Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 04 | Issue : 03 | July-Sept. | 2015
Pages: 602-612

Effect of some Natural Coating Materials on Storability and Fruit Quality of Zaghloul Date Palm cv. under Cold Storage

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ABSTRACT

This experiment was carried out during two successive 2013 & 2014 seasons in the post-harvest laboratory of Agricultural Development System (ADS) project in Faculty of Agric. Cairo University, Giza Governorate, Egypt to investigate the efficiency of using some natural substances i.e., gelatin at 1,2,4 %; lemongrass oil at 0.25, 0.5 % and peppermint oil at 5 and,10%, beside untreated fruits as control on storability of Zaghloul date palm fruits and their quality under cold storage (0.0 °C ± 2 and 90 – 95 % R.H.). It was quite evident that two conflicted trends were detected with the advancement of storage duration during both seasons. Hence, percentage of (fruit weight loss, decay, fruit juice total soluble solids and total sugars were increased, however flesh firmness, titratable acidity % and tannins contents were relatively reduced. Moreover, the response of different Zaghloul fruits measurements to various investigated dipping treatments varied not only from one treatment to other from one hand, but also each characteristics reflected its own trend from the other side. So, it could be generally concluded that all dipping treatments significantly decreased percentage of both fruit weight loss and decay below control (water dipping), whereas 0.50 % lemongrass oil treatment was the superior, while 1 % gelatin ranked last. On the other hand, fruit juice total acidity was slightly responded by different treatments and difference was more pronounced particularly with both 0.25 and 0.50 % lemongrass oil during two seasons. In addition, fruit flesh firmness, fruit juice total sugars and tannins content did not significantly respond to various treatments. Meanwhile, fruit juice total soluble solids% of Zaghloul date palm fruits showed different considerable influence to most investigated treatments in both seasons of study.

Key words: Date palm, postharvest, natural substances, gelatin, lemongrass, peppermint, physical and chemical properties

Introduction

Date palm (*Pheonix dactifera,* L.) belongs to Palmaceae family, possibly the oldest cultivated plant. Fruits of date palm are very commonly consumed in many parts of the world and are a vital component of the diet and a staple food (Vayalil, 2002). Arab countries are the main source of date palm in the world (Mohamed, 1982). The world production of dates according to the recent statistics is about 7533887 metric tons. The Arab countries produce about 5727088 metric tons, which represents about 76% of the total international production. Egypt ranked the first among the date's producers in the Arab countries where it produces about 1352950 metric tons, representing about 18% of the world production of dates (FAOSTAT, 2010). Zaghloul date palm is one of the most important soft cultivar planted in Egypt.

Several studies show that edible films and coatings can be used to help in fruits and vegetables preservation because they provide a partial barrier to moisture loss, O_2 and CO_2 permeability, (Olivas & Barbosa-Ca novas, 2005).

Gelatin is an important functional biopolymer widely used in foods to improve elasticity, consistency, and stability) Mariod and Adam, 2013**)**.

Essential oils are made up of many different volatile compounds and the composition of the oil quite often varies between species (Mishra and Dubey, 1994). It is difficult to associate the antifungal activity to single compounds or classes of compounds. It seems that the antifungal and antimicrobial effects are the result of many compounds acting synergistically (Bagamboula *et al.,* 2004). Thus, there would be negligible chance of development of resistant races of fungi after application of essential oils to fruits and vegetables. As a consequence essential oils are one of the most promising candidate groups of natural compounds for the development of safer antifungal agents. The role of essential oil has been discussed in terms of antibiotic activity, allelopathy, attractants, feeding deterrents and phytoalexin. Many researches point out that essential oil from different herbal plants demonstrates antifungal activity against a wide range of postharvest pathogen

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(Wilson *et al.,* 1987; Dube *et al*., 1989; Deans, 1991; Jobling, 2001; Duamkhanmanee, 2008; Mahanta *et al.,* 2007). Lemongrass (*Cymbopogon citratus* L.) is an aromatic herb and mainly grown as an medicinal plant. Its leaves and stem are used to extract oil by the hydro-distillation method that produces a yellow color oil contains the following compounds: (1) Geranial (41.67 %) 'Citral A'. (2) Neral (40.33%) 'Citral B'. (3) Myrcene (9.99%). (4) Borneol (1.62%). (5) Methyl-2, 4-decadienoate (1.28%). (6) Geranyl acetate (0.95%) (Masamba *et al*., 2003). It is known that oil of lemongrass is one of the most important essential oil-bearing herbaceous species of the *Gramineae* because of its high citral content (up to at least 75% of the oil) (Jayasinha, 1999). Furthermore, lemongrass contains terpenes, alcohols, ketones, aldehyde, esters and flavonoids (luteolin, isoorientin 2-Orhamnoside, quercetin, kaempferol and apiginin (Shah *et al*., 2011). Recently, bioactive studies have shown that the various components of this essential oil contain antimicrobial, antifungal, antibacterial and mosquito repellent properties (Schaneberg and Khan, 2002).

Peppermint oil is obtained from the leaves of the perennial herb, *Mentha piperita,* L. and *M. arvensis var. piperascens* a member of the Labiatae family. This family includes many well-known essential oil plants such as spearmint, basil, lavender, rosemary, sage, marjoram and thyme. However, few numbers of researches till date have been conducted on using gelatin and essential oil as an edible coating material for fresh fruits and vegetables.

The main purpose of this study aimed to find out an alternative safer ways for protecting and eradicating the post-harvest diseases in order to prolonging storability of Zaghloul dates and maintaining their well quality that consequently could be replaced the chemicals used in this concern and their harmful side effects to both human health and environment. Thus, this study was planned to evaluate the potential use of some selected edible coating substances namely: gelatin, lemongrass oil and peppermint oil as antifungal, antibacterial and antimicrobial agents for extending the storability of Zaghloul date palm fruits and maintaining their quality under cold storage.

Materials and Methods

This study was conducted to evaluate the response of cold stored mature fruits of Zaghloul date palm cv. to emulsifying with some naturally extracted substances during two successive seasons of 2012 and 2013. Mature fruits of Zaghloul date palm trees (*Pheonix dactifera,* L.) grown in the Experimental Station at the Faculty of Agriculture, Cairo University, Giza Governorate, Egypt were collected at full colored (Khalal stage), then directly transferred to the laboratory of the Agriculture Development Systems (ADS) project at the same Faculty. Defective fruits including wounded and showed other disorders were excluded, while remained ones were washed with tap water and air dried. Sound fruits were carefully selected as being undamaged, free from any apparent pathogen infection and uniformed as possible in their shape, weight and color.

After the required fruits had been selected, washed and air dried, they were divided into eight similar divisions, fruits of each section were placed in a plastic basket and devoted to be subjected to one of the following dipping treatments**:**

1- Control (tap water).
2- Gelatin at 1.0 % (w/v).
3- Gelatin at 2.0 % (w/v).
4- Gelatin at 4.0 % (w/v).
5- Lemongrass oil (L.G.) at 0.25%.
6- Lemongrass oil (L.G.) at 0.50%.
7- Peppermint oil at 5%.
8- Peppermint oil at 10%.

Experimental layout:

Fruits of each eight divisions were dipped (immersed) for five seconds in the corresponding emulsion solution devoted for each of the abovementioned eight treatments. Treated fruits were left to dry aerobically, then fruits of each treatment were subdivided into two sections (A&B). Section (A) devoted for estimating the periodical changes in some fruit physical characteristics (percentage of fresh weight loss & decay), while other section (B) for determining the changes in other investigated fruit characteristics i.e, destroyed measurements (fruit firmness, fruit juice contents of total soluble solids, total sugars, total acidity and tannins) throughout cold storage.

The complete randomized design with three replications was employed for arranging the differential eight postharvest dipping treatments investigated on fruits of each sections devoted for either (A) or (B) purpose. Every replicate was represented by one perforated carton box contained 1.5 Kg Zaghloul date palm fruits. Cold storage at 0.0 ºC ± 2 and relative humidity (RH) of 90-95%, was extended during each season till the decay % reached 50%, then it was terminated.

The responses to the differential investigated postharvest dipping treatments were evaluated periodically (at 15 days interval) by determining the changes exhibited in the following measurements of Zaghloul date palm fruits.

Gelatin was obtained as a commercial grade, and then dipping solution was prepared at the concentration of 1, 2 and 4% (w/v) using distilled water. The essential oil of lemongrass (*Cymbopogon citratus* Stapf) extracted by steam distillation and emulsified in water at 0.25 and 0.5 % as described by Shaarawi *et al*. (2013).

Peppermint oil is obtained from the leaves of the perennial herb, *Mentha piperita* L. The solution may show an opalescence. Peppermint oil is extracted from the whole above ground system just before flowering. The oil is extracted by steam distillation from the fresh or partly dried plant and the yield is 0.1 – 1.0%, respectively. Shrivastava Alankar, (2009).

Measurements:

I- Fruit physical properties:

1-Weight Loss (%): Fruits were periodically weighted and the loss in mass weight was recorded for each replicate as percentage of the initial weight after the following formula.

$$\text{Fruit weight loss \%} = \frac{\text{Initial weight} - \text{Weight at specific interval}}{\text{Initial weight}} \times 100$$

2-Decay Percentage (%): Evaluated by skin appearance, shriveling, chilling injury, and pathogenic rots. In every inspection, decayed fruits per each replicate were weighted and discarded, then decay percentage was estimated and recorded according to the following formula:

$$\text{Decay Percentage (\%)} = \frac{\text{Weight of discard fruits}}{\text{Initial weight}} \times 100$$

3-Fruit Firmness (Lb\inch): Fruit firmness was determined as Lb/inch by using fruit pressure tester mod. FT 327 (3-27 Lbs).

II-Fruit chemical properties:

1-Total soluble solids percentage (TSS %): Determined in date palm fruit juice using a hand refractometer.
2-Total sugars (g/100 g "fresh weight"): Determined in stored date fruits by method described by Smith *et al.* (1956).
3-Total acidity (TA): Estimated as g malic acid /100 ml juice according to A.O.A.C., (1995).
4-Fruit tannins content: Total tannins of Zaghloul date fruits were determined according to A.O.A.C., (1995).

Statistical Analysis:

All data obtained during both seasons were subjected to analysis of variance according to Snedecor and Cochran (1989). Means of different treatments were compared using L.S.D. test at 5% level.

Results and Discussion

1. Effect of some postharvest treatments on fruit physical properties of Zaghloul date palm.

1.1. Fruit weight loss percentage

Firstly, it is important to notice that storage life of cold stored Zaghloul date palm fruits (0.0°C±2) extended up to sixty days in both seasons. Table (1) declares that fruit weight loss percentage of Zaghloul date palm increased as the storage period was prolonged in both seasons. Hence fifteen days cold stored fruits scored the lowest fruit weight loss percentages, however after sixty days the highest percentage of weight loss was recorded. The differences in fresh weight loss % of cold stored Zaghloul date palm fruits due to the specific effect of prolonging storage duration were pronounced and reached significance as compared each other during two seasons of study.

Referring the specific effect of investigated postharvest dipping treatments**,** Table (1) shows that all studied treatments significantly decreased the fresh fruit weight loss % as compared to control, however (0.5%) lemongrass oil tended to be the most effective one in this concern. Such trend was true during both seasons as compared to either control or other postharvest dipping treatments with few exceptions particularly with comparison to the lower lemongrass oil (0.25%) and 10% peppermint during 1st and both seasons respectively. Moreover, other fruit dipping treatments were in between the aforesaid two extremes with a relative tendency showed that dipping in gelatin particularly at either 1.0 or 2.0% were the least effective as compared to the other intermediate treatments during both seasons of study.

Concerning to interaction effect between storage periods and tested postharvest treatments, data in the same Table illustrate that the interactions of fifteen days cold storage period induced the lowest fruit weight loss

percentages, especially 0.5 lemongrass oil and tap water-treated fruits in the first season and 0.5 lemongrass and 1000 peppermint oil treated fruits in the second season. On the other hand the highest fruit weight loss percentages were recorded by the interactions of sixty cold storage period, particularly control fruits. The remained interactions of the tested storage periods came in-between.

Table 1: Effect of gelatin, lemongrass oil and peppermint oil on weight loss (%) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	0.00	1.30	3.37	4.21	5.68	3.64 A
Gelatin 1%	0.00	2.17	3.17	3.50	4.86	3.43 AB
Gelatin 2%	0.00	1.90	2.63	3.45	4.41	3.10 BC
Gelatin 4%	0.00	1.63	2.33	3.07	4.21	2.81 CDE
L. G. 0.25 %	0.00	1.50	2.07	2.74	4.07	2.60 EF
L. G. 0.50 %	0.00	1.23	1.92	2.60	3.69	2.36 F
Peppermint oil 5%	0.00	1.60	2.67	3.40	4.33	3.00 CD
Peppermint oil 10%	0.00	1.50	2.20	3.08	3.92	2.68 DEF
Mean	0.00	1.60 D	2.55 C	3.26 B	4.40 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.7299						
	Second season					
Control (tap water)	0.00	1.80	2.71	3.48	4.49	3.12 A
Gelatin 1%	0.00	1.40	2.71	3.20	4.05	2.84 B
Gelatin 2%	0.00	1.18	2.52	3.03	3.94	2.67 BC
Gelatin 4%	0.00	1.08	2.02	2.69	3.27	2.27 DE
L. G. 0.25 %	0.00	1.13	1.93	2.86	3.54	2.37 DE
L. G. 0.50 %	0.00	0.97	1.70	2.36	3.00	2.01 F
Peppermint oil 5%	0.00	1.13	2.24	2.90	3.66	2.48 CD
Peppermint oil 10%	0.00	1.04	1.95	2.52	3.27	2.20 EF
Mean	0.00	1.22 D	2.22 C	2.88 B	3.65 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.4896						

Regarding the interaction effect of two studied factors (post-harvest dipping treatments and duration of cold storage), it is quite evident that both investigated factors reflected their own specific effect on the weight loss %. Hence, different combinations after 15 days under cold storage showed significantly the least fresh weight loss % in Zaghloul dates during both seasons as compared to those of later dates from one hand. On the other side, differences between combinations of the earliest sampling date (after 15 days) in most cases were not significant and did not follow a firm trend in this respect. Whereas the least loss % was in concomitant to tap water and 0.50 % L.G. during 1st and both seasons respectively. Moreover, the trend of response took the other way around as the storage duration was prolonged, whereas differences became more pronounced and in most cases reached level of significance with comparison between combinations after 30,45 and 60 days, regardless of investigated dipping treatments. Anyhow, three combinations 0.50% L.G. followed by those of 0.25 % L.G. and/or peppermint oil at 10% showed statistically the least fruit loss% as compared separately to those of other investigated treatments at each of the three later sampling dates.

The weight loss is attributed to the loss of water during metabolic processes like respiration and transpiration. In addition, moisture loss and gaseous exchange from the fruits is usually controlled by the epidermal layers provided with guard cells and stomata. Thus, the coating reduces this action because it forms a film on the top of the skin acting as an additional barrier to moisture loss. These barrier properties also reduce the oxygen uptake by the fruit which in turn slowed down the rate of respiration and associated weight loss from the fruit surface (Abbasi *et al*., 2011 and Togrul and Arslan, 2004). The aforementioned results go on line with those obtained by Attia (1995) and Baiea and EL-Badawy (2013) on orange, Manzano *et al.,* (1997), Carrillo *et al.,* (2000), Jitareerat *et al.,* (2007) and Shaarawi *et al.,* (2013) on mango, Jiang and Li (2000) on longan fruit, Rojas-Graü *et al*., (2007) and Tzortzakis and Economakis (2007) on apple.

1.2. Fruit decay percentage

Table (2) shows that there was a steadily increment in decay percentage with prolonging the storage period in both seasons. Thereupon, cold storage for sixty days at 0.0°C ±2 reduced the storability of Zaghloul date palm fruits, hence it registered the highest fruit decay percentages when compared with the corresponding ones of fifteen days cold storage. The rest storage periods came in-between in this concern in both seasons. The differences between the evaluated storage periods were so high to be significant.

With regard to specific effect of tested postharvest treatments**,** Table (2) indicates that 0.5% lemongrass oil fruits statistically recorded the lowest fruit decay percentages, followed by 10% peppermint oil treatment in both seasons. Moreover, 4% gelatin and 0.25% lemongrass oil treated fruits in the first season and 5% peppermint oil and 4% gelatin-treated fruits in the second one exerted similar and lower fruit decay percentages.

On reverse, the highest fruit decay percentages were coupled with tap water dipped fruits "control" followed by 1% gelatin-treated fruits in both seasons. Discussing interaction effect between storage periods and tested postharvest treatments**,** it is clear from Table (2) that the interactions of fifteen days storage period scored the lowest fruit decay percentages in comparison with the corresponding ones of thirty days, forty five days, and sixty days cold storage periods in an ascending order. So, all interactions of fifteen days storage duration produced the lowest fruit decay percentages, particularly 0.5% lemongrass oil. On the contrary, all interactions of sixty days storage duration, particularly untreated fruits "control" in both seasons scored statistically the highest fruit decay percentage. The remained interactions gave in-between values in this respect.

The obtained results go on line with those of Attia (1995) and EL-Badawy *et al.* (2012) on orange, Manzano *et al.* (1997), Pal (1998), Carrillo *et al.* (2000), Jitareerat *et al.* (2007), Shaarawi *et al.,* (2013) on mango, Mpho *et al*.(2013) on avocado, Jiang and Li (2000) on longan fruit, Togrul and Arslan (2004) on peach and Tzortzakis and Economakis (2007) on apple.

Table 2: Effect of gelatin, lemongrass oil and peppermint oil on decay (%) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	0.00	2.73	13.10	33.62	51.70	25.29 A
Gelatin 1%	0.00	2.52	12.20	31.20	47.13	23.26 B
Gelatin 2%	0.00	2.50	11.36	26.15	45.42	21.36 C
Gelatin 4%	0.00	2.13	11.00	25.10	40.30	19.63 D
L. G. 0.25 %	0.00	1.37	8.70	24.17	41.19	18.86 D
L. G. 0.50 %	0.00	1.30	7.65	21.90	37.53	17.10 E
Peppermint oil 5%	0.00	1.96	10.05	26.30	42.31	20.16 CD
Peppermint oil 10%	0.00	1.70	9.36	25.76	38.20	18.75 D
Mean	0.00	2.03 D	10.43 C	26.77 B	42.97 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 3.184						
	Second season					
Control (tap water)	0.00	2.65	11.72	34.19	50.71	24.82 A
Gelatin 1%	0.00	2.53	10.30	30.12	45.75	22.18 B
Gelatin 2%	0.00	2.12	10.20	27.15	40.32	19.95 BC
Gelatin 4%	0.00	1.86	9.15	26.76	38.63	19.10 CD
L. G. 0.25 %	0.00	2.17	9.30	28.07	40.70	20.06 BC
L. G. 0.50 %	0.00	1.56	7.92	23.74	35.20	17.10 D
Peppermint oil 5%	0.00	2.30	9.62	25.01	39.07	19.00 CD
Peppermint oil 10%	0.00	2.07	8.14	24.30	37.72	18.06 CD
Mean	0.00	2.16 D	9.54 C	27.42 B	41.01 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 4.480						

1.3. Fruit firmness (Lb/inch^2)

Data in Table (3) reveal that prolonging the storage period, increased generally softness of Zaghloul date palm fruits. The longer the storage period (60 days), the more was the softness of date palm fruits against for freshly harvested Zaghloul fruits in both seasons. The differences between storage periods on decreasing fruit firmness were pronounced and reach level of significance in most cases in both seasons.

With respect to specific effect of tested postharvest treatments, it is so clear to be noticed that response of fruit firmness to the different investigated postharvest dipping treatments was statistically absent and could be safely neglected.

Interaction effect**:** Table (3) shows that differences between various combinations (storage duration × postharvest treatments) were so little and in most cases did not significantly differ except with compared those of control treated fruits after 60 days storage with most of those of two earlier sampling dates (after 15 and 30 days) regardless of postharvest treatments. Such trend for the interaction effect of two studied factors (storage period × dipping treatments) was true during both seasons, and it could be explained on the lease of the difference in rate of response to both investigated factors which was relatively higher with storage duration and too slight to be noticed with postharvest dipping treatments.

The gained results are in conformity with those obtained by Attia (1995) on orange, Manzano *et al.* (1997), Carrillo *et al.* (2000) Jitareerat *et al.* (2007), Abbasi *et al.* (2011) and Shaarawi *et al.* (2013) on mango, Togrul and Arslan (2004) on peach, Tzortzakis and Economakis (2007) and Raybaudi-massilia *et al.* (2008) on apple.

Table 3: Effect of gelatin, lemongrass oil and peppermint oil on fruit firmness (Lb/inch^2) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	15.72	15.59	15.45	15.36	15.05	15.41 A
Gelatin 1%	15.72	15.59	15.57	15.45	15.21	15.50 A
Gelatin 2%	15.72	15.59	15.57	15.45	15.32	15.53 A
Gelatin 4%	15.72	15.68	15.59	15.48	15.39	15.57 A
L. G. 0.25 %	15.72	15.66	15.57	15.50	15.48	15.58 A
L. G. 0.50 %	15.72	15.68	15.63	15.57	15.54	15.63 A
Peppermint oil 5%	15.72	15.63	15.57	15.54	15.39	15.57 A
Peppermint oil 10%	15.72	15.63	15.57	15.54	15.48	15.57 A
Mean	15.72 A	15.64 A	15.57 AB	15.48 AB	15.34 B	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.715						
	Second season					
Control (tap water)	15.61	15.57	15.39	15.39	15.14	15.42 A
Gelatin 1%	15.61	15.57	15.41	15.68	15.30	15.51 A
Gelatin 2%	15.61	15.57	15.45	15.39	15.36	15.48 A
Gelatin 4%	15.61	15.59	15.48	15.41	15.32	15.49 A
L. G. 0.25 %	15.61	15.59	15.50	15.48	15.39	15.51 A
L. G. 0.50 %	15.61	15.59	15.50	15.48	15.41	15.52 A
Peppermint oil 5%	15.61	15.57	15.50	15.45	15.39	15.52 A
Peppermint oil 10%	15.61	15.57	15.57	15.48	15.39	15.53 A
Mean	15.61 A	15.58 A	15.48 AB	15.47 AB	15.34 B	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.408						

2. Effect of post harvest treatments on fruit chemical properties

2.1. Total soluble solid percentage (TSS %)

Table (4) demonstrates that prolonging cold storage period resulted in increasing fruit juice total soluble solids percentage of Zaghloul date palm cv. In this concern, the initial time before cold storage at 0.0°C ± 2 scored the lowest fruit juice total soluble solids percentage, whereas prolonging cold storage period up to sixty days registered the highest values in both seasons. The differences between the studied storage periods were so high to be significant. With regard to the specific effect of post-harvest treatments, Table (4) shows that the differences in most cases were pronounced during two seasons. However, it could be generally observed that peppermint oil treated fruits at either 5 or 10%, control (tap water dipping) and gelatin treated fruits (especially at 1.0 %) were statistically the richest in their TSS content as compared to those of other investigated treatments during two seasons from one hand and did not significantly differ with comparing each other from the other side. On the contrary, 0.50 % lemongrass oil treated fruits during both seasons; besides dipped fruits in either 0.25 % lemongrass oil or gelatin (2 and 4 %) in second season exhibited statistically the lowest fruit juice TSS %.

Table 4: Effect of gelatin, lemongrass oil and peppermint oil on total soluble solid percentage (TSS %) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	27.62	28.54	29.47	30.34	31.66	29.52 A
Gelatin 1%	27.62	28.91	29.46	29.59	31.50	29.41 A
Gelatin 2%	27.62	28.00	29.37	29.46	30.79	29.05 A
Gelatin 4%	27.62	28.37	28.87	29.25	30.69	28.96 AB
L. G. 0.25 %	27.62	28.25	28.34	29.79	30.29	28.86 AB
L. G. 0.50 %	27.62	27.71	27.84	29.04	30.16	29.54 A
Peppermint oil 5%	27.62	28.59	29.46	30.21	31.79	29.54 A
Peppermint oil 10%	27.62	28.29	29.50	30.25	32.04	29.54 A
Mean	27.62 E	28.34 D	29.04 C	29.74 B	31.11 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 1.111						
	Second season					
Control (tap water)	29.62	30.41	31.25	32.46	32.84	31.31 A
Gelatin 1%	29.62	29.87	31.09	32.37	32.62	31.11 AB
Gelatin 2%	29.62	30.16	30.71	31.59	32.09	30.84 BC
Gelatin 4%	29.62	30.04	30.75	31.00	31.62	30.61 C
L. G. 0.25 %	29.62	30.16	31.00	31.09	31.84	30.74 BC
L. G. 0.50 %	29.62	30.04	30.59	31.00	31.46	30.54 C
Peppermint oil 5%	29.62	30.54	31.91	32.12	32.54	31.36 A
Peppermint oil 10%	29.62	30.41	31.84	32.25	32.66	31.36 A
Mean	29.62 D	30.21 C	31.14 B	31.74 A	32.21 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 1.06						

Referring the interaction effect (storage period x post-harvest treatments), Table (4) displays that differences between various combinations of two earlier dates (after 15 & 30 days) were too slight to be taken into consideration from the statistical point of view as combinations of each date were separately compared each other during two seasons unique with a unique exception when the L.G. 0.50 % treated fruits were compared both peppermint oil treated fruits (at 5 & 10 %) after 30 days in 2nd season. However, as the storage duration was advanced differences became more pronounced and reached level of significance, particularly with comparing the 0.50 % lemongrass oil treated fruits with either control or peppermint treated fruits (at 5 & 10 %), particularly the latest conc.). Such trend could be logically explained on such fact that the influence of storage duration on fruit juice TSS % was more noticeable than that of post-harvest treatments. Pointing to specific effect of tested postharvest treatments, Table (4) shows that 5 and 10% peppermint oil-treated fruits appeared to be the most effective treatments for inducing the highest fruit total soluble solids percentage without significant differences between them in both seasons. On reverse, 0.5% lemongrass oil-treated fruits significantly produced the lowest fruit total soluble solids percentage, followed in ascending order by 0.25% lemongrass oil and 4% gelatin treated fruits in both seasons, respectively. The rest treatments gave in-between values in this concern.

The observed changes in TSS may be due to the hydrolytic conversion of polysaccharides into soluble sugar during the ripening process which resulted in an increase in TSS of the fruits (Abbasi *et al*., 2011). These results are also in agreement with those obtained by Carrillo *et al.* (2000) on Haden mango in Mexico. The abovementioned results are in agreement with those obtained by Attia (1995), EL-Badawy *et al.,* (2012) and Baiea and EL-Badawy (2013) on orange, Pal (1998) on Mango, Mpho *et al.,* (2013) on avocado, Jiang and Li (2000) on longan fruit, Togrul and Arslan (2004) on peach, Rojas-Graü *et al.,* (2007) and Raybaudi-massilia *et al.* (2008) on apple.

2.2 Fruit juice total sugars content (g/100 FW):

With regard to the specific effect of storage duration Table (5) reveals that fruit total juice total sugars content was steadily increased with prolonging storage period. The increase was significant as fruit juice total sugars content after different storage periods were compared each other during two seasons of study. This may be attributed the dilution effect resulted by the steady decrease in fruit tissues moisture content paralleled to the continuous increase in fruit weight as the storage duration was advanced.

As for the specific effect of differential investigated post-harvest treatments it is quite evident as shown from Table (5) that the difference was too little to reach level of significance during two seasons of study. However, control treated fruits and 10% peppermint-treated fruits tended relatively to show a slight increase over other investigated treatments during 1st season and 2nd one, respectively.

Table 5: Effect of gelatin, lemongrass oil and peppermint oil on total sugar (g/100 FW) of Zaghloul date palm fruits stored at 0.0 ± 2 °C during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	25.39	26.00	26.87	28.16	28.06	27.00 A
Gelatin 1%	25.39	25.95	26.46	27.71	28.59	26.82 A
Gelatin 2%	25.39	25.87	26.37	27.37	28.50	26.70 A
Gelatin 4%	25.39	25.82	26.32	27.00	27.75	26.46 A
L. G. 0.25 %	25.39	25.79	26.59	26.66	28.04	26.52 A
L. G. 0.50 %	25.39	25.75	26.46	26.62	27.75	26.40 A
Peppermint oil 5%	25.39	25.97	26.59	28.09	28.34	26.87 A
Peppermint oil 10%	25.39	25.97	26.50	27.84	28.37	26.81 A
Mean	25.39 E	25.91 D	26.52C	27.44 B	28.24 A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0. 852						
	Second season					
Control (tap water)	26.31	26.91	27.55	27.91	28.45	27.42 A
Gelatin 1%	26.31	26.79	26.29	27.87	28.37	27.32 A
Gelatin 2%	26.31	26.79	27.25	27.41	27.80	27.11 A
Gelatin 4%	26.31	26.75	27.11	27.50	28.25	27.19 A
L. G. 0.25 %	26.31	26.87	27.34	27.62	28.00	27.22 A
L. G. 0.50 %	26.31	26.66	27.10	27.79	27.66	27.10 A
Peppermint oil 5%	26.31	26.46	27.34	27.71	28.30	27.24 A
Peppermint oil 10%	26.31	26.87	27.50	28.00	28.50	27.44 A
Mean	26.31 E	26.76 D	27.31 C	27.72 B	28.16A	
L.S.D for the interaction effect between treatments and storage periods at 5%= 1.006						

Moreover, Table (5) reveals that each investigated factors reflected its own specific effect on their different combinations. Herein, the interactions of sixty days cold storage period surpassed the analogous ones of other studied cold storage periods in increasing total sugars content. However, untreated fruits in the first season and 10% peppermint oil-treated fruits in the second one stored under 0.0 °C ± 2 for sixty days gave the highest values of total sugars content. The interactions of fifteen days cold stored fruits registered the lowest values in this sphere,

especially 0.5% lemongrass-treated fruits in the first season and 5% peppermint oil-treated fruits in the second season. Meanwhile, the remained interactions were in-between in this respect.

This may be attributed to the unparalleled rate of response to both investigated factors (storage duration & post-harvest treatments) whereas the rate was more pronounced with 1st factor than 2nd one.
The aforementioned results are in parallel to those recorded by Attia (1995) on orange, Manzano *et al.,* (1997), Pal (1998), Carrillo *et al.,* (2000), Jitareerat *et al.,* (2007), Abbasi *et al.,* (2011) and Shaarawi *et al*., (2013) on mango, Mpho *et al.,* (2013) on avocado, Togrul and Arslan (2004) on peach, Tzortzakis and Economakis (2007) and Jha *et al.,* (2012) on apple.

2.3. Fruit juice total acidity %:

It is quite evident that the decrease in fruit total acidity content is proportionate with the advancement of storage period (Table, 6). Hence the highest value of fruit total acidity content (irrespective the initial readings) was recorded with fifteen days cold stored fruits. The reverse was detected with the fruits stored for sixty days in both seasons.

With regard to specific effect of tested postharvest treatments**,** Table (6) indicated that all tested treatments increased to some extent fruit total acidity over control during both seasons. However, the increase over control was significant with comparison to treated fruits with lemongrass oil (0.25 or 0.5%) during two seasons as well as dipping in two higher concentrations of gelatin (2&4%) and both peppermint oil concentrations (5&10%) during 1st and 2nd seasons respectively.

It is quite clear that tabulated data in Table (6) reflected a real picture to the relative higher rate of response to the cold storage duration from one hand and the lower (very slight) on to the investigated post-harvest treatments from the other accordingly, the sixteenth combinations of two studied factors (storage duration x post-harvest treatments) for the two earlier storage period i.e. after 15 & 30 days cold storage, exhibited generally the same values and did not significantly differ as compared each other during both seasons of study. However, with the advancement of cold storage period differences became more pronounced and in most cases varied significantly, especially as eight combinations of the latest cold storage duration were compared to those of the earlier ones (after 15 & 30 days). Generally, it could be concluded that the lowest fruit juice total acidity was always in concomitant to the control and gelatin 1% treated fruits after 60 days and differences were significant with comparison either of 0.50% lemongrass oil treated fruits (regardless of storage period) or the differential combinations of other investigated post-harvest treatments particularly after 15 and 30 days cold storage.

The obtained results showed that coatings slowed the changes on titratable acidity and effectively delaying fruit senescence. This was probably because the film formed by materials used on the surface of the fruit might have modified the internal atmosphere i.e., the endogenous CO_2 and O_2 concentration of the fruit, thus retarding ripening (Bai *et al*., 1988 and Lowings and Cutts, 1982). The aforementioned results go on the same line with those obtained by Attia (1995) on orange, Manzano *et al.,* (1997), Pal (1998) Carrillo *et al.,* (2000), Jitareerat *et al.,* (2007), Abbasi *et al.,* (2011) Samar *et al.,* (2013) on mango, Mpho *et al.,* (2013) on avocado, Jiang and Li (2000) on longan fruit and Togrul and Arslan (2004) on peach.

Table 6: Effect of gelatin, lemongrass oil and peppermint oil on total acidity (%) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	0.370	0.320	0.280	0.260	0.240	0.294 B
Gelatin 1%	0.370	0.330	0.320	0.280	0.250	0.310 AB
Gelatin 2%	0.370	0.353	0.333	0.277	0.270	0.321 A
Gelatin 4%	0.370	0.350	0.330	0.300	0.280	0.326 A
L. G. 0.25 %	0.370	0.347	0.333	0.303	0.277	0.326 A
L. G. 0.50 %	0.370	0.327	0.333	0.320	0.303	0.331 A
Peppermint oil 5%	0.370	0.333	0.300	0.280	0.260	0.309 AB
Peppermint oil 10%	0.370	0.330	0.330	0.280	0.250	0.312 AB
Mean	0.370 A	0.336 B	0.320 B	0.287 C	0.266 D	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.051						
	Second season					
Control (tap water)	0.340	0.330	0.367	0.253	0.240	0.286 B
Gelatin 1%	0.340	0.340	0.300	0.260	0.240	0.296 AB
Gelatin 2%	0.340	0.310	0.300	0.290	0.270	0.302 AB
Gelatin 4%	0.340	0.320	0.313	0.300	0.270	0.309 AB
L. G. 0.25 %	0.340	0.340	0.320	0.327	0.280	0.321 A
L. G. 0.50 %	0.340	0.340	0.310	0.300	0.300	0.318 A
Peppermint oil 5%	0.340	0.330	0.320	0.297	0.280	0.313 A
Peppermint oil 10%	0.340	0.330	0.330	0.300	0.277	0.315 A
Mean	0.340 A	0.330 A	0.307 B	0.290 BC	0.269 C	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.061						

2.4 Fruit tannins content (g tannic acid/100 g fruit fresh weight)

It is obvious from Table (7) that the reduction in tannins content of Zaghloul date palm fruits is in proportionate with the advancement of storage period. Thus, sixty days cold stored fruits scored the lowest values of fruit tannins content. On contrary, the freshly harvested fruits (zero day storage) scored the highest values in this respect. Other values of cold storage periods occupied an intermediate position between the previously mentioned two categories. The differences between the studied storage periods were obvious to be significant.

In regard to specific effect of post harvest treatments**,** statistical analysis of data in Table (7) indicates that all studied treatments failed to induce a remarkable effect on fruit tannins content. However the relative lower value of tannins content was generally coupled by control and 10 % peppermint oil- treated fruits in corresponding to relative higher content in 0.50 % lemongrass oil in both seasons. In addition, other investigated treatments were in between the aforesaid two extends with a complete absence of significance in the two seasons.

Obtained data during both seasons as shown from Table (7) pointed out that each investigated treatment reflected its own specific effect. Thereupon, eight combinations of fifteen days storage period stored generally the highest fruit tannins content, but differences were so little to be significant as they compared to the analogous ones of 30 days storage. Meanwhile, as the cold storage was advanced, the differences became more pronounced in reach level of significance, particularly with comparing tannins content of eight combinations after 15 days storage to either those of 45 or 60 days cold storage during two seasons. In other words, the rate of reduction in fruit tannins content became more acute after 45 days cold storage, whereas differences between eight combinations of such date (45 days) were significant with comparing to the sixteen combinations of the two earlier dates (15 & 30 days) regardless of post-harvest treatments applied during both seasons. The severe reduction was also continued till the last storage date (after 60 days). Herein, the least tannins content was significantly detected by eight combinations after 60 days storage as compared to twenty four ones of (15, 30 and 45 days) during two seasons regardless of post-harvest treatments used.

The obtained results are coincided with those scored by Mpho *et al.,* (2013) on avocado, Tzortzakis and Economakis (2007), Rojas-Graü *et al.,* (2007), Raybaudi-massilia *et al.* (2008), Jha *et al.,* (2012) on apple.

Conclusively, the tested essential oils have shown antifungal effects against different postharvest pathogens (Feng and Zheng 2007). It was reported by Lambert *et al*., (2001) that the essential oils (due to their hydrophobic nature) affect the partitioning the lipids of the plasma membrane and changing its integrity, permeability and the inorganic ion equilibrium. Also, the essential oils often involves in mitochondrial structure disorganization, interference with enzymatic reactions of the mitochondrial membranes, such as respiratory electron transport, proton transport and phosphorylation mechanism (Knobloch *et al*. 1989). It has been speculated that the mode of action for an essential oils with absence of phenolic groups could be due to membrane disruption by the lipophilic compounds (Mendoza *et al*. 1997). Furthermore, Edible coatings are applied to enhance the quality and extend the shelf-life of fruit by decreasing moisture loss and respiration rate. An edible coating can have a positive effect on the surface of fruit by incorporating functional ingredients, such as antimicrobials, antioxidants, colorants, and flavors (Valencia-Chamorro *et al.,* 2012). In addition, an edible coating improves the esthetic value by providing a glossy appearance (Trezza & Krochta, 2000).

Table 7: Effect of gelatin, lemongrass oil and peppermint oil on fruit tannins content (g tannic acid/100 g fruit fresh weight) of Zaghloul date palm fruits stored at 0.0 °C ± 2 during 2012 and 2013 seasons.

Treatments	First season					
	Storage periods (days)					
	0	15	30	45	60	Mean
Control (tap water)	0.650	0.590	0.533	0.400	0.247	0.484 A
Gelatin 1%	0.650	0.587	0.550	0.427	0.250	0.493 A
Gelatin 2%	0.650	0.600	0.560	0.433	0.260	0.501 A
Gelatin 4%	0.650	0.600	0.600	0.440	0.260	0.510 A
L. G. 0.25 %	0.650	0.600	0.600	0.460	0.280	0.518 A
L. G. 0.50 %	0.650	0.610	0.600	0.480	0.280	0.524 A
Peppermint oil 5%	0.650	0.590	0.540	0.410	0.250	0.488 A
Peppermint oil 10%	0.650	0.590	0.540	0.403	0.247	0.486 A
Mean	0.650 A	0.596 B	0.565 B	0.432 C	0.259 D	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.091						
	Second season					
Control (tap water)	0.590	0.523	0.440	0.340	0.237	0.426 A
Gelatin 1%	0.590	0.530	0.450	0.370	0.250	0.438 A
Gelatin 2%	0.590	0.547	0.490	0.370	0.280	0.455 A
Gelatin 4%	0.590	0.550	0.510	0.400	0.280	0.466 A
L. G. 0.25 %	0.590	0.553	0.510	0.440	0.260	0.471 A
L. G. 0.50 %	0.590	0.580	0.530	0.480	0.300	0.496 A
Peppermint oil 5%	0.590	0.520	0.450	0.320	0.230	0.422 E
Peppermint oil 10%	0.590	0.500	0.460	0.350	0.240	0.428 A
Mean	0.590 A	0.538 B	0.480 C	0.384 D	0.259 E	
L.S.D for the interaction effect between treatments and storage periods at 5%= 0.087						

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