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## A new technique for extension the storage life of date palm fruits cvs Zaghloul and Samany during cold storage

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### ABSTRACT

This experiment was carried out during two successive seasons (2007 and 2008) on two date fruits cvs (Zaghloul and Samany) harvested at full coloured stage (khlal). Experimental fruits were divided into four similar groups. Fruits of the first group left without coating (control). While, the three other groups were separately coated with prickly pear cactus mucilage (*Opuntia ficus indica*), jojoba oil emulsified and lemon grass oil. Cactus pear stems were cooked with water in the ratio of 1:5 in an autoclave at 160°C for 1h, while jojoba oil and lemon grass emulsion were used at 5 ml/L. The four groups were stored at 0°C and 90-95% RH. The fruits were examined every 15 days during 60 days storage period. Coating fruits with jojoba oil, lemon grass oil or cactus – mucilage reduced fruit decay and weight loss and increased fruits storage life. Along the storage till 60 days T.S.S. were increased, however titratable acidity and Tannins contents were decreased. Results indicated that all treatments significantly decreased the post harvest diseases of date palm fruits caused by *Penicillium* spp. and *Aspergillus* spp. during storage. Increased consumer demand for higher quality packing in combination with the environmental need to minimize packaging loss led to increase the interest in research into edible coatings. In this work prickly pear cactus mucilage, lemon grass oil and jojoba oil were investigated for coating carton. The effect of coating on tensile strength and water absorption of carton was discussed. © 2012 Trade Science Inc. - INDIA

### KEYWORDS

Post harvest treatments;  
Date palm;  
Cold storage;  
Cactus pear mucilage;  
Jojoba oil;  
Lemon grass.

### INTRODUCTION

The date palm (*Phoenix dactylifera*, L.) is considered as one of the oldest cultivated trees in the world. It is well known that dates are rich sources of nutrients mainly sugars, vitamins, pro-

teins, sodium, iron, magnesium and other minerals. In Egypt, Date palm fruits particularly Zaghloul, and Samani cultivars are one of the most luxurious highly nutritive value fruits<sup>[37]</sup>.

No doubt that the processes of handling and storage of date fruits for local market and export

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are as important as fruits production and fruits yield. Export trade however is hindered by difficulties in the transport and storage<sup>[24]</sup>. Storage is essential for extending the marketing period of fruits, regulating their supply to the market and for transportation to long distance. The marketing period could be extended by pre-cooling, storage under low temperature and some pre-storage treatments. Several attempts were conducted to prolong the marketing season of date fruits. Among these attempts, beside cold storage is the use of jojoba oil, lemon grass as emulsion and pear cactus mucilage as natural products<sup>[26]</sup>.

There is dispute need to study how the marketing period of Date fruits could be extended and how to reduce the loss of fruits in order to supply fruits frequently over long period of time.

Nagvi and Ting<sup>[20]</sup> found that jojoba oil is commonly known as liquid, colorless and odorless with unique physical and chemical properties. They also found that jojoba oil can easily be hydrogenated into a soft wax. Abd El moniem et al<sup>[2]</sup> studied the effect of different coating materials, and reported that coating Washington navel orange fruits with jojoba oil and orange oil were the best in reducing decay, weight loss and increasing fruits storage life. Abd El moniem<sup>[3]</sup> mentioned that jojoba oil coating treatments on Awis mango fruits reduced weight loss and decayed fruit percent. Fruits treated with 100% concentration of jojoba oil showed higher flesh firmness and flesh acid values. The use of pear cactus mucilage (*Opuntia ficus indica*) was investigated as an edible coating to extend the shelf-life of strawberries. Edible films were tested to determine their effect on color, texture sensory quality of the fruits. It was concluded that the use of mucilage coatings lead to increased strawberry shelf-life<sup>[39]</sup>. Packaging is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use. The use of proper packaging technology to minimize food losses and provide safe and sound food products has always been the focus of food packaging. In addition, consumer trends for better quality, fresh-like, and convenient food products have intensified during the last decades. Active packaging is a mode of packaging in which the package, the product, and the environment interact to prolong

shelf life or enhance safety or sensory properties, while maintaining the quality of the product<sup>[32]</sup>. Paper and board are the oldest and most versatile packaging materials available on the market today. However, because of their poor functional barrier properties and, particularly, high moisture sensitivity, they are often associated with other materials, such as plastic materials and aluminum for their good barrier properties that could be advantageously combined with the stiffness of paper and board. Cellulose and chitosan are widely used in coating paper and board. However, the hydrophilic nature of these polysaccharides limits their use<sup>[8]</sup>. Cactus mucilage may find applications in food, cosmetics, pharmaceutical and other industries. The complex polysaccharide is part of dietary fibre and has the capacity to absorb large amounts of water, dissolving and dispersing itself and forming viscous or gelatinous colloids<sup>[7,15,16,17]</sup>. An important point in the choice of the cactus mucilage as a coating is its low cost. The cactus needs to be pruned; therefore, the cactus stems are a waste product capable of several applications, such as aforementioned.

Postharvest diseases caused by *Penicillium* sp. and *Aspergillus* sp. are the most important fungi attack date palm fruits during storage<sup>[11]</sup>. Essential oil extracted from lemon grass (*Cymbopogon citratus* cdc.) has antifungal activity against several plant pathogens<sup>[25]</sup>. Using of lemongrass essential oils for controlling postharvest diseases of several economic fruits was reported by Dhaliwal, et al<sup>[6]</sup> on kinnow mandarin; Pawar and Thaker,<sup>[23]</sup> Pear cactus mucilage and jojoba were used for controlling of postharvest decay of fruits<sup>[9]</sup>.

The aim of this present work is to prolonging the storage period of two date palm fruits cultivars (Samani and Zaghloul) using jojoba oil, lemon grass oil emulsions and prickly pear cactus as coating treatments and for protection of date palm fruits against postharvest diseases. Also, a preliminary study of the suitability of these substances as coating materials for carton.

## MATERIAL AND METHODS

This work was carried out during the two successive seasons (2007 and 2008) on date palm fruits of Zaghloul and Samani cvs. Palms cvs were

30-years-old, grown in a private orchard at Ismailia, Egypt. Fruits were harvested at full colored stage (Khlal). Harvested fruits were directly transferred to the laboratory at the agricultural development system (Ads) project at faculty of agriculture, Cairo University. Uniform fruits, apparently free from any physical damage and disease were selected, washed with tap water and air dried. Experimental fruits in each cultivar were divided into four groups. Each group was subjected to one of the following coating treatments:

- [1] Control (tap water only).
- [2] Pear cactus mucilage (Stems were cooked with water in the ratio of 1:5 in autoclave at 160°C for 1h).
- [3] Jojoba oil emulsion at 5ml/L + 0.1 ml/L Tween 80 as emulsified material.
- [4] Lemon grass oil emulsion at 5ml/L + 0.1 ml/L Tween 80 as emulsified material.

Jojoba oil and lemon grass emulsions were prepared by mixing oil with tween 80 in water, Ju et al.<sup>[13]</sup>.

Each treatment was represented by three replicates, each of 3 carton boxes (about 2 Kg) and measure (45x35x10 cm), in one layer inside the box. Experimental boxes were stored at 0°C and 90-95 % relative humidity for 60 days. Changes in some physical and chemical fruits properties were determined at 15 days intervals.

### Physical properties

#### Fruits weight loss percentage

Each box was individually weighted before cold storage (to get the initial weight), then weighted after each period of cold storage. Fruits weight loss % were calculated according to the following equation:

$$\text{Fruit weight loss \%} = \frac{W_i - W_s}{W_i} \times 100$$

Where,  $W_i$  = initial box weight before cold storage;  
 $W_s$  = box weight at the end of sampling period.

#### Decay percentage

The decayed fruits percentage was calculated according to the following equation: (total number decayed fruits/ Initial number of stored fruits) x 100.

### Chemical properties

⇒ Soluble solids content (TSS) %: A refract so

- ids content percent in fruit flesh according to<sup>[4]</sup>.
- ⇒ Titratable acidity %: It was determined according to the method described in<sup>[4]</sup>.
  - ⇒ Total sugar %: Total sugars were determined according to the method described in<sup>[4]</sup>.
  - ⇒ Tannins content: Total tannins of date fruits were determined according to q.

### Effects of different treatments on postharvest diseases of date palm fruits under natural infection

Lemongrass essential oil, jojoba and pear cactus mucilage were evaluated against postharvest diseases of date palm fruits under natural infection.

Treatments of fruits: Fresh date palm fruits (Zaghloul and Samani fruits) apparently free from physical damage and diseases were used in those experiments. Date palm fruits were dipped for two minutes in solutions of lemongrass essential oil, jojoba and pear cactus mucilage extract then air dried. All treated fruits of each particular concentration as well as control treatment were represented with three replicate and 20 fruits for each were used. All fruits were stored at 20 ± 2°C for 15 days. Diseased fruits were counted every 15 days intervals and the percentage of diseases incidence was recorded.

### Preparation of cactus pear coating solution

Cactus pear stems were peeled and cubed. Samples were cooked with water in the ratio of 1:5 in an autoclave at 160°C for 1h. The cooked pulp was filtered, and left to cool. The slurry was centrifuged for 10 min and the supernatant obtained was used as coating material (cactus pear mucilage)<sup>[26]</sup>. (The filtrate (pulping liqre) was also used as coating solution. Polyethylene glycol (PEG) of molecular weight 2000 as a plasticizer was added to coating solutions 5% w/v. pH value of these solutions was adjusted at 7 using few drops of ammonia solution. Carton sheets of basses weight 150g/m<sup>2</sup> were dipped in coating solution for 30 s and dried in air for 24 h. The tensile strength (TS) and water uptake of coated carton was studied. In accordance with the German Standard Method by means of a Frank 468 tester the tensile strength (TS) of coated carton was measured (Sutermeister,1941). The effect of (PEG)

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with different molecular weights on mechanical properties (TS) of carton coated with cactus mucilage was studied. Jojoba oil and lemon grass are also used separately as coating solution for carton.

### Statistical analysis

The obtained data were subjected to analysis variance (ANOVA) according to [28] (1980) using M-statc program. When significant differences ( $p < 0.05$ ) were detected, the least significant difference (LSD) test was used to differentiate the mean values according.

## RESULT AND DISCUSSION

### Physical properties

#### Fruit weight loss (%)

Data in TABLES (1-2) cleared that weight loss percent significantly increased by prolonging the storage period. A remarkable reduction in weight loss percent was obtained when fruits were

**TABLE 1 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit weight loss % of date palm cv – Zaghloul in 2007&2008 seasons:**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>I</sup>	3.98 <sup>E</sup>	9.24 <sup>B</sup>	0.00 <sup>I</sup>	0.00 <sup>I</sup>	2.64 <sup>C</sup>
Cactus pear mucilage	0.00 <sup>I</sup>	2.80 <sup>GH</sup>	3.97 <sup>E</sup>	6.94 <sup>C</sup>	9.98 <sup>A</sup>	4.74 <sup>A</sup>
Jojoba oil	0.00 <sup>I</sup>	2.40 <sup>H</sup>	3.21 <sup>FG</sup>	5.39 <sup>D</sup>	8.74 <sup>B</sup>	3.95 <sup>B</sup>
Lemon grass oil	0.00 <sup>I</sup>	2.60 <sup>GH</sup>	3.73 <sup>EF</sup>	5.31 <sup>D</sup>	9.10 <sup>B</sup>	4.15 <sup>B</sup>
Mean	0.00 <sup>E</sup>	2.95 <sup>D</sup>	5.04 <sup>B</sup>	4.41 <sup>C</sup>	6.96 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.36					
Storage (B)	0.32					
(AB)	0.72					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>G</sup>	4.26 <sup>DE</sup>	10.56 <sup>A</sup>	0.00 <sup>G</sup>	0.00 <sup>G</sup>	2.96 <sup>B</sup>
Cactus pear mucilage	0.00 <sup>G</sup>	2.80 <sup>EF</sup>	3.37 <sup>EF</sup>	6.21 <sup>C</sup>	8.51 <sup>B</sup>	4.18 <sup>A</sup>
Jojoba oil	0.00 <sup>G</sup>	2.32 <sup>F</sup>	3.19 <sup>EF</sup>	5.10 <sup>CD</sup>	7.85 <sup>B</sup>	3.69 <sup>A</sup>
Lemon grass oil	0.00 <sup>G</sup>	2.54 <sup>F</sup>	3.62 <sup>EF</sup>	5.39 <sup>CD</sup>	8.46 <sup>B</sup>	4.00 <sup>A</sup>
Mean	0.00 <sup>E</sup>	2.98 <sup>D</sup>	5.19 <sup>B</sup>	4.18 <sup>C</sup>	6.20 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.73					
Storage (B)	0.66					
(AB)	1.46					

**TABLE 2 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit weight loss % of date palm cv–samani in 2007 & 2008 seasons:**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Mean
Control	0.00 <sup>G</sup>	2.97 <sup>E</sup>	7.25 <sup>A</sup>	0.00 <sup>G</sup>	0.00 <sup>G</sup>	2.04 <sup>C</sup>
Cactus pear mucilage	0.00 <sup>G</sup>	1.48 <sup>F</sup>	4.05 <sup>D</sup>	4.41 <sup>CD</sup>	6.26 <sup>B</sup>	3.24 <sup>A</sup>
Jojoba oil	0.00 <sup>G</sup>	1.27 <sup>F</sup>	3.07 <sup>E</sup>	3.93 <sup>D</sup>	5.03 <sup>C</sup>	2.66 <sup>B</sup>
Lemon grass oil	0.00 <sup>G</sup>	1.37 <sup>F</sup>	3.98 <sup>D</sup>	4.31 <sup>D</sup>	6.03 <sup>B</sup>	3.14 <sup>A</sup>
Mean	0.00 <sup>D</sup>	1.77 <sup>C</sup>	4.59 <sup>A</sup>	3.16 <sup>B</sup>	4.33 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.33					
Storage (B)	0.30					
(AB)	0.66					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Mean
Control	0.00 <sup>I</sup>	2.50 <sup>G</sup>	6.06 <sup>A</sup>	0.00 <sup>I</sup>	0.00 <sup>I</sup>	1.71 <sup>C</sup>
Cactus pear mucilage	0.00 <sup>I</sup>	1.42 <sup>H</sup>	3.20 <sup>EF</sup>	3.80 <sup>D</sup>	5.80 <sup>AB</sup>	2.85 <sup>A</sup>
Jojoba oil	0.00 <sup>I</sup>	1.35 <sup>H</sup>	2.96 <sup>FG</sup>	3.66 <sup>DE</sup>	4.92 <sup>C</sup>	2.58 <sup>B</sup>
Lemon grass oil	0.00 <sup>I</sup>	1.17 <sup>H</sup>	3.19 <sup>EF</sup>	3.93 <sup>D</sup>	5.32 <sup>BC</sup>	2.72 <sup>AB</sup>
Mean	0.00 <sup>D</sup>	1.61 <sup>C</sup>	3.85 <sup>A</sup>	2.85 <sup>B</sup>	4.01 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.25					
Storage (B)	0.22					
(AB)	0.50					

coated with jojoba oil followed by lemon grass oil and pear cactus mucilage. Result cleared that coating date fruits cvs Zaghloul and Samani with jojoba oil was associated with the lowest weight loss, followed by lemon grass oil and, pear cactus mucilage in both seasons. These results are in line with those suggested by [21] who found that coating Awis mango fruits with jojoba oil reduced weight loss, similar results obtained by [22] who revealed that edible coating films can delay ripening of climacteric fruit, reduce water loss and thereby extended shelf life.

#### Fruit decay %

Data in TABLES (3-4) cleared that fruits received jojoba oil seemed to have in general a longer life followed by lemon grass oil and pear cactus mucilage treatments than fruits of the control. Also it is clear that fruit decay % in both seasons increased gradually till the end of storage period. After 60 days fruits treated with jojoba oil especially in cv Samani exhibited the lowest values of decay % in both seasons while control fruits in Zaghloul and Samani cvs recorded the

**TABLE 3 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit decay % of date palm cv – Zaghloul in 2007 & 2008 seasons.**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>F</sup>	5.80 <sup>E</sup>	17.00 <sup>C</sup>	24.50 <sup>B</sup>	45.50 <sup>A</sup>	18.56 <sup>A</sup>
Cactus pear mucilage	0.00 <sup>F</sup>	1.27 <sup>F</sup>	5.91 <sup>E</sup>	12.07 <sup>D</sup>	16.44 <sup>C</sup>	7.14 <sup>B</sup>
Jojoba oil	0.00 <sup>F</sup>	1.52 <sup>F</sup>	5.87 <sup>E</sup>	11.95 <sup>D</sup>	17.07 <sup>C</sup>	7.28 <sup>B</sup>
Lemon grass oil	0.00 <sup>F</sup>	1.52 <sup>F</sup>	6.60 <sup>E</sup>	11.86 <sup>D</sup>	17.37 <sup>C</sup>	7.47 <sup>B</sup>
Mean	0.00 <sup>E</sup>	2.53 <sup>D</sup>	8.84 <sup>C</sup>	15.09 <sup>B</sup>	24.09 <sup>A</sup>	
LSD at 5%						
Treatments (A)	1.08					
Storage (B)	0.97					
(AB)	2.17					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>I</sup>	5.35 <sup>G</sup>	15.25 <sup>D</sup>	23.08 <sup>B</sup>	40.57 <sup>A</sup>	16.85 <sup>A</sup>
Cactus pear mucilage	0.00 <sup>I</sup>	2.00 <sup>H</sup>	8.23 <sup>F</sup>	12.00 <sup>E</sup>	18.04 <sup>C</sup>	8.05 <sup>B</sup>
Jojoba oil	0.00 <sup>I</sup>	1.79 <sup>H</sup>	7.03 <sup>F</sup>	11.93 <sup>E</sup>	17.13 <sup>C</sup>	7.58 <sup>B</sup>
Lemon grass oil	0.00 <sup>I</sup>	1.89 <sup>H</sup>	7.20 <sup>F</sup>	11.70 <sup>E</sup>	17.00 <sup>C</sup>	7.56 <sup>B</sup>
Mean	0.00 <sup>E</sup>	2.76 <sup>D</sup>	9.43 <sup>C</sup>	14.68 <sup>B</sup>	23.18 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.85					
Storage (B)	0.74					
(AB)	1.66					

highest ones. In general, fruits treated with jojoba oil, lemon grass and pear cactus mucilage seemed to have a longer storage life span. These results confirmed the findings obtained by<sup>[10,36]</sup> who found that the biologically active natural products have the potential to replace synthetic fungicides.

### Chemical properties

#### Soluble solids content (TSS%)

Data in TABLE (5-6) indicate that total soluble solids percentage increased as storage period prolonged. Generally, jojoba oil and lemon grass oil coated fruits showed the lower TSS values than uncoated fruits (control) during storage period in Zaghloul fruits. However, Samani fruits coated with jojoba oils and pear cactus mucilage exhibited lower TSS than those coated with lemon grass oil and uncoated fruits in both seasons. These results agreed with those of<sup>[1,2,19]</sup>.

#### Titrateable acidity %

Fruit acidity as shown in TABLES (7-8) decreased the storage periods and increased the low-

**TABLE 4 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit decay % of date palm cv – Samani in 2007 & 2008 seasons.**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>E</sup>	0.90 <sup>E</sup>	9.54 <sup>C</sup>	24.24 <sup>A</sup>	0.35 <sup>E</sup>	7.01 <sup>A</sup>
Cactus pear mucilage	0.00 <sup>E</sup>	0.00 <sup>E</sup>	0.00 <sup>E</sup>	6.55 <sup>D</sup>	14.37 <sup>B</sup>	4.18 <sup>B</sup>
Jojoba oil	0.00 <sup>E</sup>	0.00 <sup>E</sup>	0.00 <sup>E</sup>	5.91 <sup>D</sup>	13.61 <sup>B</sup>	3.90 <sup>B</sup>
Lemon grass oil	0.00 <sup>E</sup>	0.00 <sup>E</sup>	0.55 <sup>E</sup>	6.33 <sup>D</sup>	10.36 <sup>C</sup>	3.45 <sup>B</sup>
Mean	0.00 <sup>C</sup>	0.22 <sup>C</sup>	2.52 <sup>B</sup>	10.76 <sup>A</sup>	9.67 <sup>A</sup>	
LSD at 5%						
Treatments (A)	1.28					
Storage (B)	1.15					
(AB)	2.56					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.00 <sup>E</sup>	2.00 <sup>E</sup>	12.06 <sup>CD</sup>	22.36 <sup>B</sup>	30.99 <sup>A</sup>	13.48 <sup>A</sup>
Cactus pear mucilage	0.00 <sup>E</sup>	0.34 <sup>E</sup>	1.76 <sup>E</sup>	8.91 <sup>D</sup>	13.04 <sup>C</sup>	4.81 <sup>B</sup>
Jojoba oil	0.00 <sup>E</sup>	0.24 <sup>E</sup>	1.53 <sup>E</sup>	8.44 <sup>D</sup>	11.65 <sup>CD</sup>	4.37 <sup>B</sup>
Lemon grass oil	0.00 <sup>E</sup>	0.34 <sup>E</sup>	1.58 <sup>E</sup>	8.70 <sup>D</sup>	11.77 <sup>CD</sup>	4.48 <sup>B</sup>
Mean	0.00 <sup>D</sup>	0.73 <sup>D</sup>	4.23 <sup>C</sup>	12.10 <sup>B</sup>	16.86 <sup>A</sup>	
LSD at 5%						
Treatments (A)	1.84					
Storage (B)	1.64					
(AB)	3.67					

est acidity values were obtained from the control (untreated fruits) while, acidity values in coated fruits varied among the coating material used and from cultivar to another. In this respect Zaghloul fruits treated with lemon grass oil gave low acidity values than those obtained from fruits coated with pear cactus mucilage or jojoba oil, this effect was more obviously noticed in 2007 season. Where coating Samani fruits with pear cactus mucilage lower acidity than those treated with jojoba oil or lemon grass oil those are in line with those obtained by<sup>[1,2]</sup> orange and mango fruits.

#### Total sugar %

Total sugars % as shown in TABLES (9-10) increased significantly as the storage period prolonged. All experimental coated materials used significantly decreased total sugar content than those of the control. However, jojoba oil coated fruits showed lower total sugar % than other treatments after 45 and 60 days of storage in both seasons especially in Samani cv. Sugar content was increased during storage period in all treatments. This result was in line of<sup>[12]</sup> who concluded that

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**TABLE 5 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit SSC% of date palm cv – Zaghloul in 2007 & 2008 seasons:**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	17.67 <sup>J</sup>	19.67 <sup>H</sup>	21.98 <sup>F</sup>	25.37 <sup>CD</sup>	29.34 <sup>A</sup>	22.80 <sup>A</sup>
Cactus pear mucilage	17.53 <sup>J</sup>	18.70 <sup>I</sup>	20.57 <sup>G</sup>	22.97 <sup>E</sup>	26.30 <sup>B</sup>	21.21 <sup>B</sup>
Jojoba oil	17.67 <sup>J</sup>	18.37 <sup>I</sup>	19.97 <sup>GH</sup>	22.63 <sup>EF</sup>	24.77 <sup>D</sup>	20.68 <sup>C</sup>
Lemon grass oil	17.67 <sup>J</sup>	18.50 <sup>I</sup>	20.00 <sup>GH</sup>	22.47 <sup>EF</sup>	26.03 <sup>BC</sup>	20.93 <sup>BC</sup>
Mean	17.63 <sup>E</sup>	18.81 <sup>D</sup>	20.63 <sup>C</sup>	23.36 <sup>B</sup>	26.61 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.34					
Storage (B)	0.30					
(AB)	0.67					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	19.43 <sup>I</sup>	21.67 <sup>G</sup>	23.93 <sup>E</sup>	26.27 <sup>C</sup>	30.26 <sup>A</sup>	24.31 <sup>A</sup>
Cactus pear mucilage	19.43 <sup>I</sup>	20.93 <sup>H</sup>	22.00 <sup>G</sup>	22.93 <sup>F</sup>	27.30 <sup>B</sup>	22.52 <sup>B</sup>
Jojoba oil	19.43 <sup>I</sup>	20.63 <sup>H</sup>	21.73 <sup>G</sup>	22.80 <sup>F</sup>	25.73 <sup>D</sup>	22.07 <sup>C</sup>
Lemon grass oil	19.43 <sup>I</sup>	20.70 <sup>H</sup>	21.93 <sup>G</sup>	23.13 <sup>F</sup>	25.93 <sup>CD</sup>	22.23 <sup>C</sup>
Mean	19.43 <sup>E</sup>	20.98 <sup>D</sup>	22.40 <sup>C</sup>	23.78 <sup>B</sup>	27.31 <sup>A</sup>	
LSD at 5%						
Treatments (A)	0.18					
Storage (B)	0.16					
(AB)	0.36					

**TABLE 6 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit SSC% of date palm cv – Samani in 2007 & 2008 seasons.**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.21 <sup>I</sup>	24.74 <sup>D</sup>	27.38 <sup>C</sup>	30.56 <sup>B</sup>	31.72 <sup>A</sup>	22.92 <sup>A</sup>
Cactus pear mucilage	0.21 <sup>I</sup>	22.51 <sup>GH</sup>	23.25 <sup>FG</sup>	24.64 <sup>DE</sup>	0.28 <sup>I</sup>	14.18 <sup>B</sup>
Jojoba oil	0.21 <sup>I</sup>	22.03 <sup>H</sup>	22.97 <sup>FGH</sup>	24.00 <sup>DEF</sup>	0.28 <sup>I</sup>	13.90 <sup>B</sup>
Lemon grass oil	0.21 <sup>I</sup>	22.47 <sup>GH</sup>	23.61 <sup>EF</sup>	25.04 <sup>D</sup>	0.29 <sup>I</sup>	14.33 <sup>B</sup>
Mean	0.21 <sup>E</sup>	22.94 <sup>C</sup>	24.30 <sup>B</sup>	26.06 <sup>A</sup>	8.14 <sup>D</sup>	
LSD at 5%						
Treatments (A)	0.53					
Storage (B)	0.48					
(AB)	1.07					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.22 <sup>F</sup>	24.53 <sup>CD</sup>	26.97 <sup>B</sup>	30.24 <sup>A</sup>	0.33 <sup>F</sup>	16.46 <sup>A</sup>
Cactus pear mucilage	0.22 <sup>F</sup>	23.00 <sup>E</sup>	24.57 <sup>CD</sup>	25.36 <sup>C</sup>	0.18 <sup>F</sup>	14.67 <sup>BC</sup>
Jojoba oil	0.22 <sup>F</sup>	22.95 <sup>E</sup>	23.81 <sup>DE</sup>	24.57 <sup>CD</sup>	0.27 <sup>F</sup>	14.36 <sup>C</sup>
Lemon grass oil	0.22 <sup>F</sup>	23.11 <sup>E</sup>	24.58 <sup>CD</sup>	26.59 <sup>B</sup>	0.29 <sup>F</sup>	14.96 <sup>B</sup>
Mean	0.22 <sup>D</sup>	23.40 <sup>C</sup>	24.98 <sup>B</sup>	26.69 <sup>A</sup>	0.27 <sup>D</sup>	
LSD at 5%						
Treatments (A)	0.52					
Storage (B)	0.46					
(AB)	1.03					

**TABLE 7 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on fruit Acidity % of date palm cv – Zaghloul in 2007 & 2008 seasons.**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.51 <sup>A</sup>	0.47 <sup>C</sup>	0.40 <sup>F</sup>	0.35 <sup>H</sup>	0.27 <sup>J</sup>	0.40 <sup>C</sup>
Cactus pear mucilage	0.50 <sup>A</sup>	0.45 <sup>D</sup>	0.41 <sup>E</sup>	0.38 <sup>G</sup>	0.27 <sup>J</sup>	0.40 <sup>B</sup>
Jojoba oil	0.51 <sup>A</sup>	0.48 <sup>B</sup>	0.41 <sup>EF</sup>	0.38 <sup>G</sup>	0.28 <sup>I</sup>	0.41 <sup>A</sup>
Lemon grass oil	0.51 <sup>A</sup>	0.48 <sup>B</sup>	0.42 <sup>E</sup>	0.38 <sup>G</sup>	0.28 <sup>I</sup>	0.41 <sup>A</sup>
Mean	0.51 <sup>A</sup>	0.47 <sup>B</sup>	0.41 <sup>C</sup>	0.37 <sup>D</sup>	0.27 <sup>E</sup>	
LSD at 5%						
Treatments (A)	0.004					
Storage (B)	0.003					
(AB)	Ns					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.47 <sup>A</sup>	0.41 <sup>D</sup>	0.36 <sup>G</sup>	0.30 <sup>J</sup>	0.24 <sup>M</sup>	0.35 <sup>D</sup>
Cactus pear mucilage	0.47 <sup>A</sup>	0.42 <sup>C</sup>	0.37 <sup>F</sup>	0.32 <sup>I</sup>	0.25 <sup>L</sup>	0.36 <sup>C</sup>
Jojoba oil	0.47 <sup>A</sup>	0.42 <sup>B</sup>	0.38 <sup>E</sup>	0.33 <sup>H</sup>	0.26 <sup>K</sup>	0.37 <sup>A</sup>
Lemon grass oil	0.47 <sup>A</sup>	0.42 <sup>C</sup>	0.38 <sup>E</sup>	0.32 <sup>I</sup>	0.26 <sup>K</sup>	0.37 <sup>B</sup>
Mean	0.47 <sup>A</sup>	0.42 <sup>B</sup>	0.37 <sup>C</sup>	0.32 <sup>D</sup>	0.25 <sup>E</sup>	
LSD at 5%						
Treatments (A)	0.003					
Storage (B)	0.003					
(AB)	Ns					

**TABLE 8 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on Fruit Acidity % of date palm cv – Samani in 2007 & 2008 seasons.**

Treatments	Season 2007					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.38 <sup>A</sup>	0.31 <sup>BC</sup>	0.25 <sup>DEF</sup>	0.23 <sup>FG</sup>	0.19 <sup>G</sup>	0.27 <sup>B</sup>
Cactus pear mucilage	0.38 <sup>A</sup>	0.34 <sup>AB</sup>	0.30 <sup>BCD</sup>	0.27 <sup>CDE</sup>	0.23 <sup>EF</sup>	0.30 <sup>A</sup>
Jojoba oil	0.38 <sup>A</sup>	0.34 <sup>AB</sup>	0.30 <sup>BCD</sup>	0.27 <sup>CDE</sup>	0.23 <sup>EF</sup>	0.31 <sup>A</sup>
Lemon grass oil	0.38 <sup>A</sup>	0.33 <sup>AB</sup>	0.27 <sup>CDE</sup>	0.25 <sup>EF</sup>	0.20 <sup>FG</sup>	0.29 <sup>AB</sup>
Mean	0.38 <sup>A</sup>	0.33 <sup>B</sup>	0.28 <sup>C</sup>	0.26 <sup>D</sup>	0.21 <sup>E</sup>	
LSD at 5%						
Treatments (A)	0.03					
Storage (B)	0.02					
(AB)	Ns					
Treatments	Season 2008					
	0 days	15 days	30 days	45 days	60 days	Maen
Control	0.35 <sup>A</sup>	0.30 <sup>D</sup>	0.26 <sup>G</sup>	0.23 <sup>I</sup>	0.18 <sup>M</sup>	0.26 <sup>D</sup>
Cactus pear mucilage	0.35 <sup>A</sup>	0.32 <sup>B</sup>	0.29 <sup>E</sup>	0.26 <sup>G</sup>	0.20 <sup>K</sup>	0.28 <sup>B</sup>
Jojoba oil	0.35 <sup>A</sup>	0.32 <sup>B</sup>	0.29 <sup>E</sup>	0.26 <sup>G</sup>	0.21 <sup>J</sup>	0.29 <sup>A</sup>
Lemon grass oil	0.35 <sup>A</sup>	0.30 <sup>C</sup>	0.28 <sup>F</sup>	0.25 <sup>H</sup>	0.19 <sup>L</sup>	0.27 <sup>C</sup>
Mean	0.35 <sup>A</sup>	0.31 <sup>B</sup>	0.28 <sup>C</sup>	0.25 <sup>D</sup>	0.20 <sup>E</sup>	
LSD at 5%						
Treatments (A)	0.002					
Storage (B)	0.002					
(AB)	Ns					

**TABLE 9 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on Total sugar % of date palm cv – Zaghloul in 2007&2008 seasons.**

Treatments	Season 2007						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	17.10 <sup>I</sup>	19.43 <sup>FG</sup>	21.80 <sup>D</sup>	24.30 <sup>BC</sup>	28.83 <sup>A</sup>	22.29 <sup>A</sup>	
Cactus pear mucilage	17.10 <sup>I</sup>	17.97 <sup>H</sup>	19.77 <sup>F</sup>	21.87 <sup>D</sup>	24.60 <sup>B</sup>	20.26 <sup>B</sup>	
Jojoba oil	17.10 <sup>I</sup>	17.83 <sup>HI</sup>	19.27 <sup>FG</sup>	20.97 <sup>E</sup>	23.80 <sup>C</sup>	19.79 <sup>C</sup>	
Lemon grass oil	17.57 <sup>HI</sup>	17.67 <sup>HI</sup>	19.00 <sup>G</sup>	21.77 <sup>D</sup>	24.90 <sup>B</sup>	20.18 <sup>B</sup>	
Mean	17.22 <sup>E</sup>	18.23 <sup>D</sup>	19.96 <sup>C</sup>	22.23 <sup>B</sup>	25.53 <sup>A</sup>		
LSD at 5%							
Treatments (A)	0.38						
Storage (B)	0.34						
(AB)	0.76						
Treatments	Season 2008						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	18.83 <sup>H</sup>	20.67 <sup>G</sup>	23.57 <sup>D</sup>	25.17 <sup>C</sup>	29.00 <sup>A</sup>	23.45 <sup>A</sup>	
Cactus pear mucilage	18.93 <sup>H</sup>	19.27 <sup>H</sup>	20.67 <sup>G</sup>	22.50 <sup>EF</sup>	26.47 <sup>B</sup>	21.57 <sup>B</sup>	
Jojoba oil	18.93 <sup>H</sup>	19.00 <sup>H</sup>	20.83 <sup>G</sup>	22.07 <sup>F</sup>	24.90 <sup>C</sup>	21.15 <sup>C</sup>	
Lemon grass oil	18.93 <sup>H</sup>	18.77 <sup>H</sup>	20.80 <sup>G</sup>	22.77 <sup>E</sup>	25.20 <sup>C</sup>	21.29 <sup>C</sup>	
Mean	18.91 <sup>E</sup>	19.42 <sup>D</sup>	21.47 <sup>C</sup>	23.13 <sup>B</sup>	26.39 <sup>A</sup>		
LSD at 5%							
Treatments (A)	0.26						
Storage (B)	0.23						
(AB)	0.51						

**TABLE 10 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on Total sugar % of date palm cv – Samani in 2007&2008 seasons.**

Treatments	Season 2007						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	20.25 <sup>F</sup>	20.63 <sup>F</sup>	22.36 <sup>DE</sup>	23.10 <sup>A-E</sup>	23.87 <sup>AB</sup>	22.04 <sup>A</sup>	
Cactus pear mucilage	20.25 <sup>F</sup>	20.32 <sup>F</sup>	21.98 <sup>E</sup>	22.74 <sup>B-E</sup>	23.62 <sup>ABC</sup>	21.78 <sup>A</sup>	
Jojoba oil	20.25 <sup>F</sup>	20.50 <sup>F</sup>	22.01 <sup>E</sup>	22.68 <sup>CDE</sup>	23.31 <sup>A-D</sup>	21.75 <sup>A</sup>	
Lemon grass oil	20.25 <sup>F</sup>	20.30 <sup>F</sup>	22.08 <sup>E</sup>	22.93 <sup>A-E</sup>	23.94 <sup>A</sup>	21.90 <sup>A</sup>	
Mean	20.25 <sup>D</sup>	20.44 <sup>D</sup>	22.11 <sup>C</sup>	22.86 <sup>B</sup>	23.68 <sup>A</sup>		
LSD at 5%							
Treatments (A)	0.57						
Storage (B)	Ns						
(AB)	Ns						
Treatments	Season 2008						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	21.04 <sup>J</sup>	21.96 <sup>H</sup>	22.88 <sup>F</sup>	23.93 <sup>C</sup>	24.19 <sup>B</sup>	22.80 <sup>A</sup>	
Cactus pear mucilage	21.04 <sup>J</sup>	21.42 <sup>I</sup>	22.30 <sup>G</sup>	23.02 <sup>EF</sup>	24.13 <sup>BC</sup>	22.38 <sup>C</sup>	
Jojoba oil	21.04 <sup>J</sup>	21.33 <sup>I</sup>	21.97 <sup>H</sup>	23.20 <sup>DE</sup>	24.27 <sup>AB</sup>	22.36 <sup>C</sup>	
Lemon grass oil	21.04 <sup>J</sup>	21.79 <sup>H</sup>	22.47 <sup>G</sup>	23.24 <sup>D</sup>	24.41 <sup>A</sup>	22.59 <sup>B</sup>	
Mean	21.04 <sup>E</sup>	21.63 <sup>D</sup>	22.40 <sup>C</sup>	23.35 <sup>B</sup>	24.25 <sup>A</sup>		
LSD at 5%							
Treatments (A)	0.20						
Storage (B)	0.18						
(AB)	0.41						

**TABLE 11 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on Tannins content % of date palm cv – Zaghloul in 2007&2008 seasons:**

Treatments	Season 2007						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	0.90 <sup>A</sup>	0.83 <sup>B</sup>	0.50 <sup>C</sup>	0.42 <sup>DE</sup>	0.28 <sup>F</sup>	0.59 <sup>A</sup>	
Cactus pear mucilage	0.90 <sup>A</sup>	0.82 <sup>B</sup>	0.49 <sup>C</sup>	0.39 <sup>E</sup>	0.28 <sup>F</sup>	0.58 <sup>A</sup>	
Jojoba oil	0.90 <sup>A</sup>	0.82 <sup>B</sup>	0.47 <sup>CD</sup>	0.40 <sup>E</sup>	0.27 <sup>F</sup>	0.57 <sup>A</sup>	
Lemon grass oil	0.90 <sup>A</sup>	0.83 <sup>B</sup>	0.49 <sup>C</sup>	0.39 <sup>E</sup>	0.27 <sup>F</sup>	0.58 <sup>A</sup>	
Mean	0.90 <sup>A</sup>	0.82 <sup>B</sup>	0.49 <sup>C</sup>	0.40 <sup>D</sup>	0.28 <sup>E</sup>		
LSD at 5%							
Treatments (A)	0.03						
Storage (B)	Ns						
(AB)	Ns						
Treatments	Season 2008						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	0.84 <sup>A</sup>	0.80 <sup>A</sup>	0.48 <sup>B</sup>	0.38 <sup>BC</sup>	0.26 <sup>D</sup>	0.55 <sup>A</sup>	
Cactus pear mucilage	0.84 <sup>A</sup>	0.79 <sup>A</sup>	0.48 <sup>B</sup>	0.39 <sup>BC</sup>	0.26 <sup>D</sup>	0.55 <sup>A</sup>	
Jojoba oil	0.84 <sup>A</sup>	0.78 <sup>A</sup>	0.48 <sup>B</sup>	0.26 <sup>D</sup>	0.27 <sup>D</sup>	0.53 <sup>A</sup>	
Lemon grass oil	0.84 <sup>A</sup>	0.78 <sup>A</sup>	0.48 <sup>B</sup>	0.35 <sup>CD</sup>	0.27 <sup>D</sup>	0.55 <sup>A</sup>	
Mean	0.84 <sup>A</sup>	0.79 <sup>B</sup>	0.48 <sup>C</sup>	0.35 <sup>D</sup>	0.26 <sup>E</sup>		
LSD at 5%							
Treatments (A)	0.05						
Storage (B)	Ns						
(AB)	Ns						

**TABLE 12 : Effect of pear cactus mucilage, jojoba oil emulsion and lemon grass oil emulsion coating treatments on Tannins content % of date palm cv – Samani in 2007&2008 seasons.**

Treatments	Season 2007						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	0.74 <sup>A</sup>	0.70 <sup>A</sup>	0.56 <sup>B</sup>	0.38 <sup>CD</sup>	0.29 <sup>E</sup>	0.54 <sup>A</sup>	
Cactus pear mucilage	0.74 <sup>A</sup>	0.70 <sup>A</sup>	0.54 <sup>B</sup>	0.41 <sup>C</sup>	0.29 <sup>E</sup>	0.54 <sup>A</sup>	
Jojoba oil	0.74 <sup>A</sup>	0.70 <sup>A</sup>	0.53 <sup>B</sup>	0.35 <sup>D</sup>	0.29 <sup>E</sup>	0.52 <sup>A</sup>	
Lemon grass oil	0.74 <sup>A</sup>	0.70 <sup>A</sup>	0.55 <sup>B</sup>	0.38 <sup>CD</sup>	0.29 <sup>E</sup>	0.53 <sup>A</sup>	
Mean	0.74 <sup>A</sup>	0.70 <sup>B</sup>	0.55 <sup>C</sup>	0.38 <sup>D</sup>	0.29 <sup>E</sup>		
LSD at 5%							
Treatments (A)	0.03						
Storage (B)	Ns						
(AB)	Ns						
Treatments	Season 2008						
	0 days	15 days	30 days	45 days	60 days	Maen	
Control	0.70 <sup>A</sup>	0.61 <sup>B</sup>	0.47 <sup>C</sup>	0.34 <sup>D</sup>	0.26 <sup>D</sup>	0.47 <sup>A</sup>	
Cactus pear mucilage	0.70 <sup>A</sup>	0.58 <sup>B</sup>	0.47 <sup>C</sup>	0.34 <sup>D</sup>	0.26 <sup>D</sup>	0.47 <sup>A</sup>	
Jojoba oil	0.70 <sup>A</sup>	0.58 <sup>B</sup>	0.48 <sup>C</sup>	0.25 <sup>D</sup>	0.26 <sup>D</sup>	0.45 <sup>A</sup>	
Lemon grass oil	0.70 <sup>A</sup>	0.60 <sup>B</sup>	0.46 <sup>C</sup>	0.34 <sup>D</sup>	0.26 <sup>D</sup>	0.47 <sup>A</sup>	
Mean	0.70 <sup>A</sup>	0.59 <sup>B</sup>	0.47 <sup>C</sup>	0.32 <sup>D</sup>	0.26 <sup>E</sup>		
LSD at 5%							
Treatments (A)	0.05						
Storage (B)	Ns						
(AB)	Ns						

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**TABLE 13 : Effect of different treatments on postharvest diseases of date palm fruits under natural infections.**

Treatments	Postharvest Diseases %			
	Zaghloul cv		Samani cv	
	Disease incidence	Reduction %	Disease incidence	Reduction %
Pear cactus mucilage	15.0 c	60.50	8.0 c	69.2
Jojoba oil	25.0 b	34.20	15.0 b	42.3
Lemon grass oil	14.5 c	63.20	6.0 c	76.9
Control	38.0 a		26.0 a	

**TABLE 14 : Effect of coating solutions on breaking length and water absorption (after24h) of carton.**

Coating solution	Breaking length	Water absorption%
-----	3666.89	147.1
Cactus pear mucilage	2186.4	164.6
Cactus pear mucilage + polyethylene glycol	1601.6	168.18
Cooking liquor + polyethylene glycol	1455.2	166.6
Limon grass	1694.91	118.69
Jojoba oil	1251	102.03

fruit will reach high levels of sugar as they ripened.

### Fruit tannins content %

Data in TABLES (11-12) cleared that fruit tannins content decreased significantly with prolonging the storage periods in both seasons. However coating date palm fruits cvs Zaghloul and Samani with pear cactus mucilage,jojoba oil and lemon grass oil had no effect on tannins content during the storage period compared with the uncoated fruits (control) the decreases in fruits tannins content during maturation and storage may be attributed to the fact that soluble leucocyanidin tannins are converted during maturation into insoluble tannins,which take part in non enzymic oxidative browning thus insoluble leuco anthocyanidin decrease during storage period.<sup>[14]</sup>, the present results provided supporting evidence that coating Zaghloul and Samani date fruits with pear cactus mucilage, jojoba oil and lemon grass helped to delay ripening and preserve fruit quality.

### Effects of different treatments on postharvest diseases of Date palm fruits under natural infection

Lemongrass essential oil, jojoba and Figures extract were evaluated against postharvest diseases of date palm fruits under natural infection. Results in TABLE 13. indicate that all treatments significantly reduced the postharvest diseases of date palm fruits. The most effective treatments are lemongrass and Figures extract which reduced the diseases incidence more than 63.2 & 60.5 for Zaghloul fruit cv and 76.9 & 69.2 for Samani fruit cv. Meanwhile jojoba treatments showed moderate effect. It noticed that the *Penicillium* sp. and *Aspergillus* sp. are the most dominant fungi showing on diseased date palm fruits.

Postharvest diseases caused by the fungi *Penicillium* sp. and *Aspergillus* sp.

Postharvest diseases of caused by *Penicillium* sp. and *Aspergillus* sp. are the most important fungi attack date palm fruits during storage<sup>[11]</sup>. Lemongrass essential oils has antifungal activity against several pathogenic fungi. In this respect<sup>[6]</sup> tested ten essential oils prepared from different plants by steam distillation against *Penicillium itatum* causing fruit rot of mandarin under in vitro and In vivo conditions. <sup>[23]</sup>Examined 75 different essential oils for the inhibition of mycelium growth and spore formation of *Aspergillus niger*. Results indicate that cinnamon, cassia, clove and lemongrass, were the top five essential oils which demonstrated market inhibitory effect against mycelium growth and spore formation of A. niger. In present study lemongrass and Figures extract significantly reduced the postharvest diseases of date palm fruits during storage. Using lemongrass essential oil for controlling postharvest diseases of several fruits was reported by<sup>[30]</sup>.

### Effect of coating solutions on breaking length and water absorption of carton

In general, moisture content of prickly pear cactus stem differs according to the size of the stem. A small stem (13cm length) has a moisture content of 96.68%, while a large one (24cm length) has a moisture content of 92.58 %. At room temperature, the pH value of cactus mucilage is approximately 5.8- 6. On raising temperature the acidity of mucilage increases. Also it is noticed that pH of pulping liquor is approximately the same as mucilage. An important point in the choice of the cactus mucilage as a coating is its



low cost. TABLE 1 indicates that coating solutions used in this study decrease tensile strength of coated carton and increase water uptake. Carton coated with cactus pear mucilage containing polyethylene glycol has less tensile strength more than carton coated by mucilage only or coated with pulping liquor. This is in agreement with the fact that plasticizer increase flexibility and decrease tensile strength. Also the polarity and hydrophilic nature of this plasticizer increase water uptake of coated carton. It is clear that the complex polymer cactus pear mucilage is preferred in coating more than oil. The UV-VIS spectra of the polymer carbohydrate and its diluted form are illustrated in Figure 1. It is shown from the Figure that the characteristic peak at 300 nm are due to  $n-\pi$  transitions of the OH groups in carbohydrates and it is clearly seen also that this peak is slightly shifted due to dilution to 200-240 nm.

### The effects of PEG with different molecular weights on mechanical properties of coated carton

From Figure 2, it is observed that an increase in the molecular weights of PEG induced an increase of the TS, of carton. Figure 2 also shows that compared with uncoated carton, the addition of PEG of any molecular weight led to a decrease of the TS. Polar groups ( $-\text{OH}$ ) along plasticizer chains are believed to develop polymer-plasticizer hydrogen bonds replacing the polymer-polymer interactions in biopolymer films<sup>[38]</sup>. Hydrogen bonding ability of PEGs was affected by factors such as the number of hydroxyl groups per mole, molecular size, solubility and polarity.

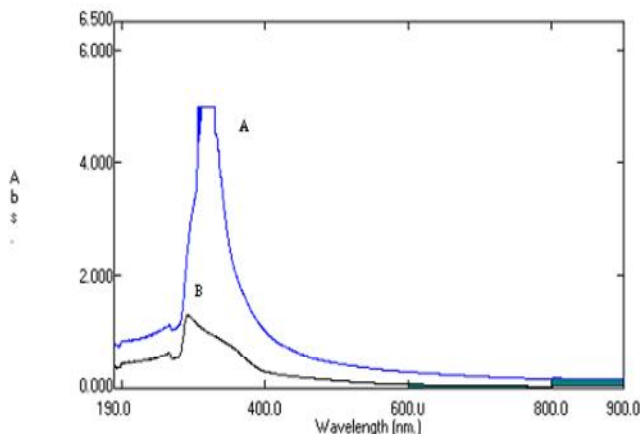


Figure 1: UV-visible spectra of cactus pear mucilage (A) and pulping liquor (B) from 200 to 400 nm.

### Breaking Length (m)

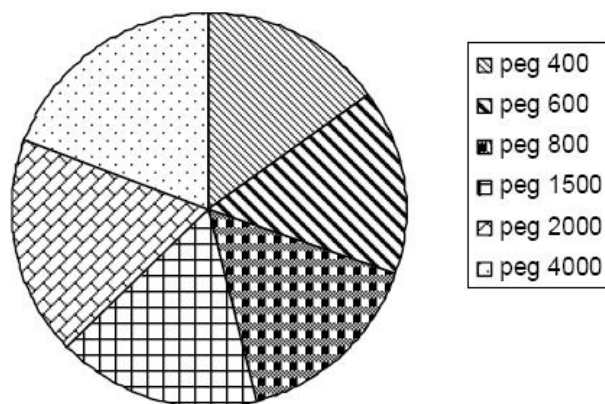


Figure 2 : The effects of PEG with different molecular weights on tensile strength of cartone coated by cactus pear mucilage.

The hydrogen bonding interactions decreased as the molecular weight of PEG increased. In addition, as the molecular weight of PEG increases, its polarity and solubility decrease, causing a decrease in its ability to interact with polymer chains. Due to all the reasons mentioned above, the high molecular weight PEGs might not be able to position themselves effectively between polymer segments and, therefore, might not be able to form sufficient hydrogen bonds with polymers<sup>[37]</sup>. Therefore, PEG of a smaller size could be more readily inserted into the polymer chains. PEG of lower molecular weight had a larger number of hydroxyl groups per mole than PEG of higher molecular weights. Thus, PEG of higher molecular weight is preferred when carton of high TS is required according to the purpose of packaging.

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