Asian Journal of Agricultural and Horticultural Research

3(3): 1-11, 2019; Article no.AJAHR.47393
ISSN: 2581-4478

Application of Arabic Gum and Essential Oils as the Postharvest Treatments of Le Conte Pear Fruits during Cold Storage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2019/v3i329999
Editor(s):
(1) Dr. Ahmed Medhat Mohamed Al-Naggar, Professor of Plant Breeding, Department of Agronomy, Faculty of Agriculture, Cairo University, Egypt.
(2) Dr. Paola A. Deligios, Department of Agriculture, University of Sassari, Italy.
Reviewers:
(1) Gerald Ngo Teke, University of Bamenda, Cameroon.
(2) Ola T. Alhalabi, General Commission for Scientific Agricultural Research (GCSAR), Syria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47393

Original Research Article

Received 12 November 2018
Accepted 15 February 2019
Published 14 March 2019

ABSTRACT

The present study was conducted during 2015 and 2016 seasons on Le Conte pear fruits harvested at mature stage, to investigate the application of (10% w/v) Arabic Gum (AG), Jojoba oil (JO) and Moringa oil (MO) at the rate (100 %) alone on physical and chemical properties. Fruits stored at 0 ± 1°C and 85-90 % relative humidity (RH) for 105 days. A fruit sample of each treatment was taken out at the end of cold storage period and left at room temperature (23 ± 2°C) and 47% (RH) up to 7 days was examined for quality Assessments. Fruit physical properties (weight loss, decay percentages and fruit firmness "Lb/inch2") and fruit chemical properties (total soluble solids percentage and total acidity percentage were evaluated. The results obtained that, all treatments including control succeeded in preventing fruit decay percentage up to 30 days in the two seasons. It is worth mentioning that, Le Conte pear fruits were coated with MO with stands free from deterioration up to 75 days of cold storage period. Beside, fruits coated MO progress in reducing the percentages of weight loss and decay throw cold storage periods for 105 day. The rate of softening increased in fruits with increasing the storage time in both fruits coated and uncoated, but it was significantly declined in uncoated treatments. Moreover, JO coating was more effective in firmness retention compared to the other treatments. Followed by pear fruits was

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coating with MO and AG in this respect. Furthermore, all coated fruits enhancement fruit quality during storage periods. Finally, it can be concluded that coating Le Conte fruits by Moringa oil recorded successfully reduction in fruit weight loss, decay percentages, improving fruit quality and extended storage fruit life as well as stimulate marketing period (shelf life), also safe on environmental and human health.

Keywords: Le Conte pear; postharvest; Arabic gum; jojoba oil; moringa oil; fruit quality.

1. INTRODUCTION

Pears (*Pyrus communis*, L.) are climacteric fruits whose ripening is regulated by ethylene and exhibiting a relatively short shelf life. During ripening of pears, some changes are observed in colour, firmness, acidity and sugar content [1]. The prolong shelf life of pears using edible coating that are used to improve the mechanical integrity or handling properties of the fruits, reporting the ability of the technological strategy to retard changes in oxygen, moisture, aromas and soluble transport [2,3].

Arabic Gum (AG) is used in partial destruction on many alkaloids including morphine, homatropine, atropine, scopolamine, apomorphine, hyoscyamine, physostigmine and cocaine [4]. AG coating might reduce the sources of energy, hormones, water and nutrients and also this leads to a rapid initiation of senescence [5] used of Arabic Gum as postharvest covering of fruits cause reduce water loss and weight of fruits and delay fruit ripening [6]. In addition, use of AG in dentistry because it enhance some antimicrobial activity [7]. Arabic Gum is the least viscous and is used extensively in the industrial sector because of its emulsification, encapsulation properties and film forming [8].

Application of coatings has long historical backgrounds and commercially applied about sixty years ago [9]. Fruit quality is improved with the application of surface coated by essential oil such as Jojoba oil and Moringa oil through retarding the water loss, improving the external skin layer and making the skin for differential permeable to O^2 and CO^2 gases and transpiration rate is reduced [10]. Jojoba oil (JO) had response to the effect of antibiotic activity [11]. Furthermore, [12] they concluded that edible coating with Jojoba oil (*Simondisia chinensis*) Monodyglycerides Water gave the best in terms of physico-chemical properties of fruits and significantly increased the shelf life.

Moringa (*Moringa oleifera*) is a special food for the tropics. Almost all parts are used as food and forage for livestock 27. Moringa had long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavor compounds and reducing microbial growth [13]. The role of edible coatings fresh produce provides a partial barrier to the movement of moisture on the surface of fresh produce, thereby, minimising moisture loss during postharvest storage; ages barrier there by establishing a modified atmosphere around the product, which slows down respiration, senescence and enzymatic oxidation and preserves colour and texture, helps to retain volatile compounds contributing to produce natural aroma and restrict foreign odours; maintains fresh produce structural integrity, protect an against mechanical damages and serve as carriers of functional or active compounds such as nutraceutical, flavoring and colouring agents, antioxidants and anti-microbial that will improve product quality and safety [14,15].

The objective of this research was to evaluate the potential of Arabic Gum, Jojoba oil and Moringa oil to improve fruit quality and storability during cold storage periods and stimulating marketing period (shelf life) of Le Conte pear fruits.

2. MATERIALS AND METHODS

2.1 Pear Orchard

The present study was conducted during 2015 and 2016 seasons on uniform in vigor twenty year's old pear trees cv. Le Conte (*Pyrus communis*, L.) budded on *Pyrus communis* rootstock grown in a clay loamy soil, spaced 5 x 5 m. under flood irrigation system, grown in a private orchard located at Kalubia Governorate Egypt. Selected trees were healthy, nearly uniform in growth vigor and received regularly the recommended horticultural practices.

2.2 Fruit Sample

Fruits harvested at commercial maturity stage at the first week of August 2015 and 2016 seasons.

Maturity fruits were selected undamaged, uniformed in shape, freedom from blemishes, pathogen infection, and immediately transferred to the laboratory of Agriculture Development Systems (ADS) project in the Faculty of Agriculture, Cairo University.

2.3 Preparation of Arabic Gum (AG), Jojoba Oil (JO) and Moringa Oil (MO)

Jojoba and Moringa oils obtained from Cairo for oil and soap company (Giza, Egypt) and Arabic Gum (Giza, Egypt) were of commercial grade. The optimum concentrations of AG, JO and MO were selected based on previous findings [16]. AG (10% w/v) was prepared by dissolving 10 g of AG powder in 100mL purified water. The solution was stirred with low heat (40 ◦C) for 60 min using a hot plate magnetic stirrer (Model: LMS-HTS-1003, Bunkyo-Ku, Tokyo, Japan) and filtered using cheesecloth to remove the undissolved materials. Essential oils of JO and MO (100 %) were used 100 % natural.

2.4. Treatments and Storage Condition

Fruits were coated with thin layer of each above mentioned oils treatment (100 %), separately and left to air dried. The control treatment, anther fruits without coated. Every treatment has ten replicates, every replicate contained 6 fruits. Each replicate per treatment were packed in fiberboard cartons and stored at 0 ± 1ºC and 85 – 90% relative humidity (RH) for 105 days. At 15 days intervals, fruit samples (5 fruits in each treatment) were removed from cold storage and fruit quality measurements were assessed. Marketing Period, A sample of 20 fruits of each treatment was taken out at the end of cold storage period and left at room temperature (23 ± 2°C) and 47% (RH) for one week was examined for quality Assessments.

2.5 Fruit Quality Assessments

2.5.1. Physical Characters

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

ii. Decay percentage: Fruits which were decayed by different physiological and pathological factors were periodically counted and discarded. Then percentage of fruits was calculated in relation to the total number of fruits.

iii. Fruit firmness: Was determined as Lb/inch^2 by using fruit pressure tester model FT 327 (3-27Lbs).

2.5.2 Chemical Characters

i. Total soluble solids percentage (TSS %) by using hand refractometer.
ii. Total acidity (TA %) was estimated as percentage of Malic acid in fruit juice [17].

2.6 Statistical Analysis

The data were subjected to statistical analysis using computer based software “MS-Excel” and results were submitted to analysis of variance [18]. Differences among treatment means were determined by using the LSD test at a significance level of 0.05 [19].

3. RESULTS AND DISCUSSION

3.1 Fruit Physical Properties

3.1.1 Fruit weight loss percentage

The results in (Table 1) showed that in both seasons, all tested treatments succeeded in reducing weight loss percentage of Le Conte pear fruits in comparison with untreated fruits (control). Meanwhile, fruits were coated with MO proved to be the most efficient treatment in reducing weight loss (%) followed by JO then AG in compared with the control a descending order in this respect. As for the effect of storage periods, it is quite evident that fruit weight loss percentage was increased with advancing the cold storage periods, so 15 days storage period scored the lowest values, while the highest values was against after 105 days storage periods in both seasons. Regarding the interaction effect between the tested postharvest treatments and storage periods, results indicated that, the lowest fruit weight loss percentages were registered by the combination of 15 days cold storage periods, especially MO (0.52 and 0.60 %) in both seasons. the highest fruit weight loss percentages were obtained by the interactions of 105 days cold storage period, particularly control fruits (9.28 and 12.23 %) in both seasons. the remained interactions of the tested storage periods came in between them.

The positive effect of MO in reduction of weight loss may be due to edible coating provide a semi permeable barrier against oxygen, carbon

dioxide, moisture and solute movement, thus reducing respiration, water loss and oxidation reaction [20]. The obtained results are in agreement with the findings of [5,21] on apple fruit and [22] on tangerine citrus fruit. They found that fruit treated with edible coating showed a significant delay of weight loss (%) during cold storage compared to the uncoated fruits (control).

3.1.2 Fruit decay percentage

The results in (Table 2) showed that fruit decay (%) increased by progress the storage periods, with high significant differences between them in both seasons. Meanwhile, the periods15 and 30 days of storage durations produced healthy fruits free from decay and recorded zero decay percentage of all treatments in the 1st and the 2nd seasons. Concerning the effect treatments, all treatments had positive effect in this connection. Le Conte pear fruits were coated with MO with stands free from deterioration up to 75 days of cold storage period and gave the lowest means value of decay which recorded (5.71 & 3.76 %), respectively in both seasons. It is worth mentioning that, fruits AG coated behave the same behavior fruits MO coated in the second season only, it successes to prevent decay up to 60 days. As for fruits JO coated followed by fruits MO coated in the first season but, came next fruits AG coated in this respect. It can be noticed, 105 days cold storage scored significantly the highest fruit decay (%) followed descending those cold stored of 90 days in both seasons. Also, fruits AG coated and uncoated fruits recorded the highest statistical decay % in those periods. On the other hand, the highest fruit decay at the end storage (66.70 and 58.35 %) was obtained from uncoated fruits consecutively in the two seasons.

The reducing decay % of Le Conte pear fruits coated with MO, JO and AG was due to the effects of these coatings on delaying senescence. Also, the function of edible coating showed inhibitory effect on pectinase and cellulose enzymes and in delay in ripening, which makes the commodity more vulnerable to pathogenic infection as a result of loss of cellular or tissue integrity [23]. In additions, the results are in harmony with [6]. They mentioned that Arabic gum was more effective in decay slowly and delaying senescence as compared to control.

3.1.3 Fruit firmness (Lb/inch^2)

Results in (Table 3) demonstrated that, fruit firmness of Le Conte pear was affected by using all examined postharvest treatments. Moreover, the lowest value of fruit firmness was scored by uncoated fruits and nearly of AG. Referring to the effect of cold storage periods, data indicated that, fruit firmness decreased as the storage period prolonged in both seasons. In general, the results obtained that JO retained the highest firmness of Le Conte pear fruits in the two seasons in the same period and acted a barrier against nutrient and water loss. The maximum means firmness was maintained by JO (19.30 & 20.04 Lb/inch^2), followed by fruits were coated with MO (18.24 & 19.21 Lb/inch^2) and AG (16.33 & 17.36 Lb/inch^2) as compared uncoated fruits (16.25 & 16.92 Lb/inch^2), consecutively in both seasons. It is worth to be mentioned, there were high significant differences between all treatments including the control.

These results confirm of [24] they found that the retention of firmness can be explained by retorted degradation of in soluble protopectins to the more soluble pectic acid and pectin. During fruit ripening, polymerization or shortening of chain length of pectin substances occurs with an increase in pectin esterase and poly galactronases activities. Jojoba oil is completely different from the structure for all plant oils. It is chemically classify as a liquid wax output of union fatty acids and alcohol with a carbon chain and one long containing 40-44 carbon atoms, for this the areas use of very multi [25]. This may be due to the inhibition of water loss and the activities of pectin-degrading enzymes closely related to fruit softening by reducing the rate of metabolic processes during senescence [26]. Our results are in harmony with the findings by [27,28] they arrived that edible coating such as jojoba and moringa oils may help in maintaining firmness and provide gloss to coated fruits. In this regarding, [29] found that apples fruit were coating with tragacanth gum at 10 kg m^{-3} have preserved firmness of fruit tissue in storage and prevented the softening and senescent breakdown.

3.2 Fruit Chemical Properties

3.2.1 Total soluble solids percentage (TSS %)

Data as shown in Table 4 was gradually increased by progress the storage period.

However, the highest significant values of TSS % at the end of storage period (105 days) were obtained with all coated treatments comparing with uncoated treatment. Nevertheless, AG revealed pronounced in this respect, it is recorded (15.35 & 16.25 %) at 105 days of cold storage, consecutively in the two seasons followed by, fruits coated with MO (13.15 %) and JO (12.90 %) in the 1st season. While, fruits coated with JO (14.90 %) about MO (14.00 %) in the 2nd season in this respect, but with no significant among them in both seasons. The lowest significant values of TSS % recorded by fruits uncoated (12.40 & 12.25 %) at 105 days of cold storage, respectively in the two seasons.

The obtained results are confirmed with those obtained by [16] they revealed that significant effects were observed for all AG and essential oil treatments alone as well as in combination in terms of total soluble solids of both tested fruits banana and papaya during cold storage. While, ten percent A Galone more pronounced effects in maintaining the quality parameters as compared with essential oils alone and the control. Moreover, [30,31] they found that fruit coated with AG had a significant higher TSS % during storage periods.

Also, [32] who indicated that the treatment of edible coatings with moringa and jojoba oils have long been known to protect perishable food products from deterioration by improving textural quality. Similar results were obtained by [33, 34] where the use of edible coating on pears variety “Huanghua” and variety “Flor de Invierno,” respectively, has no significant differences between the treatments.

3.2.2 Total Acidity percentage (TA %)

The results in Table 5 indicate that, there were no significant differences between tested postharvest treatments as well as the interaction between it and storage periods, in both seasons when TA% was concerned. Also data appeared that there was gradual decline in juice fruit TA% of Le Conte pear with advancing the storage period throw cold storage in the two seasons. So, stored fruits for 15 days scored the highest values of this parameter as compared with other different storage periods in both seasons. While, stored fruits for 105 days registered the lowest values in this respect.

Our results are in harmony with [20] on banana and papaya fruits, [21] on apple fruits and [35] on pear fruits. They detected edible coating of fruits including AG, JO and MO enhanced fruit quality.

3.3 Shelf Life

A glance to Table 6 indicated that all treatments under study approximately gave the same direction on influence of Le Conte fruits physical and chemical characteristics through cold storage (0 ± 1° C) for 105 days plus one week at room temperature (23 ± 2°C) as a simulated marketing period (shelf-life) during 2015 and 2016 seasons. Moreover, all edible coating more effective in improving Le Conte fruit quality when compared with uncoated fruits. Moringa oil fruits coated were more pronounced in reducing percentages of weight loss (1.52 & 0.58 %) and decay (0.0 & 0.0 %), then jojoba oil ("3.17 & 0.62 %" and "0.0 & 12.5 %") and gum arabic ("3.37 & 2.33 %" and "25.0 & 12.5 %"), respectively in the two seasons. Jojoba oil fruits coated progress in increasing firmness (11.30 & 11.95 Lb/inch^2), followed by MO (10.75 & 10.90 Lb/inch^2) and AG (9.90 & 10.50 Lb/inch^2), consecutively in both seasons. Gum Arabic fruits coated advancing in increment percentage of total soluble solids (10.80 & 11.75 %), while MO (10.50 & 10.55 %) and JO (10.20 &10.30 %), sequentially in the 1st and the 2nd seasons. Meanwhile, the control treatment obtained the highest significant values of weight loss, decay and total acidity (0.55 & 0.55 %) as well as it recorded the lowest significant values of firmness (9.00 & 9.20 Lb/inch^2) and total soluble solids (9.60 & 9.85 %), alternately in both seasons.

The obtained results were nearly in the same line with obtained by [32] who indicated that the treatment of edible coatings with moringa and jojoba oils have long been known to protect perishable food products from deterioration by improving textural quality and extend the shelf life. [36] they said that the essential oils play an important role in the protection of plants. Also, [35] on pear fruits found that edible coating application represent a good alternative to keep pears freshness for longer periods. The same trend were detected, [20] on banana and papaya fruits as well as [21] on apple fruits. They detected edible coating of fruits including AG, JO and MO improving fruit quality as well as extending shelf life.

Table 1. Effect of Arabic Gum, Jojoba oil and Moringa oil on weight loss (%) of Le Conte pear fruits stored for 105 days at 0° C during 2015 and 2016 seasons

Treatments	1st season							Means	2nd season							Means
	Storage periods (days)								Storage periods (days)							
	15	30	45	60	75	90	105		15	30	45	60	75	90	105	
Arabic Gum	0.44	1.73	3.49	4.47	5.46	6.70	8.33	**4.37**	1.51	2.58	4.74	5.82	6.91	7.74	8.42	**5.39**
Jojoba oil	0.78	1.35	3.07	4.13	4.15	5.16	6.32	**3.56**	0.67	1.02	2.77	3.40	4.05	5.30	5.28	**3.21**
Moringa oil	0.52	1.03	2.14	2.69	3.23	3.46	5.47	**2.65**	0.60	1.11	1.63	2.45	3.26	4.29	4.34	**2.52**
Control	1.02	1.89	3.24	4.73	6.20	7.32	9.28	**4.81**	2.48	2.66	4.32	6.78	9.14	10.14	12.23	**6.82**
Means	**0.69**	**1.50**	**2.98**	**4.00**	**4.76**	**5.66**	**7.35**		**1.31**	**1.84**	**3.36**	**4.61**	**5.84**	**6.86**	**7.56**	
$LSD_{0.05}$:																
Treat		0.007	***							0.02	***					
Time		0.014	***							0.04	***					
Treat X Time		0.03	***							0.07	***					

Table 2. Effect of Arabic Gum, Jojoba oil and Moringa oil on decay (%) of Le Conte pear fruits stored for 105 days at 0° C during 2015 and 2016 seasons

Treatments	1st season							Means	2nd season							Means
	Storage periods (days)								Storage periods (days)							
	15	30	45	60	75	90	105		15	30	45	60	75	90	105	
Arabic Gum	0.00	0.00	8.35	8.35	8.35	25.00	41.65	**13.10**	0.00	0.00	0.00	0.00	8.35	16.70	25.00	**7.15**
Jojoba oil	0.00	0.00	8.35	8.35	8.35	16.70	24.80	**9.51**	0.00	0.00	8.35	8.35	8.35	15.00	23.35	**9.06**
Moringa oil	0.00	0.00	0.00	0.00	0.00	16.70	23.30	**5.71**	0.00	0.00	0.00	0.00	0.00	11.65	14.65	**3.76**
Control	0.00	0.00	16.70	16.70	16.70	58.35	66.70	**25.02**	0.00	0.00	16.70	16.70	25.00	41.65	58.35	**22.63**
Means	**0.00**	**0.00**	**8.35**	**8.35**	**8.35**	**29.19**	**39.11**		**0.00**	**0.00**	**6.26**	**6.26**	**10.43**	**21.25**	**30.34**	
$LSD_{0.05}$:																
Treat		2.13	***							3.7	***					
Time		6.03	***							6.2	***					
Treat X Time		9.54	***							9.84	**					

NS: Not significant

Table 3. Effect of Arabic Gum, Jojoba oil and Moringa oil on firmness (Lb/inch^2) of Le Conte pear fruits stored for 105 days at 0^o C during 2015 and 2016 seasons

Treatments	1st season							Means	2nd season							Means
	Storage periods (days)								Storage periods (days)							
	15	30	45	60	75	90	105		15	30	45	60	75	90	105	
Arabic Gum	24.90	19.75	16.75	15.65	14.50	12.50	10.25	**16.33**	27.25	20.50	17.65	16.50	15.25	13.25	11.15	**17.36**
Jojoba oil	27.75	21.75	19.45	18.85	18.25	15.25	13.80	**19.30**	29.00	21.75	19.70	19.30	19.25	16.50	14.75	**20.04**
Moringa oil	26.75	20.00	19.50	18.40	17.25	13.75	12.00	**18.24**	29.25	21.25	19.65	19.05	18.35	14.40	12.50	**19.21**
Control	23.50	19.50	16.90	15.70	14.50	12.40	11.25	**16.25**	24.25	20.75	17.00	16.00	14.85	13.25	12.35	**16.92**
Means	**25.73**	**20.25**	**18.15**	**17.15**	**16.13**	**13.48**	**11.83**		**27.44**	**21.06**	**18.50**	**17.71**	**16.93**	**14.35**	**12.69**	
$LSD_{0.05}$:																
Treat		0.24	*							0.32	*					
Time		1.09	***							1.67	***					
Treat X Time		NS								NS						

NS: Not significant

Table 4. Effect of Arabic Gum, Jojoba oil and Moringa oil on total soluble solids (%) of Le Conte pear fruits stored for 105 days at 0^o C during 2015 and 2016 seasons

Treatments	1st season							Means	2nd season							Means
	Storage periods (days)								Storage periods (days)							
	15	30	45	60	75	90	105		15	30	45	60	75	90	105	
Arabic Gum	12.25	12.40	12.40	12.50	12.60	12.70	15.35	**12.89**	12.50	12.65	12.35	12.50	12.60	12.75	16.25	**13.09**
Jojoba oil	10.95	11.45	11.85	11.90	12.00	12.20	12.90	**11.89**	11.05	11.50	11.90	11.95	12.10	12.25	14.90	**12.24**
Moringa oil	10.85	11.45	11.25	11.60	12.20	12.80	13.15	**11.90**	11.25	11.55	11.75	12.10	12.45	13.10	14.00	**12.31**
Control	10.40	11.05	11.30	11.60	11.80	12.15	12.40	**11.53**	10.35	11.30	11.65	11.75	11.95	12.30	12.25	**11.65**
Means	**11.11**	**11.59**	**11.70**	**11.90**	**12.15**	**12.46**	**13.45**		**11.29**	**11.75**	**11.91**	**12.08**	**12.28**	**12.60**	**14.35**	
$LSD_{0.05}$:																
Treat		0.72	*							0.56	*					
Time		0.67	***							1.26	**					
Treat X Time		NS								NS						

NS: Not significant

Table 5. Effect of Arabic Gum, Jojoba oil and Moringa oil on total acidity (%) of Le Conte pear fruits stored for 105 days at 0° C during 2015 and 2016 seasons

Treatments	1st season							Means	2nd season							Means
	Storage periods (days)								Storage periods (days)							
	15	30	45	60	75	90	105		15	30	45	60	75	90	105	
Arabic Gum	1.55	1.40	1.15	0.95	0.80	0.70	0.60	**1.02**	1.50	1.35	1.00	0.85	0.75	0.70	0.60	**0.96**
Jojoba oil	1.75	1.15	0.80	0.75	0.75	0.55	0.55	**0.90**	1.75	1.25	0.90	0.80	0.75	0.55	0.50	**0.93**
Moringa oil	1.45	1.00	0.75	0.75	0.75	0.70	0.65	**0.86**	1.60	1.00	0.95	0.85	0.75	0.75	0.65	**0.94**
Control	1.40	1.25	0.95	0.85	0.75	0.65	0.60	**0.92**	1.60	1.30	0.95	0.85	0.75	0.65	0.60	**0.96**
Means	**1.54**	**1.20**	**0.91**	**0.83**	**0.76**	**0.65**	**0.60**		**1.61**	**1.23**	**0.95**	**0.84**	**0.75**	**0.66**	**0.59**	
$LSD_{0.05}$:																
Treat		NS								NS						
Time		0.14	***							0.13	***					
Treat X Time		NS								NS						

NS: Non significant

Table 6. Effect of Arabic Gum, Jojoba oil and Moringa oil on shelf life of Le Conte pear fruits stored for 105 days at 0° C + 7 days at (23 ± 2°C) during 2015 and 2016 seasons

Treatments	Weight loss (%)		Decay (%)		Firmness (Lb/inch^2)		Total soluble solids (%)		Total acidity (%)	
	2015 Season	2016 Season	2015 Season	2016 Season	2015 Season	2016 Season	2015 Season	2016 Season	2015 Season	2016 Season
Gum Arabic	3.37	2.33	25.0	12.5	9.90	10.50	10.80	11.75	0.50	0.50
Jojoba oil	3.17	0.62	0.0	12.5	11.30	11.95	10.20	10.30	0.45	0.50
Moringa oil	1.52	0.58	0.0	0.0	10.75	10.90	10.50	10.55	0.50	0.45
Control	4.22	8.40	75.0	87.5	9.00	9.20	9.60	9.85	0.55	0.55
$LSD_{0.05}$	**0.02**	**0.013**	**NS**	**53.9**	**NS**	**0.94**	**0.23**	**1.11**	**NS**	**NS**

NS: Non significant

4. CONCLUSIONS

These observations of this investigation indicated that coating Le Conte fruits by Moringa oil recorded successfully reduction in fruit weight loss, decay percentages, improving fruit quality and extended storage fruit life as well as stimulate marketing period (shelf life), also safe on environmental and human health.

ACKNOWLEDGEMENTS

We would like to thank the professors of Pomology, National Research Center (NRC) the late Dr/ Mamdouh Mohamed Nageib for providing support and was supplying us in his private farm and the late Dr/ Salwa Anwar Khafagy, to assist in this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI:10.3390/ph6121451.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47393