

Effect of Coating and Wrapping Materials on Storage Behavior of Balady Mandarin Fruits

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Abstract

This study was conducted during two successive seasons 2014 & 2015 to investigate the effect of coating and wrapping materials on storability and quality of Balady mandarin fruits during the storage period. Fruits were coated with salicylic acid, paraffin oil or camphor oil, as well as wrapped with foil paper and untreated. The fruits were stored either at room temperature or cold conditions ($0\pm 2^{\circ}\text{C}$) + humidity of $90\pm 5\%$.

The results showed that the fruit weight loss %, fruit decay %, total soluble solids % and TSS/acid ratio were significantly increased with prolonging the storage period. On the other hand, the advanced storage period induced a gradual decrease of fruit juice percentage acidity %, vitamin C and total phenolic contents levels.

All treatments caused decreased fruit weight loss and fruit decay percentage under both storage conditions. Using foil paper wrapping or salicylic acid gave the least fruit weight loss and decayed fruit percentage, respectively. The most loss reduction was associated with the cold storage than room temperature conditions. Also, all treatments improved the fruit quality during the storage period compared to the untreated ones.

So, it could be concluded that oil coating or wrapping maintained fruit freshness without negative effects on fruit quality parameters. Meanwhile, coating and wrapping fruits retained high levels of juice volume, acidity, ascorbic acid (V. C) and total phenolic contents as well as lower total soluble solids and TSS/acid ratio loss than controls during storage. Such treatments can be used as alternative of chemical application in order to maintain human health and environment.

Keyword: Coating, Wrapping, Salicylic acid, Storability, Fruit quality storage, Balady mandarin.

Introduction

Citrus fruits are important part of human diet because of their nutritional value, antioxidant activity and high consumption. Citrus fruits are rich in vitamin C and also contain large amounts of phytochemical (Heber and Lu, 2002). It is one of the most important fruit crops in the world. It ranks the third position between fruit crops and only preceded with grapes and apples. However, in

Egypt, citrus species are the most important fruit crop either for local consumption or exportation. Balady mandarin is one of the most important citrus species that Egyptian consumers and export market prefer because of its flavor and easy peeling. In developing countries, the post-harvest decay destroys more than 30% of the crop yield. Storage temperature is the most important environmental factor affecting senescence

of fruits, because it regulates the rate of physiological and bio-chemical processes (Kader, 2002).

During post-harvest storage, due to the internal and external factors, chemical and physical changes occur in fruits and vegetables, which results in losses in nutritional quality. To prevent these adverse effects, use of environmentally friendly technologies such as edible coating or salicylic acid are of prime important (Saucedo *et al.*, 2007; Ladaniya, 2011). Salicylic acid exhibits a high potential in enhancing quality, controlling post-harvest losses and mitigating chilling injury in fruits and vegetables. It is known that, the cold storage plays an important role in prolonging shelf life of many fruits and vegetables with keeping their quality during storage. Economically, it is necessary to discover a cheap and effective storage method to increase its shelf-life by decreasing the natural physiological deterioration and preventing the activity of decay organisms (Aghdam and Bodbodak, 2013).

The application of surface coating on fruits is considered as one of several treatments developed to reduce post-harvest losses and to prolong self life of fruits. Surface coating has been used as preservation technique for fruits and vegetables (Baldwin *et al.*, 1995). Surface coating of fruits reduce the water evaporation from the fruits and thereby slow the weight loss, can maintain the freshness of fruits and improve the appearance of them. Hence, surface coating on fruit, can maintain the quality of fruits and reduce the post harvest decay (Park, 1999).

Two major problems that limit facing the long term storage capability of citrus fruits are pathological and physiological breakdown leading to decay and weight loss (Kader, 2002). To solve the problem of decay development and weight loss, this needs either fungicide application or alternative environmental safe methods. The deterioration of citrus fruit during storage results mainly from transpiration and respiration (Baubaker *et al.*, 2009).

Many plants extracts and essential oils were shown to have high antifungal activity against a wide range of fungi. Also, essential oils and botanical extract are commercially available as pre-harvest and post-harvest fungicides for organic farming (Plooy *et al.*, 2009 and Mansour, 2015). Individual oil film wrapping of fresh fruits will greatly reduce weight loss by reducing the transpiration and maintaining fruit firmness (Rodov *et al.*, 2001; Abd El-Motty and El-Faham, 2013 and Mansour, 2015).

Therefore, this study aimed to recognize the benefit of using oil and salicylic acid coating and foil paper wrapping on storability of Balady mandarin fruits.

Materials and Methods

This study was conducted during two successive seasons of 2014 and 2015 on Balady mandarin (*Citrus reticulata* L.) fruits. The fruits were obtained from the Experimental Orchard of the Faculty of Agriculture, Assiut University.

Fruits were harvested in the first week of January, hand packed and carefully brought, soon after picking to laboratory of Pomology Depart-

ment, Faculty of Agriculture, Assiut University. Fruits were selected for uniformity in maturity, shape, size and weight. The fruits were free from obvious defects or mechanical damage. All fruits were washed with regular tap water and soap and then rinsed with water to remove the residue of soap, then air dried. Fruits were divided into five similar groups and subjected to one of the following treatments.

- 1- Control group (untreated).
- 2- Fruits were coated with thin layer of salicylic acid at 0.4%.
- 3- Fruits were coated with thin layer of paraffin oil at 20%.
- 4- Fruits were coated with thin layer of camphor oil at 10%.
- 5- Fruits were wrapped in foil paper (0.05 cm thickness).

Each treatment was replicated three times and each replicate put as one layer in a carton box. The half of experimental boxes were stored at ($5\pm 2^{\circ}\text{C}$) and ($90\%\pm 5$) relative humidity and the other, at room temperature. Changes in some physical and chemical fruits properties were determined every 7 days at room temperature and every 15 days at cold storage temperature, respectively.

Physical characteristics:

- 1- Weight loss as a percentage from the initial weight.
- 2- Decay percentage: the number of decayed fruits was calculated as a percentage from the total number of each sample.
- 3- Juice percentage: juice content was expressed as percent of fruit weight (W/W).

Chemical juice:

1- The total soluble solids (TSS) were determined by using the hand refractometer.

2- Titratable acidity (TA) expressed as percentage of citric acid, by using 0.1 N sodium hydroxide according to the A.O.A.C. (1985)

3- TSS/TA ratio was then calculated

4- L-ascorbic acid (V.C.) was determined by titration against 2,6-dichlorophenol indophenol blue dye, according to the A.O.A.C. (1985).

5- Total phenolic were determined by Folin-Ciocalteu method (Singleton *et al.*, 1999).

This experiment was conducted in complete randomized design with three replicate and with factorial arrangement was followed throughout the whole work. All recorded data were tabulated and statistically analyses according to Snedecor and Cochran (1990) using L.S.D. at the level of 0.05 in comparison between various treatments means.

Results

1- The percentage of fruit weight loss and decay fruits:

Data presented in Tables (1 & 2) showed the effect of oil and salicylic acid coating and foil paper wrapping on the percentage of weight loss and decay of Balady mandarin fruits during the storage in 2014 and 2015 seasons. It was obvious that results took similar trend during the two studied seasons.

Data in the previous tables cleared that fruit weight loss, as well as, decayed fruits were markedly increased with the advancement of room temperature and cold storage period. These traits were slightly increased gradually from the beginning

either in room temperature or cold till the week five or the third month, respectively.

In response to treatments, it was apparent that all treatments significantly reduced the fruit weight loss percentage and undesirable fruit decay percentage under both storage conditions compared with controls during the two studied seasons. Using foil paper wrapping had the best results, which gave the least percentage of fruit weight loss (9.14 or 9.63%) and (5.63 & 5.73%) against (12.68 & 12.83%) and (10.63 & 10.95%) on untreated ones of storage under room temperature or cold during the two studied seasons, respectively. The decrement of percentage of weight loss due to foil paper wrapping compared to controls attained (27.92 & 24.94) and (48.01 & 47.67%) under room temperature and cold storage during the two studied seasons, respectively. On the other hand, using

salicylic acid gave the least decayed fruits percentage (27.77 & 28.88%) and (21.94 & 23.33%) versus (52.22 & 54.44%) and (48.33 & 50.67%) under room temperature and cold storage during the two studied seasons, respectively. The corresponding decrement percentage attained (46.82 & 46.95%) and (54.60 & 53.96%) during the two studied seasons, respectively.

Moreover, storage under cold condition had the least percentages of fruit weight loss and decayed fruits than storage under room temperature. Also, the variation in reduction of fruit weight loss and decayed fruits depends on the natural coating. Foil paper wrapping gave the least percentage of fruit weight loss whereas, the salicylic acid coating gave the least percentage of decayed fruits compared to the other treatments under both storage conditions.

Table 1. Effect of coating and wrapping materials on weight loss of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	0.0	1.91	5.10	6.10	7.55	10.20	5.14	0.0	0.68	2.18	2.90	4.35	4.75	6.88	3.10
Paraffin oil	0.0	1.80	4.90	5.93	7.21	9.98	4.97	0.0	0.90	2.66	3.65	4.66	6.15	8.32	3.76
Camphor oil	0.0	2.10	4.45	6.01	7.53	10.28	5.06	0.0	0.72	2.33	3.18	4.67	5.81	8.17	3.55
Foil paper	0.0	1.50	4.36	5.18	6.57	9.14	4.46	0.0	0.93	2.50	3.21	4.31	5.10	5.63	3.09
Control	0.0	2.39	6.77	7.89	9.46	12.68	6.53	0.0	1.32	3.76	5.26	6.35	8.35	10.83	5.12
Mean	0.0	1.94	5.12	6.22	7.66	10.46		0.0	0.91	2.69	3.64	4.87	6.03	7.97	
LSD 5%	A:	0.16	B:	0.19	AB:	0.46		A:	0.11	B:	0.13	AB:	0.31		
2015															
Salicylic acid	0.0	1.65	5.23	6.33	7.95	10.68	5.32	0.0	0.82	2.51	3.65	5.23	5.86	7.10	3.60
Paraffin oil	0.0	1.52	4.88	6.05	7.40	10.18	5.01	0.0	1.20	2.80	4.18	5.25	7.10	8.18	4.10
Camphor oil	0.0	1.89	4.62	6.28	7.79	10.48	5.18	0.0	0.90	2.86	3.80	5.75	6.48	7.81	3.94
Foil paper	0.0	2.18	4.02	5.10	6.34	9.63	4.55	0.0	1.16	2.72	3.62	4.81	5.18	5.73	3.32
Control	0.0	2.56	6.28	8.22	9.65	12.83	6.59	0.0	1.50	4.16	5.62	6.85	7.50	10.95	5.23
Mean	0.0	1.96	5.01	6.39	7.83	10.76		0.0	1.12	3.01	4.19	5.58	6.42	7.95	
LSD 5%	A:	0.18	B:	0.22	AB:	0.53		A:	0.13	B:	0.15	AB:	0.37		

A= Period.

B: Treat

Table 2. Effect of coating and wrapping materials on decay % of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	0.0	0.0	0.0	1.22	6.67	27.77	5.94	0.0	0.0	1.22	8.89	15.55	17.78	21.94	9.34
Paraffin oil	0.0	0.0	0.0	3.33	10.0	33.74	9.84	0.0	0.0	3.33	11.11	20.10	21.11	27.18	11.82
Camphor oil	0.0	0.0	0.0	2.22	6.67	28.88	6.29	0.0	0.0	2.44	8.89	16.67	16.67	22.22	9.56
Foil paper	0.0	0.0	2.22	8.88	13.33	38.88	10.55	0.0	0.0	5.55	12.22	16.67	24.44	32.45	13.05
Control	0.0	3.33	10.0	15.55	20.00	52.22	16.85	0.0	3.33	9.76	15.56	27.78	42.22	48.33	21.00
Mean	0.0	0.67	2.44	6.24	11.33	36.30		0.0	0.67	4.46	11.33	19.33	24.44	39.42	
LSD 5%	A:	0.81	B:	0.98	AB:	2.41		A:	1.28	B:	1.51	AB:	3.68		
2015															
Salicylic acid	0.0	0.0	0.0	2.44	7.77	28.88	6.52	0.0	0.0	1.44	8.88	16.67	18.89	23.33	11.53
Paraffin oil	0.0	0.0	0.0	4.44	11.11	35.55	8.52	0.0	0.0	3.33	13.33	20.00	22.22	28.89	14.63
Camphor oil	0.0	0.0	0.0	3.33	8.88	3.09	7.05	0.0	0.0	2.44	10.0	16.67	17.78	23.33	11.80
Foil paper	0.0	0.0	1.22	8.88	13.33	40.00	10.57	0.0	0.0	6.67	11.11	16.67	25.55	34.44	15.74
Control	0.0	4.44	11.11	17.77	22.22	54.44	18.33	0.0	3.33	10.00	16.67	26.67	43.33	50.67	25.25
Mean	0.0	0.89	2.47	7.37	12.66	37.79		0.0	0.67	4.78	11.99	19.34	25.55	32.13	
LSD 5%	A:	0.88	B:	1.05	AB:	2.53		A:	0.99	B:	1.16	AB:	2.61		

The results indicated that the fruit wrapping or coating in combination with low temperature storage proved effective in reducing the percentage of weight loss and decayed fruits as well as keeping the Balady mandarin fruits for longest period.

2- The percentage juice contents:

The data introduced in Table (3) disclosed that fruit juice percentage was significantly decreased by extending cooling storage duration. The highest values were recorded at the beginning of storage, whereas, the least ones was recorded at the end of storage course under both storage conditions.

Storage under cold condition had the least reduction of juice percentage compared to storage under room temperature.

All treatments lead to significantly increased fruit juice percentage compared to controls under both storage conditions. No significant differences were found between treatments in the different storage conditions during both the studied seasons. Foil

paper wrapping gave the best effect of preserving the juice percentage (33.35 & 33.53%) under room temperature storage as well as (33.15 & 33.20%) under cold storage during the two studied seasons, respectively. All treatments were retained the juice volume higher as possible during storage compared with controls which gave the lowest juice percentage (30.20 & 30.80%) and (30.65 & 30.45%) under room temperature and cold storage conditions during two studied seasons, respectively.

3- Fruit chemical properties:

The data concerning the effect of oil, salicylic acid coating and foil paper wrapping on the chemical constituents of Balady mandarin juice during the storage condition in 2014 and 2015 seasons are presented in Tables (4 to 8). It was obvious from the data that results took similar trends during the three studied seasons.

In a general view, it could be noticed that TSS and TSS/acid ratio were gradually increased in all the

stored fruits with the extending storage period until five weeks at room temperature and three months under cold storage. On the other hand, prolonging the storage for five weeks or three months induce a gradually decrease of the titratable acidity, ascorbic acid (V.C) and total phenolic contents.

According to the treatment effects, it is clear from the previous data that, all treatments lead to sig-

nificant effects on chemical juice properties compared to untreated fruits under both storage conditions. Moreover, no significant differences were found in chemical juice quality among all treatments. At the end of storage periods, there is a difference in TSS and TSS/acid occurred between the two storage temperatures with higher values under room temperature than that under the cold storage.

Table 3. Effect of coating and wrapping materials on juice weight % of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	37.80	36.85	36.25	35.71	34.90	31.96	35.58	37.80	36.30	36.10	35.45	34.60	32.98	31.60	34.37
Paraffin oil	37.80	37.15	36.62	36.10	35.28	32.18	35.85	37.80	36.70	36.25	35.81	34.85	33.17	31.75	35.19
Camphor oil	37.80	36.90	36.16	35.61	34.68	31.85	35.40	37.80	36.87	36.13	35.33	35.10	33.28	31.53	35.15
Foil paper	37.80	37.10	36.62	35.85	35.10	33.35	35.97	37.80	36.90	36.33	35.15	35.88	33.80	33.15	35.56
Control	37.80	35.80	34.75	33.95	33.40	30.20	34.32	37.80	36.15	35.24	34.38	32.80	31.85	30.65	34.12
Mean	37.80	36.76	36.08	35.45	34.66	31.91		37.80	36.58	36.01	35.22	34.65	33.02	31.74	
LSD 5%	A:	1.28	B:	1.09	AB:	2.67		A:	1.52	B:	1.33	AB:	3.26		
2015															
Salicylic acid	36.18	35.30	34.96	34.13	33.90	32.48	34.49	36.18	39.35	34.64	34.10	33.25	32.60	31.89	33.97
Paraffin oil	36.18	35.80	35.28	34.65	34.18	32.70	34.80	36.18	35.60	34.80	34.45	33.60	32.85	32.10	34.23
Camphor oil	36.18	34.53	35.10	34.10	33.30	32.20	34.34	36.18	35.52	34.60	34.00	33.18	33.10	32.37	34.18
Foil paper	36.18	35.45	35.98	34.35	34.28	33.53	34.96	36.18	34.90	35.10	34.50	34.25	33.50	33.20	34.66
Control	36.18	34.65	33.60	32.84	32.55	30.80	33.44	36.18	35.18	34.28	34.19	32.11	31.68	30.15	33.25
Mean	36.18	36.16	34.58	34.01	33.68	32.30		36.18	35.51	34.68	34.05	33.28	32.75	32.00	
LSD 5%	A:	1.18	B:	0.98	AB:	2.37		A:	1.41	B:	1.15	AB:	2.83		

Table 4. Effect of coating and wrapping materials on total soluble solids of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	11.25	11.68	12.10	12.67	13.15	14.10	12.49	11.25	11.50	11.80	11.96	12.16	12.48	13.47	12.09
Paraffin oil	11.25	11.90	12.29	12.76	13.00	14.00	12.53	11.25	11.60	11.88	12.05	12.26	12.73	13.85	12.23
Camphor oil	11.25	11.90	12.25	12.90	13.10	13.60	12.50	11.25	11.33	11.50	11.60	11.80	12.18	13.10	11.82
Foil paper	11.25	11.83	11.90	12.58	12.96	13.34	12.31	11.25	11.30	11.36	11.48	11.65	12.08	12.60	11.67
Control	11.25	12.35	12.86	13.35	13.95	15.10	13.14	11.25	11.93	12.30	12.68	12.88	13.18	14.17	12.63
Mean	11.25	11.93	12.28	12.83	13.23	14.03		11.25	11.53	11.77	11.95	12.15	12.53	13.44	
LSD 5%	A: 0.42	B: 0.51	AB: 1.18					A: 0.35	B: 0.39	AB: 0.91					
2015															
Salicylic acid	10.80	11.35	11.95	12.75	13.32	14.41	12.43	10.80	11.05	11.46	11.68	11.92	12.30	13.00	11.74
Paraffin oil	10.80	11.20	12.35	12.80	13.15	14.22	12.42	10.80	11.11	11.53	11.75	12.00	12.58	13.33	11.87
Camphor oil	10.80	11.40	12.26	12.95	13.28	13.95	12.44	10.80	11.00	11.35	11.48	11.85	12.15	12.66	11.61
Foil paper	10.80	11.30	11.93	12.65	13.11	13.67	12.24	10.80	10.90	11.16	11.35	11.73	12.10	12.10	11.49
Control	10.80	11.85	12.15	13.33	14.10	15.45	12.95	10.80	11.13	12.10	12.43	12.57	13.20	13.60	12.28
Mean	10.80	11.42	12.13	12.89	13.39	14.34		10.80	11.09	11.52	11.74	12.01	12.47	12.99	
LSD 5%	A: 0.38	B: 0.43	AB: 1.04					A: 0.31	B: 0.35	AB: 0.86					

Table 5. Effect of coating and wrapping materials on titratable acidity of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	1.32	1.20	1.03	0.95	0.78	0.75	1.01	1.32	1.26	1.23	1.09	0.99	0.90	0.83	1.08
Paraffin oil	1.32	1.25	1.06	0.99	0.80	0.77	1.03	1.32	1.28	1.26	1.11	1.01	0.93	0.86	1.01
Camphor oil	1.32	1.20	1.03	0.96	0.82	0.70	1.01	1.32	1.27	1.20	1.08	0.98	0.89	0.86	1.08
Foil paper	1.32	1.22	1.06	1.01	0.84	0.71	1.03	1.32	1.25	1.18	1.03	1.09	0.84	0.89	1.08
Control	1.32	1.18	1.01	0.87	0.71	0.64	0.96	1.32	1.21	1.11	1.00	0.92	0.80	0.76	1.02
Mean	1.32	1.21	1.04	0.95	0.79	0.71		1.32	1.25	1.19	1.06	0.99	0.87	0.84	
LSD 5%	A: 0.03	B: 0.04	AB: 0.10					A: 0.03	B: 0.04	AB: 0.09					
2015															
Salicylic acid	1.28	1.14	1.01	0.95	0.82	0.73	0.99	1.28	1.19	1.08	1.02	0.91	0.82	0.73	1.00
Paraffin oil	1.28	1.18	1.08	1.01	0.86	0.73	1.02	1.28	1.20	1.10	1.00	0.93	0.86	0.78	1.02
Camphor oil	1.28	1.15	1.01	0.98	0.80	0.67	0.98	1.28	1.18	1.10	1.01	0.94	0.85	0.79	1.02
Foil paper	1.28	1.17	1.08	0.93	0.81	0.70	0.99	1.28	1.22	1.15	1.05	0.96	0.89	0.78	1.05
Control	1.28	1.12	0.95	0.76	0.69	0.60	0.90	1.28	1.10	0.94	0.85	0.80	0.72	0.65	0.91
Mean	1.28	1.15	1.03	0.93	0.79	0.69		1.28	1.18	1.07	0.99	0.91	0.83	0.75	
LSD 5%	A: 0.03	B: 0.03	AB: 0.07					A: 0.02	B: 0.04	AB: 0.10					

Table 6. Effect of coating and wrapping materials on TSS/acid ratio of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	8.52	9.73	11.75	13.34	16.86	18.70	13.15	9.15	8.93	9.59	10.97	12.28	13.87	12.23	11.00
Paraffin oil	8.52	9.52	11.59	12.80	16.25	18.18	12.81	9.15	9.10	9.43	10.85	12.14	13.69	16.10	11.49
Camphor oil	8.52	9.92	11.89	13.44	15.98	19.43	13.19	9.15	6.89	9.58	10.74	12.04	13.68	15.23	11.04
Foil paper	8.52	9.67	11.23	14.98	16.62	18.79	13.30	9.15	9.04	9.63	11.14	10.69	14.38	14.16	11.17
Control	8.52	10.47	12.73	15.34	19.65	23.73	15.07	9.15	10.75	11.08	12.68	14.00	16.47	18.64	13.25
Mean	8.52	9.86	11.84	13.98	17.07	18.17		9.15	8.94	9.86	11.28	12.23	14.42	15.27	11.59
LSD 5%	A:	0.58	B:	0.44	AB:	1.12		A:	0.83	B:	0.72	AB:	1.78		
2015															
Salicylic acid	2.44	9.96	11.83	13.42	16.24	19.74	13.27	8.44	9.29	10.61	11.45	13.10	15.00	17.81	12.24
Paraffin oil	2.44	9.49	11.43	12.67	15.29	19.48	12.80	8.44	9.26	10.48	11.75	12.90	14.63	17.09	12.08
Camphor oil	2.44	9.91	12.14	13.21	16.60	20.82	13.52	8.44	9.32	10.32	11.37	12.61	14.29	16.02	11.76
Foil paper	2.44	9.66	11.05	13.60	16.18	19.53	13.08	8.44	8.93	9.70	10.81	12.22	13.59	15.90	11.37
Control	2.44	12.47	12.79	17.54	20.43	25.75	16.24	8.44	10.39	12.87	14.62	15.71	18.33	20.92	14.47
Mean	2.44	10.30	11.85	14.09	16.95	21.06		8.44	9.44	10.79	12.00	13.31	15.17	17.55	
LSD 5%	A:	0.91	B:	0.85	AB:	2.06		A:	0.86	B:	0.78	AB:	1.91		

Table 7. Effect of coating and wrapping materials on ascorbic acid of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	40.33	37.20	36.17	35.00	35.68	33.00	36.23	40.33	38.25	33.86	35.45	34.45	34.10	33.42	36.34
Paraffin oil	40.33	37.10	36.50	39.93	35.80	32.85	36.25	40.33	38.11	38.10	35.60	34.60	34.18	33.10	36.29
Camphor oil	40.33	37.43	37.90	35.35	36.48	32.98	36.75	40.33	38.60	38.18	35.12	34.32	34.11	33.95	36.37
Foil paper	40.33	37.25	36.10	35.15	35.56	32.64	36.17	40.33	38.15	37.11	35.61	34.61	34.50	34.25	36.37
Control	40.33	35.65	34.28	34.10	33.70	29.85	34.65	40.33	37.65	35.10	34.18	33.18	32.88	32.62	35.13
Mean	40.33	36.93	36.19	34.91	35.44	32.26		40.33	38.15	37.37	35.19	34.23	33.95	33.47	
LSD 5%	A:	0.95	B:	1.11	AB:	2.71		A:	0.71	B:	0.83	AB:	2.05		
2015															
Salicylic acid	38.65	36.51	35.38	34.20	34.50	32.38	35.27	38.65	37.25	36.30	34.30	33.75	33.10	33.22	35.08
Paraffin oil	38.65	36.35	35.33	34.11	34.33	32.21	35.16	38.65	37.35	35.95	34.15	33.70	33.25	32.00	35.01
Camphor oil	38.65	36.83	35.60	34.50	34.88	32.40	35.48	38.65	37.90	36.75	34.85	33.28	33.38	32.20	35.29
Foil paper	38.65	36.60	35.30	34.28	34.65	31.96	35.24	38.65	37.19	35.81	34.15	33.58	33.40	32.10	34.98
Control	38.65	35.94	33.60	33.10	32.80	31.14	34.21	38.65	36.30	34.11	33.42	32.85	32.17	31.75	34.18
Mean	38.65	36.45	35.04	34.04	34.23	32.02		38.65	37.19	35.78	34.17	33.43	33.06	32.07	
LSD 5%	A:	0.85	B:	1.01	AB:	2.46		A:	0.56	B:	0.64	AB:	1.57		

Table 8. Effect of coating and wrapping materials on total phenolics of Balady mandarin fruits during storage in 2014 and 2015 seasons.

Period (A) Treat. (B)	Room temperature							Cold storages							
	Weekly							Biweekly							
	P0	1	2	3	4	5	Mean	P0	1	2	3	4	5	6	Mean
2014															
Salicylic acid	1235	1037	825	732	693	661	849	1235	1173	1170	1073	1020	951	927	1078
Paraffin oil	1235	1010	834	705	676	638	850	1235	1165	1171	1088	1023	943	930	1079
Camphor oil	1235	1974	916	743	699	655	889	1235	1318	1310	1152	1061	904	883	1123
Foil paper	1235	1041	895	748	701	688	885	1235	1365	1370	1186	1079	940	894	1153
Control	1235	985	678	526	493	463	730	1235	918	886	689	641	569	544	783
Mean	1235	1031	830	691	652	621		1235	1188	1181	1038	965	841	836	
LSD 5%	A: 45.98		B: 42.39		AB: 104.85			A: 86.56		B: 80.78		AB: 191.49			
2015															
Salicylic acid	1290	1081	869	751	713	674	896	1290	1223	1228	1129	1064	989	965	1127
Paraffin oil	1290	1052	865	743	705	663	886	1290	1220	1135	1062	980	980	958	1123
Camphor oil	1290	1134	962	780	742	705	936	1290	1372	1296	1204	1108	938	910	1160
Foil paper	1290	1078	922	851	743	693	930	1290	1377	1409	1218	1133	963	945	1189
Control	1290	1014	718	554	523	491	753	1290	1063	991	763	654	578	558	842
Mean	1290	1072	867	736	685	645		1290	1250	1229	1054	1002	890	867	
LSD 5%	A: 65.92		B: 55.58		AB: 135.28			A: 71.90		B: 68.11		AB: 167.35			

In the contrary, under cold storage, acidity percentage, ascorbic acid (V.C) content and total phenolic content were higher values than under room temperature condition.

At the end of storage period, fruits of control samples had significantly the highest level of TSS (15.10 & 15.45) and (14.17 & 13.60) and TSS/acid ratio (23.73 & 25.75%) and (18.64 & 20.92%) under room temperature and cold storage during the two studied seasons, respectively. Whereas, TSS values were (14.10, 14.0, 13.60 & 13.34) and (14.41, 14.22, 13.95 & 13.67%) and TSS/acid values were (18.70, 18.18, 19.43 & 18.79%) and (19.74, 19.48, 20.82 & 19.53) due to salicylic acid, paraffin oil, camphor oil and foil paper wrapping under room temperature during the two studied seasons, respectively. The corresponding values under cold storage were 13.47, 13.85, 13.10 & 12.60 and 13.00, 13.33, 12.66 & 12.40% and TSS/acid ratio were 12.23, 16.10, 15.23 & 14.16 and

17.81, 17.09, 16.02 & 15.90, respectively.

On the other hand, at the end of storage period, untreated fruits had significantly the lowest values of acidity (0.64 & 0.60) and (0.76 & 0.65%), V.C. (29.85 & 31.14) and (32.62 & 31.75 mg/100g) and total phenolic (463 & 491) and (544 & 558 mg/100g) under room temperature and cold storage during the two studied seasons, respectively. While, the highest values of these traits were observed due to oil coating or paper wrapping. The ascorbic acid values were 33.00, 32.85, 32.98 & 32.64 and 32.38, 32.21, 32.40 & 31.96 mg/100g as well as, total phenolic contents were 661, 638, 655 & 686 and 674, 663, 705 & 693 mg/100g due to salicylic acid, paraffin oil, camphor oil and foil paper wrapping under room temperature during the two studied seasons, respectively. The corresponding values under cold storage were 33.42, 33.10, 33.95 & 34.25 and 32.22, 32.00, 32.20 & 33.10 mg/g, as

well as total phenolic were 927, 930, 883 & 894 and 965, 958, 910 & 945 mg/100g, respectively.

Discussion

Handling and storage is an important and of vital interest to fruit production and its quality. Fresh weight loss and fruit decay percentage were increased by extending storage duration. The loss of water from fruits during storage is a substantial problem due to shrinkage and weight loss, thus, the fruits could be damaged and loss its quality (Ben-Yehoshua, 2005).

The loss of fruit weight indicated the tendency to lose water in fruits, which occurs during the fruits storage. The fruit weight decrease due to its respiratory process, the transference of humidity and some processes of oxidation and evaporation of moisture inside the fruits (Hassan *et al.*, 2014).

Coating were used widely in fruits to reduce dehydration and water loss, prevents shriveling in fruit skin. Coating can act as a semi-permeable barrier against oxygen, carbon dioxide, moisture, so, they can reduce the rate of the respiration, water loss and oxidation reaction (Park, 1999). Salicylic acid control post-harvest losses in fruits through an inhibition of the ethylene biosynthesis and delay the senescence of different products by stimulating the accumulation of biologically active compounds and antioxidant enzymes (Gerailoo and Ghasemnezhad, 2011).

Decay of mandarin fruits during storage are mostly the cause of *Penicillium* sp. Moreover, the function of coating is a partial retention of gas exchange through the fruit peel and

inhibition of the action of ethylene. Inhibition can give more prevention against post-harvest decay and water loss from the peel so decreasing the incidence of decay during storage (Abd El-Motty and El-Faham, 2013).

Coating and wrapping reduce respiration rates and may, therefore delay the utilization of organic acids (Cong *et al.*, 2007).

The decreasing in decay percentage of treated fruits was probably due to the effects of coatings and wrapping on delaying senescence, which makes the commodity more vulnerable to pathogenic infection as a result of loss of cellular or tissue integrity (Patricia *et al.*, 2005).

The results are in accordance with those obtained by Baldwin *et al.* (1995), Rodov *et al.* (2001), Plooy *et al.* (2009), Abd El-Motty and El-Faham (2013) and Mansour (2015).

It is known that during storage there is an antagonistic relation between TSS and acidity, while water loss and TSS were increased the acidity was decreased due to the process of respiration in fruits, because fruits consume acidity for respiration thereby total soluble solids increase more than acidity, thus TSS/acid ratio increases. The decrease in acid content is caused by the use of acids in the fruit as a source of energy and the conversion of organic acids to form sugar (Wills *et al.*, 1998).

Antioxidant activity in fruits is high at the beginning of storage. This increase is due to resistance to chemical and enzymatic oxidation of polyphenols and antioxidants, thereby preventing loss of antioxidants during storage. Decreasing in antioxidants activity is associated with a decrease

in the amount of phenolic compounds and ascorbic acid. The antioxidant capacity of citrus fruits was reduced during storage. Lower level of ascorbic acid in untreated fruits might be due to increased respiration. Ascorbic acid is susceptible to oxidative deterioration or the formation of dehydroascorbic acid (Wills *et al.*, 1998). Coating reduces oxygen levels and results in lower phenolic and antioxidant compounds during storage (Tietel *et al.*, 2010).

The above mentioned findings are in accordance with those obtained by Saucedo *et al.* (2007), Plooy *et al.* (2009), Tietel *et al.* (2010), Abd El-Motty and El-Faham (2013) and Mansour (2015).

Conclusion

According to the previous results, it could be concluded that oil coating or wrapping maintained fruit freshness without negative effects on fruit quality parameters. Meanwhile, coating and wrapping fruits retained high levels of juice volume, acidity, ascorbic acid (V. C) and total phenolic contents as well as lower total soluble solids and TSS/acid ratio losses than controls during storage. Such treatments use instead chemicals are preferred in order to maintain human health and environment.

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تأثير مواد التغطية واللف علي السلوك التخزيني لثمار اليوسفي البلدي

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الملخص

أجريت هذه الدراسة خلال موسمي ٢٠١٤ ، ٢٠١٥ لدراسة تأثير التغطية واللف ببعض المواد علي القابلية للتخزين وجودة ثمار اليوسفي البلدي خلال فترة التخزين. تم تغطية الثمار بحامض الساليسيليك ، زيت البرافين أو زيت الكافور وكذلك تغليفها بورق الفويل بالإضافة للمعاملة القياسية. ثم تم تخزين الثمار علي درجة حرارة الغرفة أو خزنت تخزين بارد (٥ ± °م) ورطوبة نسبية ٩٠% ± ٥.

أوضحت النتائج أن النسبة المئوية للفقد في الوزن والتالف والمواد الصلبة الذائبة الكلية والمواد الصلبة الذائبة / الحموضة قد زادت معنوياً بزيادة فترات التخزين. من ناحية أخرى حدث نقص تدريجي في نسبة عصير الثمار والنسبة المئوية للحموضة وفيتامين ج ومحتوي الفينولات الكلية بزيادة مدة التخزين.

أدت كل المعاملات لقلة الفقد في الوزن والثمار التالفة تحت ظروف التخزين العادي والبارد. أعطي استخدام ورق الفويل للتغطية أو حامض الساليسيليك أقل فقد في وزن الثمار وأقل نسبة تالف. أعطي التخزين البارد فقد في الوزن والتالف أقل من التخزين في الغرفة. أيضاً حسنت كل المعاملات جودة الثمار خلال التخزين مقارنة بالكنترول.

يمكن القول بأن التغطية بالزيوت أو لف الثمار يحافظ علي الثمار طازجة بدون تأثيرات سلبية علي صفات جودة الثمار كذلك حافظت معاملات اللف والتغطية علي مستوي العصير في الثمار والحموضة، فيتامين ج ومحتوي الفينولات وزادت من المواد الصلبة الذائبة والمواد الصلبة الذائبة / الحموضة. لذا يمكن استخدام هذه المعاملات بديلاً للمواد الكيماوية وذلك للحفاظ علي الصحة العامة والبيئة.