100.

Statistical analysis:

Complete randomized design test was chosen to determine the treatment influence according to Snedecor and Cochran (1989).Using the software package of Co-Stat, Ver. 6.303 . All measurements were carried out in triplicate and the data reported as the mean. The data means were compared using Duncan's multiple range tests by a significance level of 0.05.

RESULTS AND DISCUSSION

Weight loss (%)

The impact of investigated edible coating treatments on the percentage of weight loss to Zaghloul date palm fruits during the 6 weeks cold storage at (0±1°C) was examined and the results obtained are shown in Table (1). The most weight loss% was mentioned in the untreated sample (control) until the 6th week that recorded 6.47 % and 6.14 % in the two seasons, respectively. From the obtained results, it could be mentioned that treatment (JO 5%+AG 10%) recorded the lowest percentage of weight loss at the end of the storage time, 0.57 % and 1.33 % in the two seasons, respectively. The results matched with those reported by Hassan *et al*. (2014) and Mahmoud *et al*. (2019) .This reducing in a weight loss% of treated fruit samples compared with the untreated sample (control) was perhaps due to the positive effect of the coatings as a semi-porous barrier against oxygen, carbon dioxide, moisture, and solute movement, whereby decreasing respiration, water loss and oxidation reaction rates (Park, 1999). Edible coatings could act as barriers on the fruit surface, limiting water evaporation and protecting the fruit from drying out. (Shiri *et al*., 2013).

Table 1. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on weight loss percentage of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	0.00 h	0.00 o	1.44 c-f	2.11 ghi	3.20 b	4.23 b	6.47 a	6.14 a	2.78 a	3.12 a
JO	0.00 h	0.00 o	1.03 efg	1.40 klm	1.49 c-f	2.36 e-h	2.80 b	3.10 d	1.33 c	1.71 c
AG	0.00 h	0.00 o	1.16 def	1.48 jkl	1.75 cd	2.69 def	2.88 b	3.82 bc	1.44 bc	1.99 b
PA	0.00 h	0.00 o	1.52 c-f	1.56 jk	1.92 c	2.85 de	3.04 b	3.94 bc	1.62 b	2.08 b
JO+AG	0.00 h	0.00 o	0.09 h	0.76 n	0.21 h	0.92 mn	0.57 gh	1.33 klm	0.21 d	1.67 c
JO+PA	0.00 h	0.00 o	1.42 c-f	1.35 klm	1.69 cd	2.29 fgh	2.80 b	3.03 d	1.47 bc	1.67 c
AG+ PA	0.00 h	0.00 o	1.05 c-f	1.43 j-m	1.61 cde	2.52 efg	2.94 b	3.63 c	1.51 bc	1.86 bc
JO+AG+PA	0.00 h	0.00 o	0.27 h	1.04 lmn	0.55 gh	1.72 ijk	0.95 fg	1.91 hij	0.44 d	1.16 d
Mean F1	0.00 d	0.00 d	1.05 c	2.11 ghi	1.55 b	2.44 b	2.80 a	3.36 a	------	------
LSD 0.05	Season1→ F1=0.18 F2=0.25 F1*F2=0.51									
	Season2→ F1=0.16 F2=0.22 F1*F2=0.45									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Decay (%)

The occurrence of post-harvest diseases and quick ripening are the causes of Zaghloul date palm fruits decay. The results as shown in Table (2), through the two following seasons the decay incidence was not observed up to the 6th week of cold storage in T5 (JO5% + AG10%), which produced fruits free from decay and showed zero decay percentage. The decay incidence in Zaghloul date fruits treated with (JO 5% + AG10%) was significantly lower than other treated fruit samples included untreated fruits samples (control) up to the end of the investigation. The highest decay % was registered in the control which recorded (13.32 & 15.67 %) in both seasons, respectively. It has been described that edible coating has the capacity to minimizing the germination of fungi spores in extensive horticultural produces (Tripathi and Dubey, 2004). The

purpose of edible coating showed inhibitory effect on pectinase and cellulose enzymes and in delay ripening, which makes the products more exposed to infection by pathogenic as a consequence of the loss of cellular or tissue safety (Tanada-Palmu and Grosso, 2005). In this investigation , Jojoba oil and Arabic gum coatings can create a layer on the Zaghloul date palm fruit surfaces, and this layer functions as a barrier, to preserve the fruits from pathogen infection, which decreased decay during the cold storage. Whatever, the results are in good agreement with those of Khaliq *et al.* (2015), Saleh *et al.*(2019) and Abu-Shama *et al.*(2020) .

Table 2. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on decay percentage of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	0.00 i	0.00 h	8.14 c	10.26c	10.26b	12.26 b	13.32a	15.67a	7.93 a	9.54 a
JO	0.00 i	0.00 h	0.00 i	0.00 h	0.23 hi	0.25 h	0.25 hi	0.28 h	0.12 de	0.13 d
AG	0.00 i	0.00 h	0.19 hi	0.21 h	0.26 hi	0.28 h	0.31 hi	0.33 h	0.19 d	0.20 d
PA	0.00 i	0.00 h	1.24 g	1.30 g	2.36 e	2.82 e	3.25 d	3.90 d	1.71 b	2.00 b
JO+AG	0.00 i	0.00 h	0.00 i	0.00 h	0.00 i	0.00 h	0.00 i	0.00 h	0.00 e	0.00 d
JO+PA	0.00 i	0.00 h	0.17 hi	0.19 h	0.25 hi	0.53 h	2.06 f	2.14 f	0.62 c	0.71 c
AG+ PA	0.00 i	0.00 h	0.18 hi	0.20 h	0.38 h	0.46 h	2.37 e	2.51 ef	0.73 c	0.79 c
JO+AG+PA	0.00 i	0.00 h	0.00 i	0.00 h	0.12 hi	0.13 h	0.15 hi	0.16 h	0.06 de	0.07 d
Mean F1	0.00d	0.00 d	1.24 c	1.52 c	1.73 b	2.09 b	2.71 a	3.12 a	------	------
LSD 0.05			Season1→ F1=0.10		F2=0.14		F1*F2=0.28			
			Season2→ F1=0.17		F2=0.24		F1*F2=0.49			

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Firmness (Lb/inch^2)

Results listed in Table (3) showed that the firmness of Zaghloul date palm fruits was influenced by applying all edible coating as postharvest operations. The lowest fruit firmness value was recorded on untreated fruit (control). Regarding the impact of cold storage period, the obtained results registered that fruit firmness reduced by the extending the storage duration. Overall, the results achieved that the combination of Jojoba at 5% and Arabic gum at 10% maintained the greatest firmness of the cold stored fruits in both seasons. The height firmness was obtained by JO 5% +AG10% (16.36 & 15.86 Lb/inch^2), followed by fruits were treated with JO 5% +AG10%+PA 7.5 % (16.06 & 15.13 Lb/inch^2) as compared with the control (9.26 & 8.40 Lb/inch^2), consecutively in the two seasons. It is worth mentioning, there were highly significant differences among all tested coating treatments. These results agree with those of Yaman and Bayoındırlı (2002) who found that the maintenance of firmness can be defined by the response of the degradation of protopectins (insoluble form) into more soluble pectinic components. When ripening, polymerization, or shortening of the chain length of pectic substances occurs with an increase in the activities of pectinesterase and polygalacturonase enzymes. The jojoba oil construction is a liquid wax perhaps cause the restriction of moisture loss and the actions of pectin-degrading enzymes, which is precisely related to the softening of fruit by reducing flow of metabolic rules during senescence (Zhou *et al*., 2007) and (El-Nagdi, 2018). Our results are in agreement with the findings by Khaliq *et al*. (2015) and Saleh *et al*. (2019) they reported that edible coating may assist in supporting the firmness and present shine to coated fruits. In the present experiment, the treated fruits with JO at 5% and AG at 10% exhibited greater firmness values than the untreated fruits, and this perhaps due to dense layer of the edible coating, which performed a qualified atmosphere around the fruit surface as an effect diminished changes in pectin materials and action of cell wall enzymatic degradation.

Table 3. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on firmness (Lb/inch^2) of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	18.60 a	17.80 a	16.83 gh	15.50 ij	12.66 n	11.46 n	09.26 o	08.40 o	14.34 e	13.29 f
JO	18.60 a	17.80 a	17.90 bc	16.96 bcd	16.76 h	15.93 gh	15.13 l	14.36 k	17.10 c	16.26 c
AG	18.60 a	17.80 a	18.03 bc	17.00 bcd	17.06 fgh	16.33 ef	15.09 jk	15.36 j	17.40 b	16.62 b
PA	18.60 a	17.80 a	17.36 ef	16.33 ef	16.16 ij	15.33 j	14.53 m	13.43 m	16.66 d	15.72 e
JO+AG	18.60 a	17.80 a	18.23 ab	17.26 b	17.43 de	16.76 cd	16.36 i	15.86 ghi	17.65 a	16.92 a
JO+PA	18.60 a	17.80 a	17.76 cd	16.70 de	16.80 gh	15.50 ij	15.03 l	13.86 l	17.05 c	15.96 d
AG+ PA	18.60 a	17.80 a	18.00 bc	16.83 cd	17.03 fgh	15.80 hi	15.63 jk	14.20 kl	17.31 b	16.15 c
JO+AG+PA	18.60 a	17.80 a	18.03 bc	17.13 bc	17.16 efg	16.23 fg	16.06 ij	15.13 j	17.46 b	16.57 b
Mean F1	18.60 a	17.80 a	17.77 b	16.71 b	16.38 c	15.42 c	14.74 d	13.82 d	------	------
LSD 0.05			Season1→ F1=0.11		F2=0.16		F1*F2=0.33			
			Season2→ F1=0.13		F2=0.19		F1*F2=0.38			

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Total phenols content

Table (4) shows some variations in total phenols content (TPC) in the treated fruits compared to untreated fruits (Control) during 6 weeks of the cold storage. The total phenols content was 39.81mg/100gDW at the start of such investigation. During 6weeks of storage, a gradual decrease in the total phenol content was recognized in all treatments including control until the end of storage period. The highest TPC was determined with combination of JO at 5% and AG at 10% (19.43 and 18.18mg100gdw) followed by fruits treated with JO at 5%+AG at 10%+PA at 7.5% (18.14 and 17.61 mg100gdw) compared to control in the two seasons, respectively. The reduction in TPC could be due to a higher respiratory rate in fruits. The total phenols content is ordinarily lost when phenolic composites break down (Day, 2000). This is also due to the early deterioration and the breakdown of the cell wall due to the duration of storage (Ali *et al.*, 2013). Using a controlled environment can slow the maturation and provide higher phenol levels (Singh and Pal, 2008). In present research, coating combination treatment of Jojoba at 5% + Arabic gum at 10% may be decreased the effects of enzymes that lower phenol content by preventing the flow of oxygen in and out of the fruit. Furthermore, the use of 10% GA on tomatoes has been reported to preserve a higher phenol content in the fruit (Ali *et al*., 2013). The generation of phenol composites was induced in orange fruits which treated with jojoba oil (Hagenmaier, 2000) and in guava when treated with Arabic gum (Murmu and Mishra, 2018). In the end, structure and concentration of phenolic components depend on fruit ripeness, environmental aspects, growing season and post-harvest storage conditions (Massolo *et al*., 2011). .

Table 4. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1°C on total phenol content (mg/100gdw)of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	39.81 a	38.65 a	16.22 hi	14.36 mno	15.33 i	12.10 op	15.10 i	10.72 p	21.61 d	18.96 f
JO	39.81 a	38.65 a	28.10 de	25.64 b-e	24.55 f	19.91 ghi	18.14 gh	15.71 k-n	27.65 bc	24.98 cd
AG	39.81 a	38.65 a	27.45 de	24.78 cde	23.20 f	18.58 hij	17.63 gh	14.39 mno	27.02 c	24.10 de
PA	39.81 a	38.65 a	27.23 e	23.51 ef	22.96 j	17.90 h-l	17.55 gh	13.61 no	26.88 c	23.41 e
JO+AG	39.81 a	38.65 a	35.12 b	28.26 b	24.92 f	24.14 def	19.43 g	18.18 h-k	29.82 a	27.30 a
JO+PA	39.81 a	38.65 a	28.13 de	26.38 bcd	24.92 f	20.64 gh	17.92 gh	16.84 j-m	27.43 bc	25.63 bc
AG+ PA	39.81 a	38.65 a	29.32 cd	25.17 cde	24.31 f	19.31 g-j	18.11 gh	15.22 lmn	27.88 bc	24.58 cde
JO+AG+PA	39.81 a	38.65 a	30.27 c	27.36 bc	24.62 f	21.79 fg	18.14 gh	17.61 i-l	28.21 b	26.53 ab
Mean F1	39.81 a	38.65 a	27.73 b	24.43 b	22.97 c	19.30 c	17.75 d	15.28 d	----------	
LSD 0.05	Season1→ F1=0.64 F2=0.91 F1*F2=1.83									
	Season2→ F1=0.88 F2=1.24 F1*F2=2.49									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Total flavonoids contents

The impact of treatments and the cold duration on total flavonoid content was recorded in both seasons Table (5). Generally, total flavonoids content gradually decreased up to 6th week. The flavonoid content was higher in Zaghloul date fruits coated with the combination of JO at 5% and AG at 10% than control, followed by combination treatment (JO at 5%+AG at 10% +PA at 7.5%). However, all treatments made the most flavonoid content after the 6th week of cold duration compared to control. Different reports registered higher flavonoid content when Arabic gum coating was used on mango (Khaliq *et al.*, 2015). and guava(Murmu and Mishra, 2018).

Table 5. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on total flavonoids content (mg/100gdw) of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	9.97 a	8.37 a	1.83 jk	3.27 e-h	1.65 k	3.09 f-i	1.61 k	1.82 k	3.76 d	4.14 c
JO	9.97 a	8.37 a	7.18 cd	5.28 c	3.55 fg	3.12 e-i	2.65 g-j	2.58 h-k	5.83 bc	4.83 b
AG	9.97 a	8.37 a	6.30 de	4.20 de	3.47 fgh	2.16 ijk	2.43 h-k	1.92 jk	5.54 c	4.16 c
PA	9.97 a	8.37 a	6.01 e	3.79 efg	3.34 f-i	2.09 ijk	2.41 ijk	1.76 k	5.43 c	4.00 c
JO+AG	9.97 a	8.37 a	8.72 b	6.64 b	3.81 f	4.89 cd	2.96 f-i	3.76 efg	6.36 a	5.9 a
JO+PA	9.97 a	8.37 a	7.29 c	5.76 bc	3.60 fg	3.52 e-h	2.69 g-j	2.51 h-k	5.88 abc	5.04 b
AG+ PA	9.97 a	8.37 a	7.87 bc	5.52 c	3.62 fg	3.41 e-h	2.71 g-j	2.72 g-k	6.04 ab	5.00 b
JO+AG+PA	9.97 a	8.37 a	8.12 bc	5.92 bc	3.71 fg	3.86 ef	2.80 f-j	2.93 f-j	6.15 ab	5.27 b
Mean F1	9.97 a	8.37 a	6.66 b	3.27 e-h	3.34 c	3.26 c	2.53 d	2.50 d	------	------
LSD 0.05	Season1→ F1=0.31 F2=0.45 F1*F2=0.90									
	Season2→ F1=0.33 F2=0.47 F1*F2=0.94									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Tannins content

Data in Table (6) showed that fruit tannins content reduced significantly with extending storage period in both successive seasons. Treated fruits with combination of JO at 5% + AG at 10% had the most content of tannins compared to all treatments including control. The reduction in the fruit tannin content during ripening and storage may be related to the fact that soluble tannins are converted into

insoluble tannins during ripening, which plays a role in non-enzymatic oxidative browning and thus causes an insoluble leuco-anthocyanin reduction during storage (Zaki *et al*., 2017). The existing results presented evidence that coating Zaghloul date fruits with jojoba 5% + Arabic gum 10% prevent decay and maintain fruit quality.

Table 6. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on tannins contents (mg/100gdw) of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	18.25 a	17.36 a	4.93 kl	3.84 m	4.78 l	3.52 m	4.55 l	2.92 m	8.12 e	6.91 d
JO	18.25 a	17.36 a	11.11c	10.92bc	8.38 fg	8.17 e-i	7.32 f-i	7.54 g-j	11.26 b	10.99 a
AG	18.25 a	17.36 a	9.69 de	7.65 f-j	7.06 ghi	6.32 jkl	6.09 ijk	5.69 l	10.27 c	9.25 c
PA	18.25 a	17.36 a	8.18 fg	8.22 e-h	6.78 hi	5.84 kl	5.07 jkl	5.68 l	9.57 d	9.27 c
JO+AG	18.25 a	17.36 a	12.41b	11.97b	9.70 de	9.12 d-g	8.45 ef	8.36 e-h	12.20 a	11.70 a
JO+PA	18.25 a	17.36 a	9.92 cd	9.42 de	7.21 fgi	7.28 h-k	6.14 h-k	6.32 jkl	10.38 c	10.09 b
AG+ PA	18.25 a	17.36 a	10.31cd	9.22 def	7.46 f-i	7.41 hij	6.33 hij	6.62 i-l	10.58 c	10.15 b
JO+AG+PA	18.25 a	17.36 a	10.46cd	10.17cd	7.52 fgh	8.69d-h	6.39 hij	7.92 e-i	10.65 c	11.03 a
Mean F1	18.25 a	17.36 a	9.62 b	8.92 b	7.36 c	7.04 c	6.29 d	6.38 d	------	------
LSD 0.05	Season1→ F1=0.42 F2=0.59 F1*F2=1.19									
	Season2→ F1=0.48 F2=0.68 F1*F2=1.36									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Total sugars (g/100g fw)

The data in Table (7) revealed that the content of total sugars of Zaghloul date palm fruits recorded a high increase gradually as a consequence of all established coating treatments. Nevertheless, the most minimum amounts of total sugars content were obtained by applying the treatments of JO at 5% +AG at 10% in two investigated seasons. Nevertheless, control fruit recorded the most higher values of total sugars content. Concerning the interaction influence between the investigated coating treatments and storage duration, results indicate that treatment of Jojoba 5% + Arabic gum at10% under cold storage for 6 weeks maintained the total sugars not increasing of Zaghloul date fruits. Jojoba oil and Arabic gum and other combined treatments are a benefit to maintaining fruits throughout cold storage. The achieved results of Jojoba oil and Arabic gum in maintaining chemical fruit quality of Zaghloul date fruits are consistent with Baiea and El-Badawy (2013) and El-Sharony and Amin (2015).

Table 7. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on total sugar (g/100g fw)of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	15.20 n	16.40 j	17.53 gh	18.40 efg	19.53 b	20.33 c	21.60 a	22.16 a	18.46 a	19.32 a
JO	15.20 n	16.40 j	16.23 lm	17.40 hi	17.26 hi	18.66 e	18.40 de	19.83 cd	16.77 b	18.07 c
AG	15.20 n	16.40 j	16.86 ijk	17.96 fgh	17.86 fg	18.90 e	18.80 cd	20.36 c	17.18 c	18.40 c
PA	15.20 n	16.40 j	17.40 gh	18.53 ef	18.20 ef	19.66 ef	19.26 bc	21.00 b	17.51 d	18.90 b
JO+AG	15.20 n	16.40 j	15.93 m	17.00 ij	16.73 jkl	17.86 gh	17.13 hij	18.73 e	16.25 e	17.50 d
JO+PA	15.20 n	16.40 j	16.36 klm	.1770 h	17.26 hi	18.90 e	18.80 cd	19.63 d	16.90 d	18.15 c
AG+ PA	15.20 n	16.40 j	16.36 klm	18.00 fgh	17.36 hi	18.93 e	18.40 de	20.03 cd	16.83 d	18.34 c
JO+AG+PA	15.20 n	16.40 j	16.53 kl	17.70 h	17.13 hij	18.73 e	18.36 de	19.70 d	16.80 d	18.13 c
Mean F1	15.20 d	16.40d	16.65c	17.83 c	17.67 b	19.00 b	18.84 a	20.18 a	------	------
LSD 0.05	Season1→ F1=0.16 F2=0.22 F1*F2=0.45									
	Season2→ F1=0.19 F2=0.26 F1*F2=0.53									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Antioxidant activity (%)

The variations in antioxidant capacity presented in Table (8) gave the same trend noticed in the phenols and flavonoids content. The antioxidant capacity decreased gradually in Zaghloul date fruits until 6 weeks of storage. The fruits treated with combination of JO at 5% and AG at 10% at the end of period cold storage recorded the higher amount of antioxidant activity (68.65 % and 67.18%), compared to control (49.00% and 44.42 %) in the both investigated seasons, respectively. Such result may be attributed to a higher amount of total phenol content. Chaple *et al*. (2017) reported that, the rise in phenol content can keep an extensive variety of biochemical actions. These composites are related to subordinate metabolites, intercept Reactive Oxygen Species (ROS) and increasing antioxidant activity. It is well known that increases in total phenol levels are consistent with increases in antioxidant activity (Reyes and Cisneros-Zevallos, 2003). In the presented investigation, there was higher activity of antioxidants in the fruits, as the coating with Jojoba 5%+Arabic gum10% delays ripening. A higher amount of phenol and flavonoid levels caused an increase in antioxidant capacity. The results agree with Khaliq *et al*. (2015), Ahlawat *et al*.(2018) Murmu and Mishra (2018) and Etemadipoor *et al*. (2020) .

Table 8. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on antioxidant activity (%) of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	90.26 a	88.37 a	62.57 j	59.14 i	52.57 k	48.22 j	49.00 l	44.42 j	63.60 e	60.04 e
JO	90.26 a	88.37 a	82.27 c	80.00 bc	69.56 e	67.41 f	65.11 hi	63.27 f-i	76.80 b	74.76 b
AG	90.26 a	88.37 a	73.51 d	72.53 de	67.72 efg	65.84 fg	64.63 hij	62.13 ghi	74.03 c	72.22 cd
PA	90.26 a	88.37 a	73.09 d	72.37 de	65.74 ghi	63.56 f-i	62.64 j	59.78 hi	72.93 d	71.02 d
JO+AG	90.26 a	88.37 a	87.07 b	82.22 b	74.59 d	75.43 cd	68.65 ef	67.18 fg	80.14 a	78.30 a
JO+PA	90.26 a	88.37 a	83.12 c	76.61 cd	69.43 e	67.00 fg	64.12 ij	64.77 fgh	76.73 b	74.18 bc
AG+ PA	90.26 a	88.37 a	74.42 d	75.47 cd	68.32 ef	66.98 fg	64.12 ij	63.18 f-i	74.28 c	73.50 bc
JO+AG+PA	90.26 a	88.37 a	84.23 c	78.13 bc	69.59 e	67.94 ef	66.6f gh	64.89 fg	77.67 b	74.83 b
Mean F1	90.26 a	88.37 a	77.53 b	74.56 b	67.19 c	65.29 c	63.11d	61.20 d	------	------
LSD 0.05	Season1→ F1=0.75 F2=1.07 F1*F2=2.14									
	Season2→ F1=1.56 F2=2.21 F1*F2=4.42									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

Ion leakage (IL%)

A gradual increase in the ion leakage of treated samples including untreated samples (control) was observed in Table (9). Zaghloul date fruits coated with combination of JO at 5% and AG at 10% significantly prevented the rise in IL%. End of the cold storage, the greatest IL content (78.12 % and 81.13%) was observed in the control in both seasons, respectively. However, the Zaghloul date fruits coated with combination of JO at 5% and AG at 10% presented the minimum level of IL% (35.43% and 37.10). Ion leakage is frequently viewed as an indirect determination of the destruction of the fruit cell membrane. The lower temperature is the primary reason for generalizing oxidative destruction due to the high rate of generation of reactive oxygen species during periods of stress in fruit samples. Chilling causes a type of stress that alters the rate of unsaturated fat to saturated ones. This happens when the cell membrane changes from a flexible crystal-liquid building to a solid gel formation (Antunes and Sfakiotakis, 2008) .The results can be verified by the previous examination on the treatment of AG to guava Etemadipoor *et al.* (2020), which reported the decrease in IL and the possible maintenance of the cell membrane at low-temperature levels.

Table 9. Interaction effect of some edible coatings treatments and duration of cold storage at 0 ± 1 °C on ion leakage (IL%) of Zaghloul date fruits in 2018 and 2019 seasons.

Treatments (F2)	Cold storage duration in weeks (F1)									
	Zero time		2nd week		4th week		6th week		Mean F2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Control	25.62 o	27.33 m	38.90 gh	40.29 e	51.22 b	53.62 b	78.12 a	81.13 a	48.46 a	60.04 e
JO	25.62 o	27.33 m	29.12 lm	30.25 ijk	38.62 h	39.17 ef	46.52 e	48.26 cd	34.97 d	74.76 b
AG	25.62 o	27.33 m	29.86 l	30.85 ij	38.90 gh	39.82 e	47.09 de	48.81 ghi	35.36 cd	72.22 cd
PA	25.62 o	27.33 m	30.24 l	31.14 de	40.27 g	40.26 e	48.13 cd	49.17 c	36.06 b	71.02 d
JO+AG	25.62 o	27.33 m	27.13 no	28.54 lm	32.27 k	33.12 h	35.43 j	37.10 g	30.11 g	78.30 a
JO+PA	25.62 o	27.33 m	28.92 lm	29.46 jkl	37.06 i	40.06 fg	42.14 f	46.79 d	33.43 e	74.18 bc
AG+ PA	25.62 o	27.33 m	29.49 lm	29.94 i-l	39.12 gh	40.31 e	48.93 c	48.19 cd	35.79 c	73.50 bc
JO+AG+PA	25.62 o	27.33 m	28.31 mn	29.07 kl	36.73 i	38.12 fg	40.32 g	47.07 d	32.74 f	74.83 b
Mean F1	25.62 d	27.33 m	30.24 c	31.19 c	39.27 b	40.56 b	48.33 a	50.81 a	------	------
LSD 0.05	Season1→ F1=0.45 F2=0.64 F1*F2=1.29									
	Season2→ F1=0.50 F2=0.71 F1*F2=1.43									

Data are expressed as mean of three replicates. Similar letters indicate non-significant difference at 5 % level of probability using Duncan's Multiple Range Test. Control = Tap water, JO= Jojoba oil, AG= Arabic gum and PA= Paraffin oil.

CONCLUSION

Applying the natural edible coating included combination of Jojoba oil 5% + Arabic gum 10% on Zaghloul date fruits had a useful influence on the character of the fruits throughout cold storage. The examined fruits showed limited water loss along with the most level of firmness contrasted to the control application. The coated fruits also showed greater levels of bioactive components such as phenols, flavonoids, and antioxidant capacity, as well as a minimum level of IL% compared to the untreated fruits. In coated fruits, ripening was also delayed, which may be due to lesser physiological changes. It can be stated that Jojoba oil 5% + Arabic gum 10% mixture as a coating can basically preserve the quality of Zaghloul date fruits .

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فعالية بعض الأغلفة الصالحة للأكل على القدرة التخزينية لثمار نخيل البلح صنف الزغلول

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أجريت هذه التجربة خلال موسمين متتاليين (2018 و 2019) على ثمار نخيل البلح صنف الزغلول وتم الحصول عليها من اشجار تبلغ من العمر 15 عامًا ، تنمو في مزرعة خاصه بمحافظة الدقهلية و تم جمع الثمار في مرحلة اكتمال التلوين (الخلال). والغرض من هذة الدراسة هو اطالة فترة التخرين وزيادة القدرة التخزينية لثمار البلح صنف الزغلول تحت ظروف التخزين البارد بأستخدام المواد الطبيعية مثل زيت الجوجوبا بتركيز 5% ، الصمغ العربيى بتركيز 10% وزيت البرافين بتركيز 7.5 % وتم استخدامها منفردة او فى صورة مركبة حيث تم تخزين الثمار على درجة حرارة °1C±0 ورطوبة نسبية 85-90 % لمدة 6 اسابيع وقد تم أخذ العينات كل 15 يوم لدراسة تأثير المواد الطبيعية على تغيرات الصفات الفيزيقية والكيميائية التى تطرأ على الثمار خلال فترة التخرين البارد ومن خلال الدراسة تبين ان كل المعاملات سواء الفردية أو المختلطة كان لها تأثيرات ايجابية على الثمار وساهمت فى اطالة الفترة التخزينية ورفع القدرة التخزينية للثمار حيث كانت المعاملة رقم 5 وهى الخليط بين الصمغ العربى وزيت الجوجوبا هى الأكثر معنوية حيث كان لها تأثير فعال فى الحفاظ على الصلابة وتقليل التالف وتقليل الفقد فى الوزن مع الحفاظ على مستوى المواد الفينولية والفلافونية والمواد التانينية لما كان لها عظيم الاثر فى الحفاظ على مستوى مضادات الأكسدة وبالتالى تقليل التسرب الأيونى . كما كان لها تأثير فعال فى عدم زيادة مستوى السكريات الكلية . وفقا لهذة النتائج يمكن الأشارة الى ان استخدام خليط زيت الجوجوبا بتركيز 5% والصمغ العربى بتركيز 10 % يكون لها تأثير فعال على اطالة الفترة التخزينة والحفاظ على صفات الجودة الثمرية لمدة 6 أسابيع تحت ظروف التخزين البارد.