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EFFICACY OF DIFFERENT EDIBLE COATINGS IN IMPROVING "MURCOTT TANGOR" FRUIT QUALITIES DURING CHILLED AND AMBIENT STORAGE.

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ABSTRACT

This study was conducted during two successive seasons (2012 and 2013) to evaluate the effect of Carboxy Methyl Cellulose (CMC), Cellulose and beeswax at concentrations of 2 and 3% as edible coatings on some "Murcott tangor" fruit quality parameters. The coated and control (uncoated) fruits were stored under cold storage conditions (5±1˚C and 90-95% RH) and for 7 days at ambient conditions after every cold storage period. The various physiochemical attributes of fruits were recorded after 0, 20, 40, 60 days in cold storage and after 7 days at ambient conditions of every cold storage period. Fruit weight loss (%), SSC (˚Brix), SSC/acid ratio, total carotenoid (in peel) and pectic substances (in peel and edible portion) of Murcott tangor fruits were increased in most cases; whereas, titratable acidity (%), V.C (mg/100g) and juice ratio were decreased with advancing the storage period. However, the results of the study indicated that Murcott tangor fruits coated with Carboxy Methyl Cellulose showed a significant deterioration delay in the different determined parameters of Murcott tangor fruits either at cold storage or ambient condition. Fruits coated with Carboxy Methyl Cellulose (especially at 3%) can be successfully stored for 60 days under cold storage conditions and for 7 days at ambient condition after cold storage with highly acceptable sensory quality.

Keywords: Carboxy Methyl Cellulose, beeswax, Vitamin C, Cold storage and surface coating.

INTRODUCTION

‘Murcott’ is a hybrid tangerine cultivar which is a cross between tangerine (*Citrus reticulata* Blanco) and sweet orange (*Citrus sinensis* (L.) Osbeck). At the present time, it is the most widely grown cultivar in Florida. The fruit is marketed under the name of honey tangerine; however, the official variety name is Murcott (Figueiredo, 1991). The flesh has rich orange color. The fruit matures from January to March which making it the latest maturing tangerine type fruit, and it has excellent qualities for the fresh fruit market (Stephen and Jackson, 2003). The total cultivated area of tangerines, mandarins, clementines and satsumas in Egypt reached about 42060 hectares (103934.446 feddan) producing about 885365 tons (FAO, 2012). But the total cultivated area of Murcott in Egypt is limited compared to the other tangors, since it is recently cultivated.

Currently, citrus fruit (in Egypt) are coated with commercial waxes at the packing houses, in order to enhance gloss, reduce water loss and delay shrinkage (Petracek *et al.*, 1998). Recently, because of rising public concern regarding human health issues and environmental protection, there has been an increment interest in developing natural biodegradable edible coatings for maintaining postharvest quality of fruit and vegetables. These would replace the currently used commercial synthetic waxes (composed mainly of oxidized polyethylene) by natural edible coatings which are composed of polysaccharides, proteins, lipids or various composites of these (Valencia-Chamorro *et al.*, 2010 and Dhall, 2013).

In this study, we evaluated the efficacy of various polysaccharide-based edible coatings, including cellulose derivatives and beeswax which are relatively inexpensive and easy to dissolve in order to create modified atmosphere and to reduce weight loss during transport and storage by controlling the permeability and gaseous exchange (Cuq *et al.*,1995); furthermore, they retard ethylene production and seal in flavor volatiles (Baldwin *et al.*, 1995). The present work was planned to study the effect of various polysaccharide-based edible coatings [Carboxy Methyl Cellulose (CMC) and Cellulose] and beeswax at different concentrations on shelf life and quality of "Murcott tangor" fruits under cold and ambient storage conditions.

MATERIALS AND METHODS

The experiment was conducted at Postgraduate Laboratory of Pomology Department, Mansoura Univ. during 2012 and 2013. Murcott tangor (*Citrus sinensis* (L.) Osbeck x *Citrus reticulata* Blanco) fruits were harvested at proper physiological stage of maturity (when the fruits attained a specific orange color according to the variety and area) from commercial orchard at El-Khatatba city, Monifia Governorate, Egypt in mid-March. Before the disinfection, all fruits were sorted based on similar size and the absence of physical injuries or infections, and then disinfested with 1% sodium hypochlorite (v/v) for 2 min, rinsed in clean tap water carefully and left to dry on paper tissue at 21°C for 3 h. The clean dried fruits were then divided into 7 main lots each containing 90 fruits. Each treatment was replicated three times.

Preparation of coating:

Both of Carboxy Methyl Cellulose (CMC) and Cellulose coatings (2 and 3%) were prepared by dissolving 4.0 g and 6.0 g of each of them in 200 ml of water-ethyl alcohol mixture (3:1L/L) at 80 ^{o} C and stirred for 10 Min by using magnetic stirrer. Ethyl alcohol was used to reduce drying time and obtain a transparent and shiny coating. 2% propylene glycol was also added in the formulation as plasticizer. Beeswax coatings (2 and 3%) were prepared by dissolving 4.0 g and 6.0 g of beeswax in 200 ml of water-ethyl alcohol mixture (3:1L/L) at 70 ^{o} C and stirred for 10 min by using magnetic stirrer.

Coating and storage of fruits:

Different treatments at various concentrations of coating materials (T1= Control, T2= 2% CMC, T3= 3% CMC, T4= 2% Cellulose, T5= 3% Cellulose, T6= 2% beeswax and T7= 3% beeswax) were applied to the fruits. Fruits were dipped in different coating formulations for 1 min [except T1 (the untreated fruit) that was left as control), immediately taken out and dried under blowing air at 25±2 ^{o}C .The dried coated fruits were placed in ventilated carton box (50×30×12) cm which divided into three parts, each part contain a known weight of fruits, then taken for cold storage at 5±1˚C and 90-95% relative humidity (R.H) for 60 days. Two carton boxes of each treatment were taken every 20 days, one of them for physical and chemical analysis of fruits quality during cold storage and the other box was held for 7 days at room temperature (as shelf life) to evaluate the changes in physical and chemical properties of fruits during ambient conditions which determined by Thirmohydrograph as presented in the following table after each period of cold storage:

Table (1): Average temperature and relative humidity % during shelf life:

Date (day/month)	**5 -12/4**	**25/4 - 2/5**	**15 -22/5**
Average Temp.°c	15.14	18.57	22.71
Average R.H %	24.57	26.71	31.14

Physical analyses:

The weight loss due to active metabolic rate was determined by weighing the samples with digital balance and reported as percent loss in sample weight based on its initial weight. Soluble solids content (SSC) in fruit juice was recorded as ^{o}Brix by Refractometer (AOAC, 1994).

Chemical analyses:

Murcott tangor fruits were analyzed for different chemical parameters after 20 days interval. Titratable acidity was determined as citric acid (AOAC, 1994).

Soluble solids content (SSC) /acid ratio was expressed by the ratio between SSC and total titratable acidity.

Juice ratio: Fruit weighed with an electronic balance. Juice was extracted and weight was taken. The juice percentage was expressed as percentage of total weight at the time of measurement.

Juice weight × 100 / fruit weight (AOAC,1990).

Vitamin C was determined using 2,6- dichlorophenol indophenol method (Mazumadar, 2003). A Known amount of edible portion of Murcott tangor fruit was extracted with 3% metaphosphoric by thorough crushing. The extract was filtered and made up to a known volume with 3% metaphosphoric then titrated with the standard indophenol dye solution to a pink end point (persisting for 15 sec) and vitamin c was estimated by the following equations:

$$\text{Dye factor} = \frac{0.5}{\text{Average burette reading of dye solution}}$$

$$\text{Vitamin C (mg/100g)} = \frac{e \times d \times b}{c \times a} \times 100$$

where,a=weight of edible portion,b=volume made with metaphosphoric acid, c = volume of aliquot taken for estimation, d = dye factor, e = average burette reading for sample.

Peel color of Murcott tangor fruits (as total carotenoids) was determined by weighing 0.5 g fresh material which extracted by 10 ml methanol for 24 hour under laboratory temperature after adding trace amount of sodium bicarbonate. Both chlorophyll and carotenoids were determined by spectrophotometer at the wavelength 452.5, 650 and 665 nm according to the methods of Mackinny (1941) and the total carotenoid was estimated by the following equations:

Chl. A = 16.5 E_{665} – 8.3 E_{650}

Chl. B = 33.8 E_{650} – 12.5 E_{665}

Carotenoids = 4.2 $E_{452.5}$ – 0.0264 chl.A – 0.496 chl.B

$$\text{carotenoids mg/100g fresh weight} = \frac{\text{carotenoids x volume of solution x100}}{\text{Weight of sample x 1000}}$$

Total pectic substances were determined in peel and edible portion according to Mazumadar (2003) as following:

Known amount of tissue sample by weight was taken and boiled with 0.05 *N* hydrochloric acid at a 80-90ºC for 2 hours to extract the pectic substances. After extraction, the mixture was cooled to room temperature, then filtered (Whatman No.4). The extraction was repeated for maximum recovery of the pectin. The filtrate was made up to a known volume with distilled water. An aliquot from the above extract (50 ml) was taken in a conical flask and neutralized with 1 *N* sodium hydroxide solution. The excess amount of sodium hydroxide solution was added to it with thorough mixing till the mixture becomes slightly alkaline. The solution is allowed to stand overnight, then 10 ml of 1*N* acetic acid was added to it. After 5 minutes, 5 ml of 1 *N* calcium chloride solution was mixed with constant stirring and left for an hour to precipitate the calcium pectate. The solution was then filtered through a dried and pre-weighed filter paper (Whatman No.4). The precipitate was washed repeatedly with boiling water to eliminate chloride ions presented in the precipitate. The filter paper containing calcium pectate was dried at 50º-60ºC and weighed. The amount of total pectic substances (as calcium pectate) presented in the sample was calculated by the following formula:

Pectic substances (as calcium pectate) in sample % = d × c / b × a × 100

where, a = Weight of sample, b = Volume of aliquot taken for estimation,

C = Volume made with distilled water and d = Weight of calcium pectate.

Statistical analysis: Data were statistically analyzed as a completely randomized design with three replicates by analysis of variance (ANOVA) according to the procedure outlined by Snedecor and Cochran (1994), using the statistical package software SAS (SAS Institute Inc. Cary, NC, USA). Comparisons between means were made by using the least significant differences test (LSD) at 5% level of probability as mentioned by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Fruit weight loss %:

Regarding to the effect of the tested treatments, Tables 2 and 3 illustrate that all evaluated treatments succeeded in reducing weight loss percentage of Murcott tangor fruits during storage duration in comparison with uncoated fruits (control) in both seasons. Generally, the treatment of 3% CMC proved to be the most efficient treatment in this concern, followed by 2% CMC treatment, without any significant differences in the second season.

Table 2: Weight loss percentage in "Murcott tangor" fruits under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Weight loss % (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	0.00	2.34	4.20	5.71	3.06	0.00	4.12	6.57	8.47	4.79
2% CMC	0.00	1.81	2.66	4.44	2.23	0.00	3.43	4.67	7.16	3.82
3% CMC	0.00	1.75	2.21	3.83	1.95	0.00	3.23	4.07	6.81	3.53
2% Cellulose	0.00	1.94	2.83	5.05	2.45	0.00	3.64	5.62	7.67	4.23
3% Cellulose	0.00	1.87	2.86	4.87	2.4	0.00	3.56	5.17	7.42	4.04
2% beeswax	0.00	2.02	3.52	5.26	2.7	0.00	3.72	5.78	7.85	4.34
3% beeswax	0.00	2.16	3.79	5.38	2.83	0.00	3.79	6.08	8.05	4.48
Mean of storage period	0.00	1.98	3.15	4.93	-	0.00	3.64	5.42	7.63	-
LSD at 5%	Treatment (T) = 0.16 Storage period(S) = 0.09 T x S = 0.23					Treatment (T) = 0.078 Storage period(S) = 0.059 T x S = 0.16				

These results agree with Rong *et al.* (2012), who reported that CMC edible coating exhibited a beneficial impact on the overall quality of "Nanfeng" mandarin by reducing the moisture loss and fruit spoilage, maintaining the titratable acidity and ascorbic acid contents in comparison with uncoated fruits.

That may be because the polymer chains of CMC edible coating reduce moisture loss, restrict oxygen exchange, decrease respiration, retard ethylene production and seal in flavor volatiles. Furthermore, CMC exhibits excellent gas permeability properties, resulting in desirable modified atmosphere that enhance the shelf life of the product without creating anaerobic conditions (Baldwin *et al.*, 1995).

As for the effect of storage periods, it is quite clear from Tables 2 and 3 that "Murcott tangor" fruits lost weight with the advancement of storage period during ambient and cold storage. So, sixty days storage period under cold storage recorded the highest value of loss, whereas "irrespective of the initial reading" the lowest value was obtained after twenty days cold storage in both seasons. The differences between the aforementioned cold storage periods were highly significant. These results are in agreement with those reported by Alam and Paul (2001) who studied the effects of cellulose-based coating (carboxyl methyl cellulose) on the shelf life of Kinnow mandarin fruits and found that carboxyl methyl cellulose coating (0.5%) were the most suitable for extending the shelf life up to 40 days without adversely affecting the quality. Moreover, Abbasi *et al*. (2011) found that Carboxy Methyl Cellulose (CMC) at 2% level delayed fruit ripening and improved the keeping quality of the produce of mango by extending storage life with appreciable retention of all the quality parameters.

Table 3: Weight loss percentage in "Murcott tangor" fruits under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Weight loss % (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	0.00	2.44	4.29	5.81	3.14	0.00	4.34	6.76	8.74	4.96
2% CMC	0.00	1.91	2.76	4.54	2.30	0.00	3.69	4.80	7.47	3.99
3% CMC	0.00	1.85	2.19	3.93	1.99	0.00	3.59	4.50	7.34	3.86
2% Cellulose	0.00	2.04	2.59	5.15	2.45	0.00	3.91	5.75	7.77	4.36
3% Cellulose	0.00	1.97	2.62	4.64	2.31	0.00	3.83	5.52	7.65	4.25
2% beeswax	0.00	2.12	3.62	5.36	2.78	0.00	4.15	5.92	7.97	4.51
3% beeswax	0.00	2.26	3.89	5.45	2.89	0.00	4.23	6.20	8.15	4.64
Mean of storage period	0.00	2.08	3.14	4.98	-	0.00	3.96	5.63	7.87	-
LSD at 5%	Treatment (T) = 0.18 Storage period(S) = 0.13 T x S = 0.35					Treatment (T) = 0.051 Storage period(S) = 0.069 T x S = 0.10				

Considering the interaction effect between tested edible coating treatments and storage period, data presented in Tables 2 and 3 show that the interactions of twenty days storage duration had the lowest percentages of weight loss especially, CMC and Cellulose treated fruits in both seasons but 3% CMC treatment was the best in this respect. On the contrary, the highest percentage of weight loss was observed under those of 60 days storage period combinations, particularly those uncoated fruits “control” in both seasons. The other combinations showed an intermediate values in this concern during ambient and chilled storage.

The recorded results on weight loss of "Murcott tangor" fruits go in line with the findings of Cuq *et al*. (1995) who demonstrated that edible films and coatings are used to create modified atmosphere and to reduce weight loss during transport and storage by controlling the permeability and gaseous exchange. Furthermore, Togrul and Arslan (2004) stated that weight loss is mainly attributed to the loss of water during metabolic processes like respiration and transpiration which is usually controlled by the epidermal layers provided with guard cells and stomata; coating helps to reduce these processes because it forms a film on the top of the skin acting as an additional barrier to moisture loss.

Soluble solids content (SSC; ^{o}Brix):

Data in Tables 4 and 5 reveal that SSC of "Murcott tangor" fruits was affected by using the different edible coating treatments in both seasons.

However, the highest value of this parameter was gained by uncoated fruits in both seasons during ambient and cold storage. Also, fruits coated with beeswax increased SSC as compared with the other edible coatings during both seasons.

Referring to the effect of storage period, SSC of "Murcott tangor" fruits steadily increased with advancing the storage periods till reach the maximum increase after sixty days under storage period in both seasons.

As for the interaction effect between the tested edible coating treatments and storage periods, data in the same Tables indicated that all resulted combinations increased SSC of "Murcott tangor" fruits as compared with the initial readings, and the superiority was for the combinations of sixty days storage period in most cases in both seasons. Anyway, the highest values of this parameter were scored by uncoated fruits under cold storage for sixty days at both seasons. On the opposite, the lowest values of this parameter were related to the combination of twenty days storage period with 3% CMC coated fruits in both seasons during ambient and cold storage.

The results on this concern go in line with the findings of Wills *et al.* (1980) who reported that the increase in SSC during storage may possibly due to the breakdown of complex organic metabolites into simple molecules. The slightly increase in SSC over a longer period of time in coated Murcott fruits might be attributed to that coatings delayed the metabolic and respiratory activity of fruit and hence might have retarded the fruit ripening and senescence processes. These results are in agreement with the findings of Sidhu *et al.* (2009) for wax coated pear fruits.

Table 4: SSC (^{o}Brix) in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	SSC (^{o}Brix) (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	12.40	12.98	13.48	14.78	13.41	12.40	13.28	13.98	15.48	13.79
2% CMC	12.40	12.77	13.27	13.97	13.10	12.40	13.07	13.77	14.67	13.48
3% CMC	12.40	12.55	13.09	13.79	12.96	12.40	12.85	13.52	14.49	13.32
2% Cellulose	12.40	12.87	13.37	14.17	13.20	12.40	13.17	13.87	14.87	13.58
3% Cellulose	12.40	12.81	13.31	14.11	13.16	12.40	13.11	13.81	15.81	13.78
2% beeswax	12.40	12.91	13.41	14.31	13.26	12.40	13.21	13.91	15.01	13.63
3% beeswax	12.40	12.95	13.45	14.35	13.29	12.40	13.25	13.95	15.05	13.66
Mean of storage period	12.40	12.82	13.32	14.21	-	12.4	13.13	13.83	15.05	-
LSD at 5%	Treatment (T) = 0.02 Storage period(S) = 0.02 T x S = 0.05					Treatment (T) = 0.27 Storage period(S) = 0.20 T x S = 0.53				

Table 5: SSC (^{o}Brix) in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	SSC (^{o}Brix) (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	12.90	13.49	13.86	15.28	13.88	12.90	13.78	14.49	15.98	14.29
2% CMC	12.90	13.28	13.78	14.48	13.61	12.90	13.32	14.28	15.17	13.92
3% CMC	12.90	13.06	13.59	14.29	13.46	12.90	13.27	14.03	14.99	13.79
2% Cellulose	12.90	13.38	13.88	14.68	13.71	12.90	13.67	14.38	15.37	14.08
3% Cellulose	12.90	13.32	13.82	14.62	13.66	12.90	13.57	14.32	15.31	14.03
2% beeswax	12.90	13.42	13.92	14.82	13.77	12.90	13.71	14.42	15.51	14.14
3% beeswax	12.90	13.46	13.69	14.86	13.73	12.90	13.75	14.46	15.56	14.17
Mean of storage period	12.90	13.34	13.79	14.71	-	12.9	13.58	14.34	15.41	-
LSD at 5%	Treatment (T) = 0.05 Storage period(S) = 0.04 T x S = 0.11					Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.19				

Titratable acidity (%):

Data in Tables 6 and 7 showed that the lowest fruit acidity (%) of "Murcott tangor" was gained by uncoated fruits in both seasons, whereas the highest fruit acidity content was scored by those treated by 3% CMC in both seasons. It was interesting to note that there was a negative relationship between fruit acidity and storage periods. Hence, as the storage period increased, the values of fruit acidity decreased to reach the maximum reduction at the longest storage period (sixty days). This trend was true in both seasons during ambient and chilled storage which may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Echeverria and Valich, 1989). Furthermore, coatings helped in better retention of acidity as compared to uncoated fruits, which might be due to the positive role of coatings in delaying the ripening process of fruits (El-Anany *et al.*, 2009).

As for the interaction effect between the studied edible coatings treatments and storage periods, data in Tables 6 and 7 declare that the lowest values of this parameter were recorded by using the combination of sixty days storage periods, particularly those of uncoated fruits and beeswax-coated fruits in both seasons .While "irrespective of the initial reading" the highest values of this parameter were scored by using the combination of twenty days storage period. The remained treatments occupied an intermediate position between the aforementioned treatments in both seasons during ambient and chilled storage.

Table 6: Titratable acidity % in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Titratable acidity % (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.28	1.05	0.93	0.79	1.01	1.28	0.83	0.72	0.62	0.86
2% CMC	1.28	1.24	1.13	1.02	1.17	1.28	1.03	0.92	0.81	1.01
3% CMC	1.28	1.27	1.16	1.05	1.19	1.28	1.06	0.95	0.84	1.03
2% Cellulose	1.28	1.17	1.06	0.95	1.12	1.28	1.06	0.95	0.84	1.03
3% Cellulose	1.28	1.20	1.10	0.99	1.14	1.28	1.03	0.93	0.82	1.01
2% beeswax	1.28	1.13	1.02	0.91	1.09	1.28	0.92	0.81	0.70	0.93
3% beeswax	1.28	1.10	0.98	0.87	1.06	1.28	0.88	0.77	0.66	0.90
Mean of storage period	1.28	1.17	1.05	0.94	-	1.28	0.97	0.86	0.76	-
LSD at 5%	Treatment (T) = 0.01 Storage period(S) = 0.01 T x S = 0.02					Treatment (T) = 0.01 Storage period(S) = 0.01 T x S = 0.03				

Table 7: Titratable acidity % in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Titratable acidity % (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.25	1.02	0.90	0.76	0.98	1.25	0.80	0.69	0.58	0.83
2% CMC	1.25	1.21	1.10	0.99	1.14	1.25	1.00	0.89	0.78	0.98
3% CMC	1.25	1.24	1.13	1.02	1.16	1.25	1.03	0.92	0.81	1.00
2% Cellulose	1.25	1.14	1.03	0.91	1.08	1.25	1.03	0.92	0.81	0.99
3% Cellulose	1.25	1.15	1.07	0.96	1.11	1.25	0.99	0.89	0.79	0.98
2% beeswax	1.25	1.10	0.99	0.88	1.06	1.25	0.89	0.78	0.67	0.89
3% beeswax	1.25	1.06	0.95	0.84	1.03	1.25	0.85	0.74	0.63	0.87
Mean of storage period	1.25	1.13	1.02	0.91	-	1.25	0.94	0.83	0.72	-
LSD at 5%	Treatment (T) = 0.01 Storage period(S) = 0.01 T x S = 0.02					Treatment (T) = 0.01 Storage period(S) = 0.01 T x S = 0.03				

SSC /acid ratio:

It is obvious from Tables 8 and 9 that uncoated "Murcott tangor" fruits increased significantly SSC/acid ratio compared to the edible coatings treatments; hence, 3% CMC coated fruits presented the lowest values in this respect in both seasons during ambient and chilled storage.

In regard to the effect of storage period, SSC/acid ratio was gradually increased as storage period advanced from harvest till 60 days either at cold storage or during shelf life at room temperature. The increment in SSC/acid ratio during the storage period mainly due to the increase of SSC content and the reduction in total acidity in fruit juice as the storage period advanced.

Concerning the interaction effect between storage period and tested edible coatings treatments, data presented in Tables 8 and 9 showed that the interactions of twenty days storage duration under cold storage recorded statistically the lowest SSC/acid ratio especially, CMC coated fruits in both seasons but 3% CMC treatment was the best in this respect. On the contrary, the highest SSC/acid ratio was observed on those of 60 days storage period combinations, particularly those uncoated fruits "control" in both seasons during ambient and chilled storage. The obtained results go in the same line with those reported by Manazano and Diaz (2003), who found that SSC/acid ratio was increased with the passage of time for coated 'Valencia' oranges.

Table 8: SSC /acid ratio in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	SSC /acid ratio (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	9.67	12.43	14.44	18.77	13.83	9.67	15.93	19.35	25.19	17.54
2% CMC	9.67	10.28	11.72	13.67	11.33	9.67	12.67	14.94	18.09	13.84
3% CMC	9.67	9.86	11.27	13.11	10.9	9.67	12.10	14.21	17.24	13.31
2% Cellulose	9.67	11.01	12.64	14.97	12.07	9.67	12.45	14.64	17.79	13.64
3% Cellulose	9.67	10.64	12.14	14.22	11.67	9.67	12.75	14.94	18.04	13.85
2% beeswax	9.67	11.40	13.13	15.73	12.48	9.67	14.34	17.19	21.34	15.64
3% beeswax	9.67	11.82	13.66	16.42	12.89	9.67	14.98	18.03	22.69	16.34
Mean of storage period	9.67	11.06	12.71	15.27	-	9.67	13.60	16.19	20.05	-
LSD at 5%	Treatment (T) = 0.16 Storage period(S) = 0.12 T x S = 0.31					Treatment (T) = 0.29 Storage period(S) = 0.22 T x S = 0.58				

Table 9: (SSC) /acid ratio in "Murcott tangor" fruit juice under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	SSC /acid ratio (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	10.31	13.29	15.35	20.19	14.79	10.31	17.16	20.96	27.39	18.96
2% CMC	10.31	10.96	12.51	14.61	12.09	10.31	13.32	16.04	19.45	14.78
3% CMC	10.31	10.51	12.02	14.01	11.71	10.31	12.88	15.24	18.52	14.24
2% Cellulose	10.31	11.76	13.52	16.09	12.92	10.31	13.31	15.71	19.12	14.61
3% Cellulose	10.31	11.56	12.97	15.20	12.51	10.31	13.71	16.03	19.38	14.86
2% beeswax	10.31	12.19	14.06	16.86	13.35	10.31	15.40	18.53	23.06	16.83
3% beeswax	10.31	12.64	14.36	17.63	13.74	10.31	16.11	19.47	24.62	17.63
Mean of storage period	10.31	11.84	13.54	16.37	-	10.31	14.54	17.43	21.65	-
LSD at 5%	Treatment (T) = 0.19 Storage period(S) = 0.14 T x S = 0.37					Treatment (T) = 0.32 Storage period(S) = 0.24 T x S = 0.64				

Juice ratio:

In general, the juice ratio of "Murcott tangor" fruits declined with the increase in storage period (Tables 10 and 11). However, the uncoated Murcott tangor fruits showed gradual reduction in juice yield as compared to those coated with different edible coatings. The average values of

Table 10: Juice ratio in "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Juice % (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	41.69	36.96	34.17	31.83	36.16	41.69	35.93	33.50	29.77	35.22
2% CMC	41.69	41.58	40.48	38.38	40.53	41.69	41.38	40.08	36.38	39.88
3% CMC	41.69	41.67	40.57	38.47	40.6	41.69	41.47	40.17	36.47	39.95
2% Cellulose	41.69	40.46	39.36	37.29	39.7	41.69	40.26	38.67	35.19	38.95
3% Cellulose	41.69	40.66	39.59	37.49	39.86	41.69	40.46	39.19	35.39	39.18
2% beeswax	41.69	39.67	38.60	36.44	39.1	41.69	39.47	38.20	34.34	38.43
3% beeswax	41.69	39.17	38.44	36.34	38.91	41.69	39.04	37.43	33.91	38.02
Mean of storage period	41.69	40.02	38.74	36.61	-	41.69	39.72	38.18	34.49	-
LSD at 5%	Treatment (T) = 0.35 Storage period(S) = 0.26 T x S = 0.69					Treatment (T) = 0.37 Storage period(S) = 0.28 T x S = 0.73				

Table 11: Juice ratio in "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Juice % (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	40.79	35.93	33.16	30.93	35.20	40.79	34.86	31.97	28.87	34.12
2% CMC	40.79	40.48	39.38	37.34	39.50	40.79	40.38	39.08	35.48	38.93
3% CMC	40.79	40.57	39.50	37.37	39.56	40.79	40.47	39.17	35.57	39.00
2% Cellulose	40.79	39.36	38.29	36.19	38.66	40.79	39.26	37.67	34.29	38.00
3% Cellulose	40.79	39.56	38.53	36.39	38.82	40.79	39.46	38.19	34.49	38.23
2% beeswax	40.79	38.57	37.54	35.36	38.07	40.79	38.47	37.20	33.44	37.48
3% beeswax	40.79	38.11	37.37	35.21	37.87	40.79	38.01	36.37	33.01	37.05
Mean of storage period	40.79	38.94	37.68	35.54	-	40.79	38.70	37.09	33.59	-
LSD at 5%	Treatment (T) = 0.33 Storage period(S) = 0.25 T x S = 0.67					Treatment (T) =0.42 Storage period(S) =0.32 T x S = 0.83				

juice yield in control (uncoated) fruits were 36.16 & 35.20% under cold storage conditions and 35.22 & 34.12% under ambient conditions during first and second seasons, respectively.

As for the interaction effect between storage period and tested edible coatings treatments, data presented in Tables 10 and 11 illustrated that the interactions of twenty days storage duration under cold storage recorded the highest juice ratio especially, CMC treated fruits in both seasons but 3% CMC treatment was the best in this respect. On the contrary, the lowest juice ratio was observed on those of 60 days storage period combinations, particularly those uncoated fruits "control" in both seasons during ambient and chilled storage. The obtained results go in line with those found by Mahajan *et al.* (2013) who reported that the maintenance of higher juice percentage in coated fruits is obvious due to the reduction of moisture loss. Moreover, Dang *et al.* (2008) reported that polysaccharide-based coatings like CMC and Cellulose are used to increase the shelf life of fruits by reducing dehydration, oxidative rancidity and permeability to water vapor.

Vitamin- C:

The vitamin-C content of fruits followed a declining trend commensurate with advancement of storage period (Tables 12 and 13) and that was in agreement with those stated by Kumar *et al.* (2000) who found that ascorbic acid decreased with increasing period of storage in kinnow fruits.

Table 12: Vitamin C (mg/100g) in "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Vitamin C (mg/100g) (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	66.87	46.85	36.57	20.31	42.65	66.87	38.66	28.02	17.31	37.71
2% CMC	66.87	59.60	55.55	45.45	56.87	66.87	54.04	45.12	33.05	49.77
3% CMC	66.87	61.59	57.41	47.31	58.30	66.87	56.06	47.17	35.11	51.30
2% Cellulose	66.87	53.43	48.42	38.33	51.76	66.87	48.16	38.15	26.09	44.82
3% Cellulose	66.87	56.40	51.23	40.79	53.82	66.87	51.14	41.13	29.13	47.07
2% beeswax	66.87	51.42	44.28	34.08	49.16	66.87	46.12	34.18	22.11	42.32
3% beeswax	66.87	50.06	42.64	31.73	47.83	66.87	44.76	32.44	20.44	41.13
Mean of storage period	66.87	54.19	48.01	36.86	-	66.87	48.42	38.03	26.18	-
LSD at 5%	Treatment (T) = 0.58 Storage period(S) = 0.44 T x S = 1.16					Treatment (T) = 0.51 Storage period(S) = 0.39 T x S = 1.03				

But the reduction in ascorbic acid was less in coated fruits as compare to control. The uncoated fruits recorded 42.65 & 40.49 under cold storage condition while 37.71 & 36.43 mg/100g vitamin-C content under room temperature conditions during first and second seasons, respectively. The CMC coatings have the potential benefit of better retention of the ascorbic acid especially 3% CMC coated fruits ; hence it recorded 58.30 & 55.55 mg/100g vitamin-C content under cold storage condition, and 51.30 & 50.14 mg/100g vitamin-C content under room temperature conditions during first and second seasons, respectively and that was in agreement with Dhaka *et al.* (2001) who observed that the retention of ascorbic acid content of "Totapuri mango" depends on the concentrations of coating. Also, Shahid and Abbasi (2011) found that coating treatments of sweet orange cv. "Blood Red" maintained ascorbic acid and Mahajan *et al*. (2002) reported higher ascorbic acid content in "Kinnow" as compared to uncoated fruits.

Table 13: Vitamin C (mg/100g) in "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Vitamin C (mg/100g) (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	65.22	44.69	33.10	18.95	40.49	65.22	37.39	26.09	17.02	36.43
2% CMC	65.22	57.44	52.45	41.35	54.12	65.22	53.04	44.14	32.12	48.63
3% CMC	65.22	59.43	54.31	43.24	55.55	65.22	55.07	46.14	34.12	50.14
2% Cellulose	65.22	51.26	45.32	34.23	49.01	65.22	47.26	37.15	25.16	43.69
3% Cellulose	65.22	54.24	48.13	36.73	51.08	65.22	50.24	40.11	27.83	45.85
2% beeswax	65.22	49.25	41.18	30.38	46.51	65.22	45.14	33.15	21.18	41.17
3% beeswax	65.22	47.89	39.54	28.39	45.26	65.22	43.83	31.44	19.49	39.99
Mean of storage period	65.22	52.03	44.86	33.32	-	65.22	47.42	36.89	25.27	-
LSD at 5%	Treatment (T) = 0.48 Storage period(S) = 0.37 T x S = 0.97					Treatment (T) = 0.52 Storage period(S) = 0.39 T x S = 1.05				

Total carotenoids in peel (mg/100g):

Data in Tables 14 and 15 declared that all tested edible coatings treatments statistically increased total carotenoids significantly in peel of "Murcott tangor" fruits, with superior for uncoated fruits as compared with coated fruits in both seasons. As for the effect of storage periods, the same tables showed that total carotenoid in peel of Murcott tangor fruits increased with prolonging the storage periods in both seasons. So, sixty days storage period scored the highest values in this sphere while twenty days storage period “regardless of the initial reading” registered the lowest values in this respect. This trend was true in both seasons. These results were confirmed by Mohamed *et al.* (2013) who reported that edible coatings increased the total carotenoids in "prickly pear" during 9 days of storage and that may be due to that edible coatings serve as carriers of antioxidants and texture enhancers and nutraceuticals which help in decreasing the water vapor and oxygen gas transfer, resulting in the diminished respiration rate and ethylene production (Rojas-Graü *et al.*, 2008). Hence, Ethylene causes the loss of chlorophylls, produces some minor changes in carotenoids, induces carotenoid synthesis and thus has the potential to re-establish the orange colors (El-Zeftawi and Garrett, 1978).

Referring to the interaction effect between edible coatings treatments and storage periods, data in Tables 14 and 15 indicated that the combination of sixty days storage period was the most promising in producing the highest values of this parameter, especially those of uncoated fruits in both seasons. On the reverse, the lowest values of this parameter were scored by the combination of sixty days storage periods, particularly those coated with CMC in both seasons. The remained combinations came in-between the abovementioned treatments in both seasons.

Table 14: Total carotenoids in peel (mg/100 g) of "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Total carotenoids in peel (mg/100 g) (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.79	2.30	2.80	3.30	2.55	1.79	3.00	3.63	4.13	3.14
2% CMC	1.79	1.84	2.34	2.84	2.20	1.79	2.54	3.04	3.54	2.73
3% CMC	1.79	1.81	2.31	2.81	2.18	1.79	2.51	3.01	3.51	2.71
2% Cellulose	1.79	1.92	2.42	2.92	2.26	1.79	2.62	3.12	3.62	2.79
3% Cellulose	1.79	1.87	2.37	2.87	2.23	1.79	2.57	3.07	3.57	2.75
2% beeswax	1.79	1.97	2.47	2.97	2.30	1.79	2.67	3.17	3.67	2.83
3% beeswax	1.79	2.03	2.53	3.03	2.35	1.79	2.73	3.23	3.73	2.87
Mean of storage period	1.79	1.96	2.46	2.96	-	1.79	2.66	3.18	3.68	-
LSD at 5%	Treatment (T) = 0.03 Storage period(S) = 0.02 T x S = 0.05					Treatment (T) = 0.04 Storage period(S) = 0.03 T x S = 0.08				

Pectic substances % (as calcium pectate) in peel and edible portion of "Murcott tangor" fruits:

It was clear from the results in Tables 16, 17, 18 and 19 that all examined edible coating treatments succeeded in decreasing the pectic substances percentage in peel and edible portion of Murcott tangor fruits in both seasons.

Table 15: Total carotenoids in peel (mg/100 g) of "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Total carotenoids in peel (mg/100 g) (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.88	2.40	2.90	3.40	2.65	1.88	2.50	3.00	3.50	2.72
2% CMC	1.88	1.94	2.44	2.94	2.3	1.88	2.04	2.54	3.04	2.37
3% CMC	1.88	1.91	2.41	2.91	2.28	1.88	2.01	2.51	3.01	2.35
2% Cellulose	1.88	2.02	2.52	3.02	2.36	1.88	2.12	2.62	3.12	2.44
3% Cellulose	1.88	1.97	2.47	2.97	2.32	1.88	2.07	2.57	3.07	2.39
2% beeswax	1.88	2.07	2.57	3.07	2.40	1.88	2.17	2.67	3.17	2.48
3% beeswax	1.88	2.13	2.63	3.13	2.45	1.88	2.23	2.73	3.23	2.52
Mean of storage period	1.88	2.06	2.56	3.06	-	1.88	2.16	2.66	3.16	-
LSD at 5%	Treatment (T) = 0.03 Storage period(S) = 0.02 T x S = 0.05					Treatment (T) = 0.03 Storage period(S) = 0.02 T x S = 0.05				

However, the highest pectic substances percentage in peel and edible portion of "Murcott tangor" fruits was recorded by uncoated fruits followed in descending order by 3% beeswax-coated fruits, whereas the lowest values of this parameter were scored by 3% CMC-coated fruits followed in ascending order by 2% CMC-coated fruits. This trend was true in both seasons during ambient and chilled storage and that might be due to the role of edible coatings in reducing moisture loss and respiratory activity and thus maintained the turgidity of the cells (Ribeiro *et al.*, 2007 and Adetunji *et al.,* 2012); furthermore, this reducing in moisture loss and respiratory activity keep unbound water and that the balance between the unbound and bound water is undisturbed thus enabling the compact cell structure and good firmness of the fruit (Cyril and Methodius, 2012).

Referring to the effect of storage periods, the same tables indicate that, regardless of the initial reading, the pectic substances percentage in peel and edible portion of "Murcott tangor" fruits was progressively increased as the cold storage period was increased from twenty to sixty days. However, stored "Murcott tangor" fruits for sixty days scored the highest values as compared with storage periods for twenty days in both seasons. Pectic substances are primarily responsible for the firmness of fruits; hence, during ripening and maturation, protopectin (insoluble form of pectic substances) is gradually broken down to lower molecular weight fraction (soluble pectin), which are more soluble in water and cause softening of fruits (Wills *et al.*, 1981).

Table 16:Pectic substances % (as calcium pectate) in peel of "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Pectic substances % (as calcium pectate) in peel (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	2.55	5.62	6.73	8.23	5.78	2.55	7.34	8.45	10.56	7.23
2% CMC	2.55	3.57	4.68	6.18	4.24	2.55	4.74	5.85	7.93	5.27
3% CMC	2.55	3.23	4.34	5.84	3.99	2.55	4.49	5.59	7.70	5.08
2% Cellulose	2.55	4.29	5.40	6.90	4.79	2.55	5.51	6.62	8.72	5.85
3% Cellulose	2.55	4.07	5.15	6.65	4.61	2.55	5.22	6.33	8.44	5.64
2% beeswax	2.55	4.62	5.73	7.23	5.03	2.55	5.68	6.79	8.86	5.97
3% beeswax	2.55	5.15	6.26	7.76	5.43	2.55	6.19	7.30	9.41	6.36
Mean of storage period	2.55	4.36	5.47	6.97	-	2.55	5.59	6.70	8.80	-
LSD at 5%	Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18					Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18				

Table 17:Pectic substances % (as calcium pectate) in peel of "Murcott tangor" fruit under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Pectic substances % (as calcium pectate) in peel (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	2.95	6.02	7.13	8.63	6.18	2.95	7.74	8.85	10.96	7.63
2% CMC	2.95	3.97	5.08	6.58	4.64	2.95	5.14	6.25	8.33	5.67
3% CMC	2.95	3.63	4.74	6.24	4.39	2.95	4.89	5.99	8.10	5.48
2% Cellulose	2.95	4.69	5.80	7.30	5.19	2.95	5.91	7.02	9.12	6.25
3% Cellulose	2.95	4.47	5.55	7.05	5.01	2.95	5.62	6.73	8.84	6.04
2% beeswax	2.95	5.02	6.13	7.63	5.43	2.95	6.08	7.19	9.26	6.37
3% beeswax	2.95	5.55	6.66	8.16	5.83	2.95	6.59	7.70	9.81	6.76
Mean of storage period	2.95	4.76	5.87	7.37	-	2.95	5.99	7.11	9.20	-
LSD at 5%	Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18					Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18				

Table 18:Pectic substances % (as calcium pectate) in edible portion of "Murcott tangor" fruits under cold storage and shelf life (seven days at room temperature) during 2012 season.

Treatment	Pectic substances % (as calcium pectate) in edible portion (Season 2012)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.41	4.48	5.59	7.09	4.64	1.41	6.19	7.31	9.42	6.08
2% CMC	1.41	2.43	3.54	5.04	3.10	1.41	3.60	4.71	6.79	4.13
3% CMC	1.41	2.09	3.20	4.70	2.85	1.41	3.35	4.46	6.56	3.94
2% Cellulose	1.41	3.15	4.26	5.73	3.64	1.41	4.37	5.48	7.58	4.71
3% Cellulose	1.41	2.93	4.01	5.51	3.47	1.41	4.08	5.19	7.30	4.49
2% beeswax	1.41	3.48	4.59	6.09	3.89	1.41	4.54	5.65	7.72	4.83
3% beeswax	1.41	4.01	5.12	6.62	4.29	1.41	5.05	6.16	8.32	5.23
Mean of storage period	1.41	3.22	4.33	5.83	-	1.41	4.45	5.57	7.67	-
LSD at 5%	Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18					Treatment (T) =0.09 Storage period(S) =0.07 T x S = 0.19				

Regarding the interaction effect between the tested edible coatings treatments and storage periods, data in Tables 16, 17, 18 and 19 demonstrated that, "irrespective of the initial data (zero storage period)" the lowest values of pectic substances percentage in peel and edible portion were recorded by the combination of twenty days storage periods, especially 3% CMC-coated fruits. On the contrary, the highest values of this parameter were registered by the combination of sixty days storage periods, particularly those of uncoated fruits in both seasons. This trend was true in both seasons during ambient and cold storage and go in the same line with Maria *et al.*

(2006) and Mahajan *et al.* (2013) who reported that coating improved firmness of mandarin and Kinnow fruits compared to uncoated samples.

Table 19:Pectic substances % (as calcium pectate) in edible portion of "Murcott tangor" fruits under cold storage and shelf life (seven days at room temperature) during 2013 season.

Treatment	Pectic substances % (as calcium pectate) in edible portion (Season 2013)									
	Cold storage (day)					7 Days during shelf life after cold storage period				
	0	20	40	60	Mean of treatment	0	20	40	60	Mean of treatment
Control	1.87	4.94	6.05	7.55	5.11	1.87	6.66	7.77	9.88	6.54
2% CMC	1.87	2.89	3.99	5.49	3.56	1.87	4.06	5.17	7.25	4.59
3% CMC	1.87	2.55	3.66	5.16	3.31	1.87	3.81	4.92	7.02	4.40
2% Cellulose	1.87	3.61	4.72	6.22	4.11	1.87	4.83	5.94	8.04	5.17
3% Cellulose	1.87	3.39	4.47	5.97	3.93	1.87	4.54	5.65	7.76	4.96
2% beeswax	1.87	3.94	5.05	6.54	4.35	1.87	5.00	6.11	8.18	5.29
3% beeswax	1.87	4.47	5.58	7.08	4.75	1.87	5.51	6.62	8.73	5.68
Mean of storage period	1.87	3.68	4.79	6.29	-	1.87	4.92	6.03	8.12	-
LSD at 5%	Treatment (T) = 0.09 Storage period(S) = 0.07 T x S = 0.18					Treatment (T) =0.09 Storage period(S) =0.07 T x S = 0.18				

Overall, coating "Murcott tangor" fruits coated with CMC followed by storage under cold storage and at ambient conditions was found to be beneficial because this treatment helped to extend the shelf life without deterioration in fruit quality. This coating reduced the weight loss and maintained the overall quality of Murcott tangor fruits up to 60 days under cold storage (5±1˚C and 90-95% RH) and for 7 days after this period which gives an opportunity to presence of Murcott tangor in the Egyptian market during May as the only kind of Rutaceae family members at this time, and in turn increasing its economic value.

REFERENCES

Abbasi, K.S.; N. Anjum, S. Sammi; T. Masud and S. Ali (2011). Effect of coatings and packaging material on the keeping quality of Mangoes (*Mangifera indica* L.) stored at low temperature. Pakistan Journal of Nutrition, 10 (2): 129-138.

Adetunji, C.O.; O.B. Fawole; K.A. Arowora; S.J. Nwaubani; E.S. Ajayi; J.K. Oloke; O.M. Majolagbe; B.A. Ogundele; J.A. Aina and J.B. Adetunji (2012). Effect of edible coatings of Aloe Vera gel on quality and postharvest physiology of pineapple fruits during ambient storage. Global Journal Science Frontier Research, 12: 39-43.

Alam, M.S. and S. Paul (2001). Effect of cellulose based edible coating on shelf life of kinnow. J. Res. Punjab Agric. Univ., 38 (1-2): 76-81.

AOAC, 1990. Official Methods of Analysis. Association of Official Analytical Chemists, Washington, DC., USA.

AOAC (1994). Official Methods of Analysis. Association of Official Analytical Chemists. 1111 North 19th Street, Suite 20, 16th Edi. Arlington, Virginia, USA. 22209.

Baldwin, E.A.; M.C. Nisperos and R.A. Baker (1995).Use of edible coating to preserve lightly processed products.Rev.Food Sci.Nutr.,35:509-524.

Cuq, B.; N. Gontard and S. Guilbert (1995). Edible films and coatings as active layers. In Active Food Packaging (M.L. Rooney, ed.), Champan and Hall, Glassgow U.K, pp: 111-141.

Cyril and Methodius (2012). The potential application of novel beeswax edible coatings containing coconut oil in the minimal processing of fruits. Department for Food Technology and Biotechnology, Skopje, FYRM. UDC 634.1:664.8

Dang, K.T.H.; Z. Singh; E.E. Swinny (2008). Edible coatings influence ripening, quality, and aroma biosynthesis in mango fruit. Journal of Agricultural and Food Chemistry 56 (4): 1361–1370.

Dhaka, R.S.; M.K. Verma and M.K. Agrawal (2001). Effect of post-harvest treatments on physico-chemical characters during storage of mango cv. Totapuri. Har. J. Hort. Sci., 30: 36-38.

Dhall, R. (2013). Advances in edible coatings for fresh fruits and vegetables: a review. Crit. Rev. Food Sci. Nutr., 53: 435–450.

Echeverria, E. and Valich, J. (1989). Enzymes of sugar and acid metabolism in stored Valencia oranges. Journal of American Society of Horticultural Science, 114: 445-449.

El-Anany, A.M.; G.F.A. Hassan, and F.M.R. Ali (2009). Effect of edible coatings on the shelf life and quality of ‘Anna’ apple (*Malus domestica,* Borkh) during cold storage. Journal of Food Technology, 7: 5-11.

El-Zeftawi, B.M. and R.G. Garrett (1978). Effects of ethephon, GA and light exclusion on rind pigments, plastid ultrastructure and juice qualit of Valencia oranges. Journal of Horticultural Science, 53, (3): 215-223.

FAO (2012). FAOSTAT: Statistical Database. Food and Agriculture Organization of the United Nations, Rome, Italy. http://faostat.fao.org/site/339/default.aspx.

Figueiredo, J.O. (1991). Varieties cup of commercial value. In: Rodriguéz, O.; Viegas, F.; Pompeu Júnior, J.; Amaro, A.A., eds. Brazilian citrus. Fundação Cargill, Campinas, SP, Brazil. (in Portuguese).

Kumar, J.; R.K. Sharma and R. Singh (2000). The effect of different methods of packing on the shelf life of kinnow. Haryana J. Hort. Sci., 29 (3-4): 202-203.

Mackinny, G. (1941). Absorption of light by chlorophyll solution. J. Biol. Chem., 140: 315-322.

Mahajan, B.V.C.; A.S. Dhatt and Rattan, G.S. (2002). Evaluation of various wax formulations on the post-harvest characteristics of kinnow. Indian Journal of Citriculture, 1: 185-88.

Mahajan B.V.C.; W.S. Dhillon and M. Kumar (2013). Effect of surface coatings on the shelf life and quality of kinnow fruits during storage. Journal of Postharvest Technology, 01 (01): 008-015.

Manzano, J.E. and A. Diaz (2003). Effect of storage time, temperature and wax coating on the quality of fruits of ‘Valencia’ orange (*Citrus sinensis* L.). Proc. Int. Soc. Tropical Hort., 44: 24-29.

Maria, L.l.; N. Tarazaga and M.B.P. Gaga (2006). Effect of edible coatings on quality of mandarins cv. Clemenules proc Fla. State Hort.Soc., 119: 350-352.

Mazumadar, B.C. (2003). Methods on Physico-Chemical Analysis of Fruits. Daya Publishing House, Delhi, India, pp: 103-105.

Mohamed, A.Y.I; H.E. Aboul-Anean and A.M. Hassan. (2013). Utilization of edible coating in extending the shelf life of minimally processed prickly Pear. Journal of Applied Sciences Research, 9 (2): 1202-1208.

Petracek, P.D.; H.T. Dou and S. Pao (1998). The influence of applied waxes on postharvest physiological behavior and pitting of grapefruit. Postharvest Biol. Technol., 14: 99–106.

Ribeiro, C.; A.A. Vicente; J.A. Teixeira and C. Miranda (2007). Optimization of edible coating composition to retard strawberry fruit senescence. Postharvest Biology and Technology, 44: 63-70.

Rojas-Graü, M.A.; M.S. Tapia; F.J. Rodríguez; A.J. Carmona; O. Martin-Belloso (2008). Using polysaccharide-based edible coatings to maintain quality of fresh-cut Fuji apples. LWT - Food Science and Technology, 41(1): 139-147.

Rong, Z.; Z. Ashan and C. Jinyin (2012). Effects of carboxymethyl cellulose coating enriched with bacteriostatic preparation on cold preservation of Nanfeng mandarin. Transactions of the Chinese Society of Agricultural Engineering (7): 281-2.

Shahid , M.S. and N.A. Abbasi (2011). Effect of beeswax coatings on physiological changes in fruits of sweet orange Cv. "Blood red". Sarhad Journal of Agriculture, 27 (3): 385-394.

Sidhu, G.S.; W.S. Dhillon and B.V.C. Mahajan (2009). Effect of waxing and packaging on storage of pear cv. Punjab Beauty. Indian Journal of Horticulture, 66: 239-244.

Snedecor, G.W. and W.G. Cochran (1994). Statistical Methods (Eighth edition), Journal of Educational and Behavioral Statistics, 19 (3): 304-307.

Stephen, H.F. and L.K Jackson (2003). Murcott (honey Tangerine). Institute of Food and Agric. sci. Univ. of Florida.

Togrul, H. and N. Arslan (2004). Extending shelf life of peach and pear by using CMC from sugar beet pulp cellulose as hydrophilic polymer in emulsions. Food Hydrocolloids, 18: 215-226.

Valencia-Chamorro, S.; M. Perez-Gago; M. Del Rio; L. Palou (2010). Effect of antifungal hydroxypropyl methylcellulose-lipid edible composite coatings on Penicillium decay development and postharvest quality of cold-stored ‘Ortanique’ mandarins. J. Food Sci. 75, S418–S426.

Waller, R.A. and D.B. Duncan (1969). A bays rule for the symmetric multiple comparison problem. J. Am. Assoc., 64 (328): 1484-1503.

Wills, R.B.H.; P.A. Cambridge and K.J. Scott (1980). Use of flesh firmness and other objective tests to determine consumer acceptability of delicious apples. Australian Journal of Experimental Agriculture and Animal Husbandry, 20: 252-56.

Wills, R.H.; T.H. Lee; D. Graham; W.B. McGlasson and E.G. Halls (1981): Post Harvest: An Introduction of the Physiology and Handling of Fruits and Vegetables. AVI publish. Co. West post. 63p.

"فعالية الأغلفة المختلفة الصالحة للأكل في تحسين جودة ثمار الماركوت تانجور خلال التخزين البارد و وجو الغرفة"

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أجريت هذه الدراسة خلال موسمين متتاليين ٢٠١٢ و ٢٠١٣ لتقييم تأثير الكربوكسي ميثيل سليلوز(CMC) ، السليلوز وشمع عسل النحل بتركيزات ٢ و ٣٪ كمواد مغلفة صالحة للأكل على بعض معايير الجودة لثمار الماركوت تانجور ، حيث تم تخزين الثمار المغلفة و الغير مغلفة تحت ظروف التخزين البارد (٥ ± ١ درجة مئوية و رطوبة نسبية ٩٠-٩٥٪) و لمدة ٧ أيام تحت ظروف الغرفة بعد كل فترة من التخزين البارد. و قد تم تقدير الصفات الفيزيائية و الكيميائية المختلفة للثمار عند فترات ٠، ٢٠، ٤٠ و ٦٠ يوما تحت ظروف التخزين البارد وبعد ٧ أيام من كل فترة تخزين باردة تحت ظروف الغرفة. و لقد زاد كل من الفقدان في وزن الثمرة، المواد الصلبة الذائبة ، نسبة المواد الصلبة الذائبة للحموضة، الكاروتينات الكلية في قشرة الثمار والمواد البكتينية في كل من القشرة والجزء الصالح للأكل ، في حين انخفضت نسبة الحموضة، فيتامين سى و نسبة العصير فى ثمار الماركوت تانجور مع تقدم فترة التخزين. و قد أشارت نتائج الدراسة إلى أن ثمار الماركوت تانجور المغلفة بالكربوكسي ميثيل سليلوز أظهرت تأخير كبير في تغيير خصائصها المختلفة سواء في التخزين البارد أو تحت جو الغرفة و أن هذه الثمار المغلفة بالكربوكسي ميثيل السليلوز و بخاصة عند تركيز ٣٪ يمكن تخزينها بنجاح لمدة ٦٠ يوما تحت ظروف التخزين البارد ولمدة ٧ أيام تحت جو الغرفة بعد هذه الفترة من التخزين البارد محتفظة بجودة نوعية و حسية مقبولة للغاية.