Effect of some postharvest treatments with edible coating materials on storability and quality of Murcott Tangor fruits during cold storage.

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ABSTRACT

Murcott tangor [*Citrus reticulata* × *Citrus sinensis* (L.) Osbeck] is a promising export mandarin variety due to its extended harvest season and fruit quality attributes. Mandarin fruit is perishable; it losts its marketability rapidly due to the growth of microbial pathogens, desiccation and softening. So, the present study aimed to investigate the effects of gum Arabic (GA), jojoba oil (JO), and chitosan (CHI) as edible materials on storability and keeping the quality of cold stored Murcott tangor fruits in the 2018 and 2019 seasons. Fruits were dipped for five minutes in one of the following solutions: distilled water, GA (5, 10, and 15% W/V), JO (0, 05, 0.1, and 0.15% V/V), and CHI (1, 2 and 3% W/V), air dried, put in carton boxes and stored at 5±1C° and 95% relative humidity for 100 days. The results indicate that fruit decay and quality characteristics were affected positively by the application of the edible coating, while 10% of GA recorded the lowest fruit decay incidence and weight loss percentages in both seasons. Fruit firmness, total soluble solids, total acidity and vitamin C has been decreased gradually by progress in the storage period for all treatments while 0.15 %of JO recorded the lowest values of decreased compared to the other treatments in both seasons. It can be recommended to use 0.15 % of JO for extending the shelf life of Murcott tangor fruits while preserving the highest quality characteristics and the lowest percentage of spoilage up to 100 days at 5±1 C° and 95% relative humidity.

Keywords: Murcott Tangor, Gum arabic, Jojoba oil, Chitosan, cold storage, and edible coatings

INTRODUCTION

Murcott tangor [*Citrus reticulata* × *Citrus sinensis* (L.) is a promising mandarin cultivar in Egypt due to its extended harvest season (from January to the end of March) and its excellent qualities that coincide with the world market demand (Fahmy *et al.,* 2018). Postharvest wastage is a global concern as surveys revealed that huge amount of produce is wasted annually due to poor postharvest practices as well as the inability to prolong post-harvest shelf life (Tasneem, 2004).

Mandarin varieties lose their quality during storage readily susceptible to infection by microbial pathogens during the period between harvest and consumption. The postharvest diseases of citrus fruit cause considerable losses during storage and transportation. Therefore, postharvest wastage is one of the global concerns (Tripathi and Dubey, 2004 and Fahmy *et al.,* 2018). Several synthetic fungicides are used for rot control but many countries do not allow the use of those fungicides, or they have a restricted approved list of authorized ingredients. Consequently, more studies to find safe materials as alternatives for synthetic fungicides are needed (Zoffoli *et al.,* 2008).

Gum Arabic (GA) is one of the biopolymers, obtained from acacia tree branches of *Acacia spp.* plants which are composed of Galactose, Rhamnose, Arabinose, and Glucuronic acid (Yadav and Karthikeyan, 2019). GA coating was applied on many other fruits giving good results (Sultan, 2014).

Jojoba oil (JO) is taken out from the seed of the jojoba (*Simmondsia chinensis* (Link) C. K. Schneid) plant and has been widely used by the cosmetic and pharmaceutical industries for several years (El-Emam *et al.,* 2019 and Sturtevant *et al.,* 2020). JO is not a triglyceride like other plant oils but a mixture of long-chain esters (97–98%) of fatty acids and fatty alcohols, thus, it is referred to as wax or oil-wax (Sturtevant *et al.,* 2020). Postharvest application of plant oils as alternatives to synthetic fungicides has been reported (Shehata *et al.,* 2017, and Taheri *et al.,* 2020). Postharvest application of JO reduced weight loss, decay incidence in kinnow mandarin (Din *et al.,* 2015) fruits.

Chitosan (CHI) is one of the most common natural polymers that can be obtained from the exoskeletons of crustaceans, also it's found in the cuticles of insects and in the cell walls of fungi and some algae (Suhag *et al.,* 2020). CHI coating is considered the best edible and biologically safe preservative coating for different types of fruits, with functional advantages, such as slower respiration, extending of storage period, shelf life of fruits, firmness retention and controlling microbial pathogens (Vilaplana *et al.,* 2020). The present study is planned to investigate the effect of JO, CHI and GA as edible coating materials on storability and keeping quality of Murcott tangor fruits stored at 5±1 C° and 95% relative humidity (RH) of 100 days.

MATERIALS AND METHODS

Plant material:

Murcott tangor [*Citrus reticulata* × *Citrus sinensis* (L.) Osbeck] fruits were picked from six years old trees grown in a private orchard located at Wady Elmolak, El-sharqia Governorate, Egypt. The trees were planted at 4 × 4 meters apart, budded on Volkamer lemon (*Citrus volkameriana*) rootstock and grown in sandy soil under drip irrigation system.

Fruit samples were randomly collected from the four directions North, East, South, and West) and three levels (top, medium, and bottom) of the tree canopy. The fruits were all in one size, color and free from any visual defects. Maturity indices were adjusted when the TSS of fruit juice reached 12-13% and 0.9-1.0 % TA according to (Elnaggar, 2017).

Postharvest treatments:

The harvested fruits were immediately transferred to the laboratory of "Egypt - California" project, Faculty of Agriculture, Cairo University. All fruits sorted, washed in running tap water, disinfected with 1% (w/v) borax for 3 minutes and air-dried. The fruits were divided into 10 groups (300 fruits per each group). The fruits in the groups were dipped for five minutes in one of the following solutions:

Control treatment (Distilled water).

GA at concentrations of 5, 10 and 15 % (W/V).

JO at concentrations of 0.05, 0.10 and 0.15 % (V/V).

CHI at concentrations of 1, 2 and 3% (W/V).

All solutions were supplemented with 0.05 % tween 20 as a surfactant and fruits were air-dried. Fruits were packed in carton boxes in a single layer (25 fruits / box) three replicates for every treatment, each replicate contain 4 boxes (10 treatments x 3 replicates x 4 boxes) as two boxes to determine (decay, weight loss, rind color and respiration rate) and the other two boxes for determining (firmness and chemical analysis), each box contains (25 fruits) and No. of fruit experiments (12 boxes for each treatment x 25 fruits = 300 mandarin fruits). Fruits put in a single layer and stored at 5±1 C° and 95% RH for 100 days in refrigeration, Agriculture Development Systems (ADS) project in the Faculty of Agriculture, Cairo University. Fruit quality parameters determine every 20 days during storage period.

Measurements:

Decay incidence:

Decay incidence was determined by calculating the number of decayed fruits on the sampling date and expressed as a percentage of the initial fruit number Decayed fruits % = {(A / B) × 100} where (A) is a number of decayed fruits at the time of sampling and (B) is a number of the initial fruits (El-Anany et al., 2009).

Weight Loss:

The weight loss was calculated as follows: weight loss (%) = [(W0 – W1)/W0] X100, where (W0) is the initial weight and (W1) is the weight of fruits that is measured at the sampling date.

Peel color:

Fruit peel color was determined by a Minolta colorimeter type (CR-400/410) and data expressed as hue angle as described by (Tietel *et al.,* 2012).

Fruit firmness:

Fruit firmness was measured on the two opposite sides of three fruits per box by pressure tester (Digital Force-Gouge Model FGV-0.5A to FGV-100A Shimpo instruments) with a probe 5mm in diameter and a penetration depth of 4 mm and data were expressed as kg/cm^2.

Total soluble solids (TSS):

TSS of fruit juice were estimated by digital refractometer (ATAGO, mod. N-1E, Japan) and data were expressed as % according to (A.O.A.C., 2000).

Total acidity (TA):

TA was determined by titration of 0.1 N, Na OH, using phenolphthalein as an indicator and the data were expressed as g citric acid per 100 ml fruit juice according to (A.O.A.C., 2000).

Ascorbic acid (VC):

Ascorbic acid in filtered juice was determined by titration with 2, 6-dichlorophenol indophenol dye and data were expressed as mg / 100 ml fruit juice (Denre, 2014).

Respiration rate:

Four fruits per replicate were weighed, marked and devoted to follow the respiration rate by using a closed system. The fruits were filled into airtight glass flasks of known volume. After packaging, the flask was tightly closed and kept for two hours at 5 C°, RH 95 %. Both O_2 and CO_2 concentrations in the jar were monitored using a Servomex 1450C Food Package Analyzer (Crowborough, Sussex, UK) and the data were expressed in ml CO_2/kg/h as described by (Ahmed and Sobieh, 2007).

Statistical analysis:

This experiment was arranged as a factorial completely randomized factorial design with three replications. The treatment means were compared using the least significant difference test (LSD) at 5% level of significance according to (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Decay incidence %:

The results in the table (1) showed that there were continuous increases in decay percentage with a prolonging storage period in all treatments. The treatment of JO at 0.1% recorded the best results were possessed the lowest decay percentage of fruits in the first season, while in the second season the treatment of JO at 0.15% recorded the lowest decay percentage that caused the best results of decay followed in descending order JO at 0.1% and GA at 15 %.

These results agreed with (Hassan *et al.*, 2014) who recorded that, the application of edible coating will partially restrict gas exchange through the fruit peel and inhibit the action of ethylene; this inhibitory action can provide better protection against postharvest decay in fruits.

On the other side, control and GA at 15% treatments recorded the highest decay percentage in both seasons.

Furthermore, the increase in fruit decay during storage period is mainly due to loss in fruit weight which led to shriveling and deterioration, as it is known that the dipping treatments reducing the weight loss rate which led to decreasing the fruit decay percentage (El- Eryan and Tarabih, 2020).

In the same direction, (Tripathi and Dubey, 2004) reported that the decay of citrus fruits may be due to low pH, high moisture content, and many nutrients in fruit juice, which let them susceptible to be attached by pathogenic fungi, which causes rotting, producing mycotoxins and making them unfit for consumption.

2.1. Weight loss %:

The weight loss percentage of Murcott tangor fruits was affected by different dipping treatments during cold storage at 5±1C° in both seasons, as shown in table (2). It is clear from the data that weight loss percentage has been affected by cold storage periods.

A continuous loss in fruit weight existed with the extending of storage periods in both seasons for all treatments. In the same context, (Plácido *et al.*, 2016) and (Mshraky *et al.*, 2016) reported that the weight loss percentage for Eureka lemon and Valencia orange fruits increased significantly with the increase in storage period.

However, weight losses were lower in the fruits that have been treated by JO at "0.15 - 0.1 "%, GA at 10% and CHI at 3% in the first season, while in the second season the treatments of JO at "0.15 - 0.1, 0.05%" and GA at 15% recorded the lowest values of weight loss percentage of fruits respectively. Moreover, (Layla *et al.*, 2018) reported that the application of JO in combination with low-temperature storage played an effective role in reducing the weight loss percentage of the Navel orange fruits, we can say that JO has the same effect as commercial wax.

Moreover, the reduction in weight loss was probably due to the effect of the coating as a semi-permeable barrier against O_2, CO_2, moisture, and solute movement, and hence, reducing respiration, water loss, and oxidation reaction rates (Abdel-Salam, 2016). Furthermore, the treatments of control, GA at 5%, and CHI at 1% recorded the major weight loss percentage of fruits in both seasons. Results agreed with (Nasrin et al., 2020) who observed maximum weight loss that occurred in uncoated lemon whereas coated lemons preserved their weight nicely throughout the storage period.

Rind color (Hue angle h°) :

Table (3) shows the effect of different dipping treatments on the hue angle of Murcott tangor fruits during cold storage at 5±1C° in both seasons.

It was clear that, the fruit hue angle values in general decreased with the progress of the storage period for all fruits hold at 5±1C° in both seasons, while the hue angle values reached the minimum values after 100 days of storage in both seasons. The highest significant value of hue angle value" obtained from GA at 10 %, JO at 0.15 % JO and CHI at 3% treatments compared with the control in both seasons. On the other hand, the lowest hue angle values observed at Control, GA at 15%, and CHI at 1% during the storage period in both seasons. In addition, 3% of CHI reflected the highest hue angle value for mandarin fruits in this respect with regard to the effect of the interaction during the different periods of storage in two seasons of study. The increase in color decreased in the hue angle value" due to the acceleration of ripening which occurred by the age progress of fruit and accompanied by decreasing of phenolic compounds content which prevents the enzyme activity responsible for carotene content (Bill, 2012).

These results coincided with (El-Eryan and Tarabih, 2020) who revealed that the hue angle value of coated Egyptian Banzahir lime fruits decreases during the cold storage period compared with uncoated fruits, the edible coating (CHI, JO, and GA) significantly reduced the change rate in hue angle of Valencia Orange, mandarin, 'Navel' oranges, and 'Star Ruby' fruits compared with control during the cold storage period (Arnon *et al.,* 2014, Mshraky *et al.,* 2016, Plácido *et al.,* 2016, and Nasrin *et al.,* 2018). While, (Nasrin *et al.,* 2020) found that the hue angle value decreases gradually with extending of storage period for lemons to turn from green to yellow color. The reason is that, during the storage period, ethylene production and respiration rate were increased which stimulate to degree lemons changes of color (from green to yellow).

Fruit firmness kg/cm2:

Table (4) showed that fruit firmness showed a linear decline with the advancement of storage period for all fruits hold at 5, C° in both seasons. These results agreed with (Zagzog *et al.,* 2011) who noticed slight and gradual decline in firmness of Kinnow mandarin fruits during cold storage.

However, the fruit firmness values were higher in fruit treated with JO at 0.15% and 0.1%" and CHI at 3% in both seasons. These results coincided with (Mshraky *et al.,* 2016, Nasrin *et al.,* 2018, Shibambu 2018, and Atrash *et al.,* 2018) who found that GA, JO, and CHI treatments maintained the firmness of Valencia orange, mandarin "M37" and Mexican Lime fruits during cold storage.

Application of GA has been shown to reduce the activity of cell wall–degrading enzymes during ripening and provided protection for cell membrane and maintained fruit firmness (Mshraky *et al.,* 2016).

On the other side, the lowest values of fruit firmness were recorded in the fruits treated by Control, followed in descending order by CHI of 1%, and GA at 15% in both seasons. This is due to that excessive water loss that occurs in citrus during storage, as well as increasing ethylene biosynthesis, therefore activating polygalacturonase and degradation of insoluble protopectin to the more soluble pectic acid contributes to the decrease of firmness of fruits (Liplap, 2013).

Total soluble solids (TSS) %:

The results in table (5) showed that there were gradual slight increases in TSS % in general with the extended storage periods, while the TSS % reached the maximum value at the end of storage 100 days at 5±1 C° in both seasons.

The highest values of TSS were recorded by control, followed in descending order by CHI of 1%, GA at 15%, in both seasons. on the other side, the lowest values of TSS were recorded with the treatments of JO at 0.15% followed by JO at 0.1%, CHI at 3%, and GA at 10% in both seasons.

These results agreed with (Abdel-Salam 2016) who demonstrated that there were slight increases in the TSS during the storage of sweet lemon and grapefruit fruits for 80 days at cold storage. In the same direction, (Ennab *et al.,* 2020) recorded that the increase in TSS of Murcott mandarins throughout the storage period was less in coated fruits compared with control.

On the other hand, the cell walls contain large amounts of polysaccharides, mainly pectin and cellulose and are digested due to the activity of the cell wall degrading enzymes leading to a slight increase in TSS content during storage (Nasrin *et al.,* 2020).

Total acidity (TA) %:

Data in the table (6) illustrated that TA % was decreased during storage in all fruit treatments. The highest values of the TA % were recorded in the fruits dipped in JO at 0.15% followed in descending order by JO at 0.1% CHI 3% in both seasons. On the other hand, the lowest values of the TA% of fruit were recorded with control, followed in descending order by GA of 15%, and CHI of 1% during the storage period in the 1st and 2nd seasons. As for the combined effect of storage period and treatments on TA %, JO and CHI, they were more effective in delaying the changes decreasing TA % during cold storage in both seasons of study.

These results were consistent with (El-Eryan and Tarabih 2020, Shibambu 2018, and Din *et al.,* 2015) who reported that the fruit acidity continuously decreased with the increase in cold storage period at 5±2 C° with 85-90% RH for all Banzahir lime fruits but the decrease in acidity was slightly less in the fruits treated by GA, JO, and CHI compared with control. The decreasing trend in TA with the increasing storage period might be due to the oxidation of organic acid and its further utilization in metabolic processes (Obenland *et al*., 2011).

Ascorbic acid content (VC) mg/ 100 ml:

It is clear from table (7) that the different dipping treatments affected the Vc content of Murcott tangor fruits during cold storage at 5±1 C° in both seasons.

The Vc content values, in general, decreased with the progress in the storage period for all treatments and reached the minimum values after 100 days of storage at 5±1 C° in both seasons. The results were consistent with (Nasrin *et al.,* 2020 and (EL-Eryan and Tarabih, 2020) who found that the Vc of Kinnow mandarin fruits reduced throughout the cold storage.

Furthermore, the values of Vc content has differed between the treatments, the Vc content values were higher in fruit treated by JO at 0.15%, followed by JO at 0.1%, and CHI of 3% in both seasons respectively. The retention of Vc in the coated fruits could be due to the decreasing of respiration process and reduction of oxidation of Vc content according to (Abdel-Salam 2016 and Atrash *el al.,* 2018).

On the other hand, the lowest Vc content values were recorded with "Control and GA at 15%" in both seasons. The decreasing level of Vc in these treatments might be due to the increased respiration process and rapid conversion of L- ascorbic acid into dehydroascorbic acid in the presence of L-ascorbic acid oxidize (Abdel-Salam 2016, and Atrash *el al.*, 2018).

Respiration rate (mg CO2. kg-1. H-1):

The fruit respiration rate was initially high and then decreased once storing fruits at 5±1 C° after 20 days, in general. The respiration rate also increased gradually by the progress in the storage period for all Murcott tangor fruits in both seasons regardless of treatments as shown in (Table 8). Mandarin is non-climacteric fruit and does not exhibit a rise in respiration rate associated with ripening and senescence (Luengwilai *et al.*, 2007).Moreover, the treatments of JO of 0.15 % followed by CHI of 3 %, JO of 0.15 % and GA10 % recorded the lowest respiration rate in the first and second seasons. On the other hand, the treatments of control and GA of 15% recorded the highest respiration rate in both seasons. Interaction data show significant reduced respiration rate by CHI of 3% treatment. The results agreed with (Nasrin *et al.*, 2018) who mentioned that the initial respiration rate of mandarin was reduced to even less than half when mandarin was coated with liquid paraffin wax,

CHI and coconut oil, where the application of edible coating partially restricted gas exchange through the fruit peel, and inhibited ethylene and reduced respiration rate, thus delaying the aging of fruits (Hassan *et al*,. 2014). Furthermore, (Arnon *et al.*, 2014) found that one of the main problems in using edible coatings is their negative effects on gas permeation, which results in the accumulation of CO_2 and stimulation of anaerobic respiration. This explains the rise in respiration rate of fruits treated by high concentrations of GA.

CONCLUSION

It could be recommended to use postharvest coating 0.15 % of JO, was the most effective in controlling postharvest decay of Murcott Tangor mandarin fruits during storage up to 100 days at 5±1 °C and 95% RH and maintain on compositional changes by delaying physical and chemical changes, slowing down respiration rate and extending postharvest life.

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Treatments	Decay incidence (%)													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	– –	4.00	17.33	22.67	37.33	50.00	21.89	– –	1.33	5.33	17.33	40.00	54.67	19.78
5% GA	– –	0.00	6.67	13.33	30.67	42.00	15.44	– –	1.33	2.67	13.33	25.33	38.67	13.56
10% GA	– –	1.33	5.67	12.00	28.67	41.33	14.83	– –	0.00	4.00	14.67	29.33	44.00	15.33
15% GA	– –	0.00	12.00	20.00	38.67	51.00	20.28	– –	2.67	4.00	20.00	33.33	52.00	18.67
0.05% JO	– –	1.33	5.33	13.33	26.00	39.33	14.22	– –	2.67	5.33	13.33	29.33	40.00	15.11
0.1% JO	– –	0.00	5.33	10.67	26.33	38.67	13.50	– –	0.00	1.33	12.00	32.00	37.33	13.78
0.15%JO	– –	1.33	4.00	10.67	26.33	39.67	13.67	– –	0.00	1.33	6.67	17.33	33.33	9.78
1% CHI	– –	1.33	8.00	18.67	35.00	44.33	17.89	– –	1.33	2.67	13.33	32.00	46.67	16.00
2% CHI	– –	2.67	8.00	13.33	29.00	38.67	15.28	– –	1.33	5.33	14.67	36.67	42.67	16.78
3%CHI	– –	0.00	8.00	12.67	22.67	39.50	13.81	– –	0.00	5.33	14.67	32.00	40.00	15.33
Mean	_ _	1.13	7.72	14.82	30.31	43.47	_ _	_ _	1.03	3.69	14.05	31.54	43.38	_ _
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	1.23		0.59		2.14			2.39		0.75		2.68		

Table 1. Effect of some postharvest treatments with edible coating materials on decay incidence of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Table 2. Effect of some postharvest treatments with edible coating materials on weight loss of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	Weight loss (%)													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	_ _	4.59	9.54	18.02	21.38	24.38	12.99	_ _	5.18	9.81	14.71	17.89	21.83	11.57
5% GA	_ _	4.61	8.22	15.56	20.04	22.97	11.90	_ _	5.14	10.89	14.47	17.87	21.15	11.59
10% GA	– –	3.68	7.18	13.10	15.91	18.84	9.79	– –	5.87	11.36	14.19	16.51	17.89	10.97
15% GA	_ _	3.00	8.39	14.51	16.20	18.25	10.06	_ _	4.68	9.42	13.07	17.41	20.42	10.83
0.05% JO	_ _	1.87	6.96	13.44	15.97	19.77	9.67	_ _	4.44	9.16	13.26	17.34	20.15	10.72
0.1% JO	_ _	2.10	6.38	10.99	15.21	18.39	8.84	_ _	5.15	9.50	13.12	16.58	18.83	10.53
0.15%JO	_ _	1.81	5.61	9.09	11.77	16.66	7.49	_ _	4.01	8.33	13.94	18.01	18.01	10.38
1% CHI	_ _	3.70	8.12	15.78	19.77	22.59	11.66	_ _	5.56	12.29	14.63	16.66	19.53	11.45
2% CHI	– –	3.46	6.93	14.76	17.40	19.91	10.41	– –	5.16	10.74	14.47	17.44	20.64	11.41
3%CHI	– –	2.99	6.59	13.49	16.64	19.68	9.90	– –	5.38	10.88	14.46	17.26	18.86	11.14
Mean	_ _	3.32	7.49	14.33	17.39	20.24	_ _	_ _	4.98	10.22	14.12	17.46	19.90	_ _
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.56		0.28		1.01			0.85		0.23		0.84		

Table 3. Effect of some postharvest treatments with edible coating materials on the hue angle of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	Hue angle													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	68.26	64.58	62.40	62.17	61.33	60.06	63.13	66.13	63.77	62.63	61.80	61.30	58.20	62.30
5% GA	68.26	66.35	64.58	63.28	63.85	63.12	64.91	66.13	65.25	63.85	62.82	61.68	59.51	63.21
10% GA	68.26	67.23	66.12	64.78	62.68	61.31	65.06	66.13	66.40	65.37	64.09	61.73	60.45	64.03
15% GA	68.26	66.83	65.22	62.37	61.50	57.07	63.54	66.13	65.83	62.47	60.77	60.38	60.07	62.61
0.05% JO	68.26	66.25	64.50	63.85	61.85	61.45	64.36	66.13	67.40	65.30	63.20	61.92	59.07	63.84
0.1% JO	68.26	67.18	65.70	64.20	62.82	62.05	65.03	66.13	65.14	64.57	64.32	62.40	61.13	63.95
0.15%JO	68.26	67.65	66.19	64.82	64.38	63.05	65.72	66.13	67.70	65.90	63.67	61.97	60.00	64.23
1% CHI	68.26	65.92	64.09	62.98	61.25	60.11	63.77	66.13	64.70	63.03	61.12	60.72	60.77	62.74
2% CHI	68.26	66.55	65.35	64.78	62.82	61.02	64.79	66.13	65.90	63.33	63.24	61.55	60.82	63.49
3%CHI	68.26	67.34	66.05	65.05	64.52	62.88	65.68	66.13	66.55	64.18	63.55	62.68	59.68	63.80
Mean	68.26	66.51	64.96	63.86	62.62	61.08	– –	66.13	66.07	64.21	62.62	61.38	59.93	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.71		0.42		1.51			1.02		0.58		2.08		

Table 4. Effect of some postharvest treatments with edible coating materials on the firmness of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	Firmness kg/cm^2													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	2.92	2.66	2.31	2.26	2.21	2.04	2.40	2.42	2.15	2.08	1.93	1.72	1.67	1.99
5% GA	2.92	2.78	2.54	2.40	2.27	2.06	2.50	2.42	2.32	2.19	2.02	1.89	1.67	2.08
10% GA	2.92	2.72	2.52	2.42	2.35	2.31	2.54	2.42	2.27	2.18	2.12	2.03	1.81	2.14
15% GA	2.92	2.69	2.55	2.29	2.21	2.07	2.46	2.42	2.25	2.09	1.95	1.85	1.72	2.05
0.05% JO	2.92	2.81	2.57	2.53	2.49	2.48	2.63	2.42	2.30	2.21	2.05	2.00	1.82	2.13
0.1% JO	2.92	2.82	2.64	2.61	2.56	2.44	2.67	2.42	2.37	2.32	2.21	2.17	2.04	2.25
0.15%JO	2.92	2.85	2.79	2.59	2.56	2.50	2.70	2.42	2.40	2.35	2.24	2.14	2.09	2.27
1% CHI	2.92	2.58	2.50	2.30	2.21	2.06	2.43	2.42	2.37	2.23	1.82	1.79	1.63	2.04
2% CHI	2.92	2.68	2.52	2.47	2.38	2.11	2.51	2.42	2.36	2.17	2.00	1.89	1.80	2.11
3%CHI	2.92	2.73	2.68	2.57	2.49	2.19	2.60	2.42	2.40	2.32	2.13	1.98	1.89	2.19
Mean	2.92	2.72	2.57	2.44	2.36	2.21	– –	2.42	2.31	2.21	2.04	1.93	1.82	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.03		0.03		0.10			0.04		0.02		0.08		

Table 5. Effect of some postharvest treatments with edible coating materials on the Total soluble solids (TSS) of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	TSS %													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	12.18	12.23	12.37	12.48	12.78	13.02	12.51	13.24	13.39	13.55	13.64	13.72	13.82	13.56
5% GA	12.18	12.25	12.38	12.56	12.65	12.72	12.46	13.24	13.32	13.47	13.57	13.65	13.64	13.48
10% GA	12.18	12.24	12.30	12.49	12.50	12.60	12.38	13.24	13.25	13.42	13.52	13.60	13.63	13.44
15% GA	12.18	12.33	12.42	12.56	12.61	12.72	12.47	13.24	13.38	13.52	13.60	13.68	13.78	13.53
0.05% JO	12.18	12.27	12.38	12.51	12.63	12.76	12.46	13.24	13.28	13.43	13.59	13.63	13.67	13.47
0.1% JO	12.18	12.18	12.27	12.30	12.51	12.62	12.34	13.24	13.25	13.41	13.48	13.57	13.60	13.42
0.15%JO	12.18	12.20	12.28	12.41	12.45	12.51	12.34	13.24	13.26	13.39	13.50	13.52	13.56	13.41
1% CHI	12.18	12.26	12.33	12.46	12.70	13.00	12.49	13.24	13.37	13.50	13.65	13.68	13.77	13.54
2% CHI	12.18	12.28	12.34	12.48	12.56	12.63	12.41	13.24	13.27	13.44	13.52	13.58	13.71	13.46
3%CHI	12.18	12.19	12.25	12.29	12.50	12.71	12.35	13.24	13.25	13.42	13.52	13.60	13.65	13.45
Mean	12.18	12.25	12.33	12.46	12.59	12.74	– –	13.24	13.30	13.45	13.56	13.63	13.69	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.03		0.02		0.08			0.04		0.04		0.14		

Table 6. Effect of some postharvest treatments with edible coating materials on the Total acidity (TA) of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

2018 Season	TA %													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	1.31	1.26	1.21	0.99	0.85	0.85	1.08	1.22	1.19	0.83	0.83	0.77	0.77	0.94
5% GA	1.31	1.25	1.25	1.12	1.00	0.90	1.14	1.22	1.19	0.85	0.96	0.95	0.85	1.00
10% GA	1.31	1.30	1.24	1.07	0.96	0.96	1.14	1.22	1.21	1.02	0.93	0.93	0.92	1.04
15% GA	1.31	1.20	1.19	1.08	0.92	0.88	1.10	1.22	1.18	0.92	0.89	0.83	0.70	0.96
0.05% JO	1.31	1.29	1.28	1.13	0.91	0.98	1.15	1.22	1.22	0.97	0.92	0.90	0.85	1.01
0.1% JO	1.31	1.32	1.26	1.25	0.95	0.96	1.17	1.22	1.23	1.08	0.94	0.88	0.87	1.04
0.15%JO	1.31	1.28	1.25	1.24	1.07	1.02	1.19	1.22	1.21	1.12	1.07	0.97	0.90	1.08
1% CHI	1.31	1.30	1.25	1.15	0.90	0.88	1.13	1.22	1.22	1.18	0.94	0.82	0.75	1.02
2% CHI	1.31	1.28	1.26	1.15	0.90	0.95	1.14	1.22	1.21	1.09	0.97	0.89	0.79	1.03
3%CHI	1.31	1.24	1.21	1.13	1.08	0.98	1.16	1.22	1.21	1.00	0.96	0.92	0.92	1.04
Mean	1.31	1.27	1.24	1.13	0.96	0.94	– –	1.22	1.20	1.01	0.94	0.88	0.83	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.03		0.03		0.10			0.08		0.02		0.10		

Table 7. Effect of some postharvest treatments with edible coating materials on the Ascorbic acid content (VC) of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	VC mg/ 100 ml													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	35.68	32.87	31.00	29.04	28.18	27.19	30.66	35.72	32.79	30.42	29.23	29.21	28.33	30.95
5% GA	35.68	33.96	33.21	30.95	29.40	28.33	31.92	35.72	33.46	31.55	30.02	29.72	29.74	31.70
10% GA	35.68	33.65	32.87	30.71	29.40	29.14	31.91	35.72	32.77	34.51	30.90	30.61	29.36	32.31
15% GA	35.68	33.97	31.33	29.73	28.10	26.87	30.95	35.72	33.84	32.01	30.30	29.36	27.69	31.49
0.05% JO	35.68	34.96	33.89	31.74	30.78	28.93	32.66	35.72	35.25	33.43	33.19	31.51	30.27	33.23
0.1% JO	35.68	35.29	34.88	30.71	30.53	29.38	32.75	35.72	34.47	33.43	32.91	33.19	31.03	33.46
0.15%JO	35.68	35.74	34.24	32.01	30.52	29.79	33.00	35.72	34.49	34.22	33.42	32.96	30.27	33.51
1% CHI	35.68	34.00	34.21	29.02	29.00	26.19	31.35	35.72	34.84	31.65	30.02	29.36	28.24	31.64
2% CHI	35.68	34.30	33.54	32.54	30.30	28.33	32.45	35.72	34.84	33.77	31.23	30.40	28.89	32.47
3%CHI	35.68	35.31	33.87	31.70	30.73	29.94	32.87	35.72	35.32	35.34	33.76	30.82	28.98	33.32
Mean	35.68	34.39	33.06	30.78	29.71	28.32	– –	35.72	34.23	32.94	31.47	30.59	29.36	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.58		0.32		1.14			0.78		0.51		1.84		

Table 8. Effect of postharvest treatments with edible coating materials on the respiration of Murcott tangor fruits stored at 5±1 C° in 2018 and 2019 seasons.

Treatments	Respiration mg CO2. kg^{-1}. H^{-1}													
	2018 Season							2019 Season						
	Storage period (days)													
	0	20	40	60	80	100	Mean	0	20	40	60	80	100	Mean
Control	7.72	4.76	4.92	5.83	7.04	9.26	6.59	7.28	4.24	4.37	4.90	5.77	7.06	5.60
5% GA	7.72	3.46	3.87	4.62	5.93	6.49	5.35	7.28	4.16	4.17	4.43	4.88	5.13	5.01
10% GA	7.72	3.78	3.79	4.40	5.21	5.83	5.12	7.28	3.95	4.08	4.27	4.66	5.03	4.88
15% GA	7.72	4.55	5.07	5.67	6.53	9.80	6.56	7.28	4.34	4.49	4.88	5.89	6.91	5.63
0.05% JO	7.72	3.70	3.84	4.71	5.43	6.79	5.37	7.28	4.01	4.07	4.30	4.72	5.29	4.94
0.1% JO	7.72	3.54	3.97	4.20	5.25	5.83	5.09	7.28	3.92	4.07	4.21	4.64	5.13	4.87
0.15%JO	7.72	3.13	3.88	4.05	4.75	5.70	4.87	7.28	4.16	4.16	4.18	4.33	4.89	4.83
1% CHI	7.72	4.01	4.98	5.56	6.00	6.58	5.81	7.28	4.36	4.62	4.85	5.04	6.01	5.36
2% CHI	7.72	3.84	4.27	4.95	5.16	6.08	5.34	7.28	4.26	4.33	4.36	4.75	5.19	5.03
3%CHI	7.72	3.56	3.89	4.12	4.77	5.75	4.97	7.28	3.98	3.96	4.11	4.43	5.04	4.80
Mean	7.72	3.89	4.31	4.83	5.68	6.88	– –	7.28	4.18	4.26	4.48	4.97	5.62	– –
LSD at 5%	Treatments		Storage period		Treatments × Storage period			Treatments		Storage period		Treatments × Storage period		
	0.39		0.26		0.97			0.42		0.29		1.03		

تأثير بعض معاملات ما بعد الحصاد بمواد تغليف قابلة للاستهلاك على القدرة التخزينية وجودة ثمار الموركوت تانجور أثناء التخزين المبرد.

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الملخص العربى

يعتبر يوسفى الموركوت تانجور {*Citrus reticulata* × *Citrus sinensis* (L.) Osbeck} من أصناف اليوسفي الواعدm لتأخر موسم حصاده وجودة ثماره, ونظراً لأن ثمار اليوسفى سريعة التلف وتفقد قيمتها التسويقية بسرعة لإصابتها بالأعفان وكرمشة وليونة الثمار لذا يتم إستخدام المبيدات الفطرية الصناعية، ولكن متبقيات المبيدات ذات تأثير ضار على صحة المستهلك لذا فهناك حاجة إلى إيجاد مواد آمنة أخرى وتقييمها وتهدف الدراسة إلى إختبار تأثير (الصمغ العربي وزيت الجوجوبا والشيتوزان) كمواد تغليف قابلة للاستهلاك على القدرة التخزينية وجودة ثمار الموركوت تحت ظروف التخزين المبرد. وقد اجريت التجارب فى موسمى 2018و2019م.على ثمار اليوسفى الموركوت حيث تم غمس الثمار لمدة خمس دقائق فى [الماء المقطر، والصمغ العربى (بتركيزات 5-10-15% وزن/حجم) وزيت الجوجوبا (بتركيزات 0.05-0.10-0.15%حجم/حجم) الشيتوزان بتركيزات (1-2-3%وزن/حجم)] وتركت لتجف فى الهواء، وتم وضع الثمار فى صناديق كرتون وخزنت تحت درجة حرارة 5±1 درجة مئوية ورطوبة 95٪ وسجلت عدد الثمار التالفة وصفات الجودة دورياً كل 20 يومًا طوال مدة التخزين المبرد. أظهرت النتائج أنه من بين جميع المعاملات، سجلت معاملات زيت الجوجوبا 0.15% أقل نسبة ثمار تالفة وفقد فى الوزن طوال مدة التخزين في كلا الموسمين، كما انخفضت صلابة الثمار، المواد الصلبة الذائبة الكلية، ,الحموضة الكلية وحامض الاسكوربك تدريجيًا مع زيادة مدة التخزين لكل المعاملات ولكن حافظت الثمار المعاملة بزيت الجوجوبا 0.15% على أعلى القيم لتلك الصفات مقارنة بباقى المعاملات الاخرى في كلا الموسمين. توصي النتائج بتغليف ثمار الموركوت تانجور بشمع الجوجوبا 0.15% لإطالة العمر التخزينى للثمار مع الحفاظ على أعلى قدر من صفات الجودة وأقل نسبة تالف حتى 100 يوم من التخزين تحت درجة حرارة 5±1 مئوية ورطوبة 95٪.

الكلمات الاسترشادية: موركوت تانجور، الصمغ العربي، زيت الجوجوبا ، الشيتوزان ، طلاء قابل للاستهلاك ، التخزين المبرد