

Effect of Using Some Biological Post Harvest Treatments on Storability of Washington Navel Orange Fruits Compared with Imazalil Post Harvest Chemical Treatments

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Abstract: This study was carried out during two successive seasons 2008-2009 and 2009-2010 on Washington Navel orange at Fruit Handling Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Orange fruits were picked from a private farm at El-Fayom Government. Fruits were transported directly to the laboratory; then it was sorted after washing and dried. Fruits were subjected to the following treatments; dipped in solution of 1500 ppm *Trichoderma album* or *Bacillus megaterium* for three or five minutes for each treatment or in 1500 ppm Imazalil, the traditional packaging house treatment, or without any other treatments (waxed only) as control. Fruits were stored at 10°C and 90-95 % RH for 24 and 21 weeks during the first and the second seasons, respectively. Fruits were analyzed for physical and chemical changes at 3 weeks intervals during storage periods. Orange fruits treated with either *Trichoderma album* or *Bacillus megaterium* showed less decay and weight loss incidence during storage compared with the other fruits either treated with Imazalil or untreated at all (waxed only). Moreover, all the examined post harvest treatments significantly reduced physical and chemical properties deterioration rate of orange fruits during storage. Biological control post harvest treatments significantly reduced decreasing rate of fruit juice contents, color transition and ascorbic acid juice contents. On the other hand, these treatments increased TSS contents of fruits and reduced fruit firmness and its contents of total acidity. It could be concluded that, dipping post harvest treatments with either *Trichoderma album* or *Bacillus megaterium* had superior effect on reducing orange fruit rotting and kept fruit quality during storage in comparison with either untreated fruit or those treated with Imazalil. However, dipping post harvest treatments with *Bacillus megaterium* solution at 1500 ppm for 5 minutes was the best treatment for keeping orange fruit post harvest quality.

Key words: Post harvest • Storability • Washington Navel • Orange • Imazalil

INTRODUCTION

Orange industry is important for Egyptian National income. Orange Planted area in Egypt reached 314115 Feddans in 2010, while the produced area reached 241102 feddans producing 2401015 tons of orange fruits according to the statistics of Ministry of Agriculture, Egypt [1]. Although orange occupies the greatest planted area among all citrus grown fruit area in Egypt, the exportation of fresh orange fruits to foreign markets are still limited compared with the produced quantity. Therefore, any effort directed towards maintaining fruit quality and reducing post harvest losses is important for increasing our National income.

Consumer desire for fruit, free from synthetic chemical residues is a driving cause for a trend towards reduced using of post harvest chemicals. Biological controls of post harvest plant disease have been investigated by many scientists during the last two decades [2]. Other approaches have been tried to and identify the effective natural chemicals (i.e., those present in plant extracts), which may be more acceptable to consumers than those that are synthetically produced.

Penicillium digitatum and *Penicillium italicum* causes green and blue mold diseases which are universal post harvest diseases of citrus. The extensive spore production by these pathogens ensures its presence wherever fruit was handled, including field, packing

house, equipments, de-greening, storage rooms, transit containers and market place [3]. Promising post harvest bio control agents had been identified and significant efforts were made to develop them for commercial use. Many investigators used antagonistic isolates of fungi and bacteria as bio control agents to reduce post harvest disease of citrus [4]. In order to reduce post harvest losses, synthetic fungicides are applied either pre- or post harvest. However, the application of synthetic chemical compounds to control post harvest diseases often result in chemical residues on fruit that may affect human health [5]. Therefore, the development and use of alternative post harvest control options, involving biological agents or natural plant extracts, have become important since it is perceived as being environmentally safer and more acceptable to the general public [6]. It has been mentioned that, weight loss continuously increased during fruit storage [7, 8]. It was reported that inoculating orange fruits with the *Trichoderma hamatum*, *Trichoderma harzianum* and *Bacillus subtilis* as biological control agents reduced the severity of fruit rot and increased fruit firmness and ascorbic acid content, with considerable decrease in fruit acidity. These changes differed according to the concentration of the tested biological control agents [9, 10].

Ten yeast and some *Bacillus* isolates significantly reduced surface area of visible *P. digitatum* growth ($\geq 50\%$) of lemon and Valencia fruits, when applied 3 h before inoculation with the pathogen [11, 12]. Ning *et al.* [13] in a study on mandarin fruit, illustrated that isolate *Bacillus amyloliquefaciens* performed better than water control in reducing the incidence of green and blue mold and sour rot, but was not effective comparing fungicide treatment. Orange fruit juice contents and fruit firmness significantly decreased by increasing of storage period [14, 15]. Also, they added that orange fruits color was transferred from green yellow to yellow with increasing storage period. Wangchu and Hazarika [16] in their study on orange fruits, that freshly harvested and washed, air dried and dipped five minutes in some biological agents including *Trichoderma*, reported that Titrable acidity showed the highest increase with bavistin 500 ppm, *Trichoderma* 5000 ppm, GA₃ 25 ppm and UV 10 minutes.

MATERIALS AND METHODS

Fruit Material, Post Harvest Treatments and Storage Period: Washington Navel orange fruits (*Citrus sinensis* Osbeck) were harvested at maturity stage according to Abd El-Hafeez [17] in December during the two seasons from a private orchard in El-Fayoum governorate, Egypt.

Fruits were directly transported to the laboratory of Fruit Handling Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Fruits were washed, air dried. Fruits were subjected to the following treatments by dipping in wax only (control), Imazalil 1500 ppm for 3 minutes, *Trichoderma album* 1500 ppm for 3 or 5 minutes and *Bacillus megatrium* 1500 ppm for 3 or 5 minutes. Then all fruits were air dried again, waxed and packed in carton boxes in one layer and stored at 10°C and 85-90 RH. Six boxes of each treatment, each box contain 20 fruits, three boxes were used in order to determine weight loss and decay percentage while the other boxes were used in order to determine the other physical and chemical properties.

Measurements: At 21 days intervals, Samples (3 replicates each had 2 fruits) of each treatment were taken for the following physical and chemical properties determinations.

Physical Properties

Weight Loss Percentage: Was calculated as a percentage of the average loss in fruit weight separately, at the examined date in relation to the initial weight of the whole fruits.

Decay Percentage: Fruits affected with either pathological or physiological disorders were weighted and calculated as percentage (treatments stopped at 50% rotted in control fruits).

Juice Percentage: Was determined by extracting the juice of six fruits for each treatment representing three replicates were squeezed by handy squeezer and then juice percentage was calculated (w/w).

Fruits Firmness: Was determined using Lfra Texture Analyzer in 5 mm depth and 0.2 mm /second speed, for measuring firmness of Orange. These values were determined by taking the firmness value of six fruits from two sides and the average of the fruit firmness was calculated as (g/cm²).

Peel Color: Was estimated in six fruits by using hunter colorimeter model DP9000. (Hue angle) were determined and the values were calculated according to McGuire [18].

Chemical Properties

Total Soluble Solids (TSS) Content: Was determined by Abbe-Digital Refractometer.

Total Acidity Percentage: Was determined according to AOAC [19].

Ascorbic Acid Content (Vitamin C): Was determined according to Lucas [20].

Statistical Analysis: The obtained data in the two seasons of the experiment was statistically analyzed as factorial randomized complete design. Means were compared by the least significant difference test (L.S.D) at the 5% level of probability according to Silva and Azevedo [21].

RESULTS AND DISCUSSION

Fruit Physical Properties

Weight Loss Percentage: Data shown in Table 1 clearly indicated that weight loss percentage of orange fruits stored at 10°C and 85-90% RH significantly increased with increasing storage period. Also, post harvest treatments with either *Trichoderma album* or *bacillus megaterium* at 3 or 5 minutes significantly decreased weight loss incidence of stored fruits compared with that treated by Imazalil or untreated ones. The highest weight loss percentages (10.59% and 9.42 %) were recorded with untreated fruits (control) during the two seasons in this study followed by fruits treated with imazalil. While the lowest weight loss percentage (6.51% and 5.28%) were recorded in the fruits treated with *bacillus megaterium* for 5 minutes in both the first and the second seasons in this

study followed by fruits treated with *bacillus megaterium* for 3 minutes in the first season and followed by fruits treated with *Trichoderma album* for 5 minutes in the second season. These results are in accordance with the mentioned that weight loss percentage of orange fruits increased gradually and significantly with the increasing of storage periods [7, 8].

Decay Percentage: Table 2 clearly showed that decay percentage significantly increased with increasing of storage period during the two seasons in this work. Data also cleared that post harvest treatments with either *Trichoderma album* or *bacillus megaterium* at 3 or 5 minutes significantly decreased decay incidence of stored fruits comparing with other fruits treated by imazalil or untreated ones. Moreover, the decreasing was increased with increasing the time of dipping in the two seasons without significant differences during the two seasons. These results are in accordance with those obtained by may investigators [9-11, 13] as they mentioned that *Trichoderma harzianum* and *Bacillus subtilis* as biological control agents reduced the severity of fruit rot during storage. While these results disagree with the last author's foundation, they illustrated that, these isolate was not as effective as the fungicide treatment.

Juice Percentage: Data shown in Table 3 clarified that juice percentage contents of orange fruits significantly decreased with the increasing of storage periods during the two seasons of this investigation. Data also indicated

Table 1: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megatrium* on weight loss percentage of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.	(3) Min.	(5) Min.	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	2.10	0.79	0.66	0.69	0.66	0.64	0.92	2.71	0.79	0.52	0.60	0.62	0.60	0.97
42	3.61	2.11	1.71	1.76	1.42	1.53	2.02	4.55	2.49	1.64	2.10	1.89	1.80	2.41
63	5.60	4.00	3.07	3.33	2.93	2.59	3.59	6.93	4.54	3.60	3.74	3.41	3.26	4.25
84	8.50	6.54	5.88	5.65	5.60	4.82	6.16	9.91	6.91	5.35	5.56	5.21	4.96	6.32
105	11.18	9.61	8.47	8.49	8.46	7.43	8.94	13.34	8.89	7.48	7.85	7.68	7.30	8.76
126	14.67	12.10	11.54	11.00	11.06	11.10	11.91	16.17	12.55	10.45	10.16	10.65	10.41	11.73
147	22.20	16.59	15.38	15.64	14.28	14.27	16.39	21.72	16.79	14.82	14.21	14.09	13.94	15.93
168	27.45	22.85	19.91	19.74	19.32	16.22	20.91	-	-	-	-	-	-	-
Means	10.59	8.29	7.40	7.37	7.08	6.51	7.87	9.42	6.62	5.48	5.53	5.44	5.28	6.30

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	0.43	0.52	1.28	0.60	0.70	1.71

Table 2: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on decay percentage of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.			
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	6.94	3.17	2.80	6.91	4.96	3.92	4.78	4.60	3.48	0.00	0.00	4.94	0.00	2.17
42	13.31	5.96	2.80	6.91	4.96	3.92	6.31	8.07	7.94	0.00	0.00	4.94	0.00	3.49
63	17.24	5.96	2.80	6.91	8.83	3.92	7.61	13.30	7.94	0.00	0.00	4.94	0.00	4.36
84	29.22	5.96	7.62	9.24	8.83	3.92	10.80	19.41	7.94	0.00	0.00	4.94	0.00	5.38
105	41.81	10.22	11.08	9.24	8.83	3.92	14.18	38.87	13.39	0.00	0.00	10.09	0.00	10.39
126	41.81	10.22	11.08	9.24	8.83	3.92	14.18	43.28	17.86	18.20	10.14	10.09	8.40	17.99
147	44.45	18.64	16.41	14.65	8.83	5.33	18.05	51.59	20.36	18.20	10.14	10.09	8.40	19.80
168	53.73	18.64	16.41	14.65	8.83	5.33	19.60	-	-	-	-	-	-	-
Means	27.61	8.75	7.89	8.64	6.99	3.80	10.61	22.39	9.86	4.55	2.53	6.25	2.10	7.95

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	5.33	6.53	N.S.	4.37	5.05	12.36

Table 3: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on juice percentage of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.			
0	53.18	53.18	53.18	53.18	53.18	53.18	53.18	52.27	52.27	52.27	52.27	52.27	52.27	52.27
21	46.73	51.18	52.35	51.92	51.99	52.73	51.15	45.56	49.76	51.13	50.47	50.61	51.03	49.76
42	42.28	46.89	48.87	47.80	49.34	48.83	47.33	42.13	45.37	48.29	46.99	47.94	48.49	46.54
63	41.43	44.17	47.69	47.11	48.02	47.66	46.01	40.77	42.21	45.08	43.43	44.20	45.54	43.54
84	38.93	41.27	43.52	46.41	45.31	46.61	43.68	37.80	39.86	43.93	42.02	41.51	43.39	41.42
105	36.43	40.30	40.89	43.84	43.22	45.36	41.67	35.31	37.06	42.29	40.38	39.67	40.45	39.19
126	33.95	39.71	40.20	40.85	41.34	40.87	39.49	32.87	36.28	38.22	38.12	38.88	38.30	37.11
147	27.96	37.11	38.64	38.19	38.89	40.03	36.80	24.97	34.55	35.82	36.17	36.64	38.33	34.41
168	27.06	34.40	35.09	35.50	36.94	37.89	34.48	-	-	-	-	-	-	-
Means	38.66	43.13	44.49	44.98	45.36	45.91	43.75	38.96	42.17	44.63	43.73	43.96	44.73	43.03

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	1.23	1.51	N.S.	1.17	1.36	N.S.

that either biological controls used agencies or Imazalil post harvest treatments significantly decreased the deterioration rate of orange juice percentage of fruits during storage in the two seasons of study. Moreover, orange fruits treated with biological control used agencies had juice content higher than those treated with imazalil in the two seasons. Whatever, the highest juice percentages (45.91 % and 44.73) was recorded in the treatment of *bacillus megaterium* at 5 minutes and the lowest Juice percentages were 38.66 % and 38.96 % in the

control treatment in the first and second seasons, respectively. These results are in agreement with they mentioned that juice percentage contents of orange fruits significantly decreased with the increasing of storage periods [14, 15].

Fruits Firmness: Data presented in Table 4 clarified that orange fruits firmness significantly decreased with the prolongation of storage periods. On the other side, data also cleared that post harvest treatments with Imazalil and

Table 4: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on fruit firmness of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.	(3) Min.	(5) Min.	
0	210.83	210.83	210.83	210.83	210.83	210.83	210.83	206.93	206.93	206.93	206.93	206.93	206.93	206.93
21	207.83	188.50	167.00	186.00	182.00	186.33	186.28	203.93	184.60	163.10	182.10	178.10	182.43	182.38
42	182.67	170.50	164.00	167.83	166.17	166.00	169.53	178.77	166.60	160.10	163.93	162.27	162.10	165.63
63	160.00	154.17	144.83	152.17	151.17	150.17	152.08	156.10	150.27	140.93	148.27	147.27	146.27	148.18
84	152.50	147.50	141.00	144.83	144.00	143.50	145.56	148.60	143.60	137.10	140.93	140.10	139.60	141.66
105	145.33	141.33	134.17	134.00	136.17	135.50	137.75	141.43	137.43	130.27	130.10	132.27	131.60	133.85
126	139.50	137.67	123.67	131.83	130.33	133.50	132.75	135.60	133.77	119.77	127.93	126.43	129.60	128.85
147	135.50	128.50	121.67	114.17	125.33	124.00	124.86	131.60	124.60	117.77	110.27	121.43	120.10	120.96
168	128.67	105.17	99.50	100.83	102.82	104.17	106.86	-	-	-	-	-	-	-
Means	162.54	153.80	145.19	149.17	149.87	150.44	151.83	162.87	155.98	147.00	151.31	151.85	152.33	153.55
LSD at 5 % level														
Factor	Treatments		Storage Period		Interactions		Treatments		Storage Period		Interactions			
LSD values	5.41		6.63		N.S.		5.36		6.19		N.S.			

Table 5: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on peel color (hue angle) of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.	(3) Min.	(5) Min.	
0	83.94	83.94	83.94	83.94	83.94	83.94	83.94	83.03	83.03	83.03	83.03	83.03	83.03	83.03
21	77.49	81.94	83.11	82.68	82.75	83.49	81.91	76.32	80.52	81.89	81.23	81.37	81.79	80.52
42	73.04	77.65	79.63	78.56	80.10	79.59	78.09	72.89	76.13	79.05	77.75	78.70	79.25	77.30
63	72.19	74.93	78.45	77.87	78.78	78.42	76.77	71.53	72.97	75.84	74.19	74.96	76.30	74.30
84	69.69	72.03	74.28	77.17	76.07	77.37	74.44	68.56	70.62	74.69	72.78	72.27	74.15	72.18
105	67.19	71.06	71.65	74.60	73.98	76.12	72.43	66.07	67.82	73.05	71.14	70.43	71.21	69.95
126	64.71	70.47	70.96	71.61	72.10	71.63	70.25	63.63	67.04	68.98	68.88	69.64	69.06	67.87
147	58.72	67.87	69.40	68.95	69.65	70.79	67.56	55.73	65.31	66.58	66.93	67.40	69.09	65.17
168	57.82	65.16	65.85	66.26	67.70	68.65	65.24	-	-	-	-	-	-	-
Means	69.42	73.89	75.25	75.74	76.12	76.67	74.51	69.72	72.93	75.39	74.49	74.72	75.49	73.79
LSD at 5 % level														
Factor	Treatments		Storage Period		Interactions		Treatments		Storage Period		Interactions			
LSD values	1.24		1.52		N.S.		3.1		3.58		N.S.			

biological control used agencies significantly decreased orange fruits firmness during storage compared with untreated fruits. Moreover, firmness of fruits treated with biological control agencies were significantly lower than those treated with Imazalil during the two seasons.

These results are in harmony with those obtained by Mohamed *et al.* [14] as well as Singh and Reddy [15], they demonstrated that juice percentage contents of orange fruits significantly decreased with the increasing of storage periods. Moreover, these results are in line with

those obtained by Eisa *et al.* [9] and Abd-El-Aziz and Mansour [10], they mentioned that orange fruits treated with biological control agents were significantly firmer than untreated fruits.

Fruit Peel Color: Data presented in Table 5 indicated that peel color of fruits was significantly transferred from green yellow to yellow with the increasing of storage period during the two seasons. On the other side, data illustrated that all post harvest treatments significantly

Table 6: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on total soluble solids content of Navel orange Stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.	(3) Min.	(5) Min.	
0	9.53	9.53	9.53	9.53	9.53	9.53	9.53	10.33	10.33	10.33	10.33	10.33	10.33	10.33
21	9.62	9.66	9.97	10.17	10.07	10.17	9.94	10.42	10.46	11.00	10.77	10.77	10.97	10.73
42	9.67	9.73	10.50	10.57	10.27	10.40	10.19	10.47	10.53	11.03	11.03	11.28	11.20	10.92
63	9.71	10.11	10.63	10.87	10.51	11.20	10.51	10.51	10.91	11.17	11.27	11.30	11.30	11.08
84	9.82	10.19	10.69	10.70	10.57	11.13	10.52	10.62	10.99	11.31	11.43	11.36	11.33	11.17
105	9.90	10.24	10.80	10.97	10.87	11.17	10.66	10.70	11.04	11.37	11.50	11.47	11.60	11.28
126	10.10	10.28	10.82	11.07	11.23	11.60	10.85	10.90	11.08	11.43	11.53	11.53	11.77	11.37
147	10.23	10.60	11.40	11.20	11.30	11.57	11.05	10.37	10.60	11.23	11.20	10.92	11.52	10.97
168	9.10	9.63	10.43	10.93	11.00	11.23	10.39	-	-	-	-	-	-	-
Means	9.74	10.00	10.53	10.67	10.59	10.89	10.40	10.54	10.74	11.11	11.13	11.12	11.25	10.98

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	0.35	0.42	1.04	0.27	0.31	N.S.

Table 7: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on total acidity percentage of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.	(3) Min.	(5) Min.	
0	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.30	1.30	1.30	1.30	1.30	1.30	1.30
21	1.15	1.15	0.75	0.81	0.83	0.73	0.90	1.28	1.28	0.88	0.94	0.96	0.86	1.03
42	1.02	1.02	0.70	0.70	0.70	0.66	0.80	1.15	1.15	0.83	0.83	0.83	0.79	0.93
63	1.02	0.90	0.68	0.64	0.58	0.51	0.72	1.15	1.03	0.81	0.77	0.71	0.64	0.85
84	0.96	0.87	0.64	0.64	0.58	0.45	0.69	1.09	1.00	0.77	0.77	0.71	0.58	0.82
105	0.90	0.79	0.60	0.58	0.53	0.47	0.64	1.03	0.92	0.73	0.71	0.66	0.60	0.77
126	0.90	0.70	0.51	0.43	0.45	0.40	0.57	0.90	0.71	0.51	0.45	0.45	0.45	0.58
147	0.77	0.58	0.38	0.32	0.32	0.32	0.45	1.03	0.83	0.64	0.56	0.58	0.53	0.70
168	0.81	0.64	0.41	0.36	0.34	0.32	0.48	-	-	-	-	-	-	-
Means	0.97	0.87	0.65	0.63	0.61	0.56	0.71	1.12	1.03	0.81	0.79	0.78	0.72	0.87

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	0.05	0.06	0.16	0.06	0.07	0.16

inhibited fruit color transition during storage compared with control fruits. Moreover, biological control agencies were more effective than Imazalil in this aspect. These results are in accordance with those obtained by Mohamed *et al.* [14] who illustrated that orange fruit color transferred from green yellow to be yellow with the increasing of storage periods.

Chemical Properties

Total Soluble Solids (TSS), Total Acidity and Ascorbic Acid Contents: Data presented in Tables 6-8 showed that total soluble solids contents of orange juice increased gradually and significantly while total acidity and ascorbic

acid decreased, with the increasing of storage period during the two seasons in this work. Data also showed that all post harvest treatments significantly improved orange fruit chemical properties, increased TSS while decreased total acidity and ascorbic acid contents, during storage compared with untreated fruits in the two seasons.

These results are in harmony with those obtained by Eisa *et al.* [9] and Abd-El-Aziz and Mansour [10] who demonstrated that citrus fruits treated with biological control agencies significantly had less titratable acidity and higher ascorbic acid contents than untreated fruits. On contrast, these results disagree with those obtained

Table 8: Effect of post harvest treatments with *Trichoderma album* and *Bacillus megaterium* on ascorbic acid content (Vitamin C) of Navel orange stored at 10°C during 2008-2009 and 2009-2010 seasons

St. per.	First season							Second season						
	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means	Control	IMZ	<i>Trichoderma album</i>		<i>Bacillus megaterium</i>		Means
			(3) Min.	(5) Min.	(3) Min.	(5) Min.				(3) Min.	(5) Min.			
0	68.08	68.08	68.08	68.08	68.08	68.08	68.08	67.17	67.17	67.17	67.17	67.17	67.17	67.17
21	61.63	66.08	67.25	66.82	66.89	67.63	66.05	60.46	64.66	66.03	65.37	65.51	65.93	64.66
42	57.18	61.79	63.77	62.70	64.24	63.73	62.23	57.03	60.27	63.19	61.89	62.84	63.39	61.44
63	56.33	59.07	62.59	62.01	62.92	62.56	60.91	55.67	57.11	59.98	58.33	59.10	60.44	58.44
84	53.83	56.17	58.42	61.31	60.21	61.51	58.58	52.70	54.76	58.83	56.92	56.41	58.29	56.32
105	51.33	55.20	55.79	58.74	58.12	60.26	56.57	50.21	51.96	57.19	55.28	54.57	55.35	54.09
126	48.85	54.61	55.10	55.75	56.24	55.77	54.39	47.77	51.18	53.12	53.02	53.78	53.20	52.01
147	42.86	52.01	53.54	53.09	53.79	54.93	51.70	39.87	49.45	50.72	51.07	51.54	53.23	49.31
168	41.96	49.30	49.99	50.40	51.84	52.79	49.38	-	-	-	-	-	-	-
Means	53.56	58.03	59.39	59.88	60.26	60.81	58.65	53.86	57.07	59.53	58.63	58.86	59.63	57.93

LSD at 5 % level

Factor	Treatments	Storage Period	Interactions	Treatments	Storage Period	Interactions
LSD values	1.24	1.52	N.S.	1.18	1.36	N.S.

by Wangchu and Hazarika [16]. They illustrated that, orange fruits dipped for five minutes in some biological agents including *Trichoderma* had Titrable acidity were higher than in untreated fruits.

REFERENCES

1. Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, 2011. Bulletin of the Agricultural Statistics, second part, Summer and Nile Crops.
2. Baker, K.F. and R.J. Cook, 1982. Biological control of plant pathogens. *Plant Dis.*, 66: 357-364.
3. Ismail, M. and J. Zhang, 2004. Post-Harvest citrus diseases and their control, outlooks on Pest Management. *Peouen*, 15: 29-35.
4. Belal, E.B.A., A.K.H. Omar and A.E. Zaghlol, 2009. Effect of some biological and chemical post harvest treatments on storability of Washington Navel oranges. *J. Agric. Res. Kafer El-Sheikh Univ.*, 35: 134-142.
5. Norman, C., 1988. EPA sets new policy on pesticide cancer risks. *Sci.*, 242: 366-367.
6. Janisiewicz, W.J. and L. Korsten, 2002. Biological control of postharvest diseases of fruit. *Ann. Rev. Phytopathol.*, 40: 411-444.
7. Aborisade, A.T. and A.A. Ajibade, 2010. Effect of prestorage curing on storage life, internal and external qualities of sweet orange (*Citrus sinensis*). *Revista Brasileira de Fruticultura*, 32: 910-915.
8. Romero, P., M.J. Rodrigo, F. Alferes, L. Zacarias and M.T. Lafuente, 2011. Transcriptomic responses of Navelate orange (*Citrus sinensis* L. Osbeck) fruit to water stress. *Acta Horticulturae*, 892: 351-356.
9. Eisa, N.A., G.M. El-Habbaa, N.A. Fouad and Z.H. Ahmed, 2001. Controlling post harvest decay of Navel orange fruits. *Annals of Agricultural Science, Moshtohor*, 39: 1531-1550.
10. Abd-El-Aziz, S.A. and F.S. Mansour, 2006. Some safe treatment for controlling post-harvest diseases of Valencia orange (*Citrus sinensis* L.) fruits. *Annals of Agric. Sci., Moshtohor*, 44: 135-146.
11. Abraham, A.O., M.D. Laing and J.P. Bower, 2007. Isolation of yeast and Bacillus strains for postharvest control of *Penicillium digitatum* on citrus fruits in South Africa. Novel approaches for the control of postharvest diseases and disorders. *Proc. of the International Cong., Bologna, Italy, 3-5 May*, pp: 47-54.
12. Kotan, R., N. Dikbas and H. Bostan, 2009. Biological control of post harvest disease caused by *Aspergillus flavus* on stored lemon fruits. *African J. of Biotech.*, 8: 209-214.
13. Ning, H.W., L. Hui, H.M. Ying, Y. Liu and M. Rizwan-ul-Haq, 2006. Integrated control of citrus green and blue mold and sour rot by *Bacillus amyloliquefaciens* in combination with tea saponin. *Postharvest Biology and Technol.*, 59: 316-323.

14. Mohamed, M.A.A., A.A. Abdel-Hafeez and S.M.A. Mehaisen, 2003. Effect of postharvest treatments with some safe compounds on fruit properties of Valencia orange and Marsh Seedless grapefruit fruit during storage. *Annals of Agric. Sci., Moshtohor*, 41: 1253-1267.
15. Singh, K.K. and B.S. Reddy, 2006. Post-harvest physico-mechanical properties of orange peel and fruit. *J. Food Eng.*, 73: 112-120.
16. Wangchu, L. and B.N. Hazarika, 2008. Post harvest treatments of Khasi mandarin in East Siang district of Arunachal Pradesh. *Environ. and Ecol.*, 26: 1722-1727.
17. Abd El-Hafeez, A.A., 1998. Physiological studies on the handling and storage of Navel orange. Ph.D. Thesis, Fac. Agric. Al Azhar Univ., pp: 85.
18. McGuire, R.G., 1992. Reporting of objective colour measurements. *Hort. Sci.*, 27: 1254-1255.
19. A.O.A.C., 1990. *Methods of Analysis*. Association of Official Analytical Chemists, 14th Ed., Washington, USA.
20. Lucas, G.H., 1944. Determining ascorbic acid in large number of plant samples. *Ind. Eng. Chem. and Ed.*, 16: 649-652.
21. Silva, F.A.S.E. and C.A.V. Azevedo, 2009. Principal Components Analysis in the Software Assisat-Statistical Attendance. In: *World Congress on Computers in Agriculture*, 7, Renonvusa: American Society of Agricultural and Biological Engineers.