Effect of Hot Water Dips and Modified Atmosphere Packaging on Extend the Shelf Life of Bell Pepper Fruits

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Abstract

This study was carried out on sweet pepper fruits (El-Usr 3 hybrid) obtained from private farm, at Ismailia Governorate during 2007/2008 and 2008/2009 seasons to evaluate the effect of hot water dipping (HWD) at 50 ºC for 3 min and 55 ºC for 1 min, modified atmosphere packaging (sealed with polyethylene and polypropylene bags) and combination between them on quality changes in sweet pepper fruits during storage at 8 ºC plus 95% RH. In general, sweet pepper fruits treated with hot water led to slightly increasing in weight loss percentage as compared to untreated fruits (control), while those dipped in hot water plus packaging had the lowest weight loss percentage during storage. Pepper fruits stored in polypropylene bags were perceived the higher intensities of freshness, firmness and yellowness as compared with those in polyethylene bags. No decay was observed in sweet pepper fruits treated with hot water at 50 ºC for 3 min or 55 ºC for 1 min plus packaging in polypropylene bags during storage. Furthermore, it is also reduced weight loss, maintained fruit firmness and retarded the loss of ascorbic acid and carotenoids and gave fruits with excellent to good appearance without any visible injury for 28 days of storage at 8 ºC.

Keywords:
Bell pepper, hot water treatment, MAP, polyethylene, polypropylene, storage.

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Introduction

Sweet peppers (*Capsicum annum* L.) are an important crop for local and export market. The main factors of quality degradation of sweet pepper during prolonged storage are decay development (Barkai-Golan, 1981), shriveling associated with rapid water loss (Maalekuu et al, 2003), poor external appearance (Ceponis et al, 1987) and susceptibility to chilling injury (CI), which limits storage to temperature

above 7 ºC (Paull, 1990) . Refrigeration (8-10 ºC) is the major tool to maintain quality and controlling decay of peppers (Hadenburg et al, 1986). On the other hand, without refrigeration peppers deteriorate in few days as a result of rapid aging and parasitic infections (Ceponis et al, 1987). Hot water dips are one of the methods that have been successfully used to prevent decay infection in sweet pepper (Fallik et al, 1996). Thus, it has been used as supplement to refrigeration to extend storage and shelf life of sweet peppers fruits (Sakaldas and Kaynas, 2010). Dipping sweet pepper fruits for 3 min in water heated to 50 ºC significantly reduced decay caused by *B. cinerea* and *A. alternaria* (Fallik et al, 1999).

Modified atmosphere packaging (MAP) is another technique that has been used to inhibit fruit respiration, delay ripening, decrease ethylene production, retarded softening, maintains color and extended shelf life of pepper fruits (Ben-Yehoshua et al, 1983; Miller et al, 1986; Gonzalez and Tiznado, 1993). These beneficial effects can be explained by the MA created inside the package, as well as the reduction in water loss, high CO_2 and/or low O_2 atmospheres have been reported of bell peppers during storage (Luo and Makitzel, 1996).

Hot water treatment combined with polyethylene film packaging significantly improved the general appearance of fruits, reduced decay incidence, maintained fruit firmness and retarded color changes compared with untreated fruits control during storage at 8ºC (Gonzalez-Aguilar et al, 1997; Gonzalez-Aguilar et al, 1999 and Fallik et al, 1999). This study was undertaken to determine the potential benefits of hot water treatment and MAP to maintain the quality of bell pepper fruits.

Materials and Methods

Plant material

Seeds of sweet peppers (*Capsicum annuum* L.) El-Usr 3 hybrid were sown in the nursery on August 17th 2007 and 19th 2008 and seedling were transplanted on September 23th and 25th in the first and second season, respectively, in plastic house conditions at Fayed district, Esmaillia Governorate.

Postharvest treatments

Fruits were harvested with a short calyx (1 cm long) and uniformed size (170 ± 10 g) at yellow ripe stage in the first week of February in 2008 and 2009 seasons, then were transported under cooling to the Postharvest Laboratory, Faculty of Agriculture, Vegetable Crop Department, Cairo University, Giza Governorate . Peppers free of blemishes or defects were selected then divided into 7 groups for the following treatments.

1) Dipping in hot water at 50 ºC for 3 min. (T1).
2) Dipping in hot water at 55 ºC for 1 min. (T2).
3) T1 + packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).

4) T2 + packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
5) T1 + packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).
6) T2 + packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).
7) Control.

Twelve replicates were prepared for each treatment; each replicate consisted of two fruits. The samples were taken at random in 3 replicates and the samples were arranged in complete randomized factorial design and stored at 8 ºC and 95% RH.

Measurements were examined immediately after harvest and every 7 days intervals to determine: Weight loss in percentage; general appearance (GA): it was evaluated using a scale from 1-9 with 9= excellent, 7= good, 5= fair, 3= poor and 1=unsalable, and fruits rating 5 or below were considered unmarketable; decay: extent of decay was assessed based on the area of decay and amount of microorganisms growing on it. Decay was rated on scale of 1-5 where; 1=none, 2=slight, 3= moderate, 4= severe and 5= extreme; fruit firmness: It was measured by Magness and Ballouf pressure tester equipped with 3/16 inch plunger and adjusted in Newton (as recommended by ASHS Postharvest Working Group); ascorbic acid and carotenoids were determined according to A.O.A.C. (1990) as mg/1000g fresh weight.

Statistical analysis

All data were subjected to the statistical analysis according to the method described by Sendecor and Cochran (1980).

Results and Discussion

Weight loss

The effect of HWD and MAP on weight loss of sweet pepper fruits stored at 8 ºC and 95 % RH is presented in Table 1. In both seasons, weight loss percentage increased significantly with the prolongation of the storage period for all treatment. Normally, the weight loss occurs during the fruit storage due to its respiratory processes, the transference of humidity and some processes of oxidation (Sakaldas and Kaynas, 2010). However, hot water dips slightly increased weight loss percentage of pepper compared to the control. These results are similar to those reported by (Gonzalez-Aguilar et al, 1997) who found that dipping sweet pepper fruits in hot water increased respiration rate. The lowest values of weight loss were obtained in sweet pepper fruits dipped in hot water plus packaging. In this concern, sweet pepper fruits dipped in hot water at 50 ºC for 3 min or 55 ºC for 1 min and packed in PPB was the most effective in reducing weight loss percentage during all storage period. Packaging in sealed

BBP effectively retarded evaporative water loss, thus enabling the fruits to maintain high water content during storage (Gonzalez-Aguilar et al, 1997).
The lower amount of air movement around the wrapped fruits, compared with the none-wrapped fruits, would also help to maintain microclimate with a very high humidity around the fruits (Forney et al, 1989). Also, modification of the atmosphere around the fruits, in the other words, decreasing O_2 and increasing CO_2 in the storage atmosphere of fruit, decreases the rate of respiration (Wang and Qi, 1997).

General appearance

As shown in Table 2, general appearance (GA) of sweet pepper fruits decreased with the prolongation of storage period in both seasons. Similar results were reported by (Gonzalez-Aguilar et al, 1999). However, sweet pepper fruits immersed in hot water at 50 ºC for 3 min or 55 ºC for 1 min combined with packaging in PPB didn't exhibit any changes in their appearance till 21th days of storage and gave slight decrease in GA at the end of storage. Meanwhile, fruits immersed in hot water and then packed in PEB gave good appearance after 28 days of storage. As well as hot water treatment alone reflected fair appearance. On the other hand, untreated fruits (control) resulted in slightly below the fair level at the end of storage (28 days). Gonzalez-Aguilar et al, (1999) found that sweet pepper fruits packed in PEB remained more hydrate than control ones. Also they were free from wilting and shriveling.

Decay

In both seasons, decay increased significantly with the prolongation of storage period (Table 3). This finding may be due to the continuous chemical and biochemical changes in the fruits such as transformation of complex compounds to simple forms that more liable to fungal infection. These results are similar to those obtained by Gonzalez-Aguilar et al, (1999). However, all various treatments were much better in reducing decay and thus longer storage periods were gained. The decayed fruits started to be shown after 21 days of storage for the control treatment, while, no decay was observed in fruits treated with hot water combined with PPB during storage. HWD alone (at 50 ºC for 30 min and 55 ºC for 1 min) was effective up to 21 days of storage; however, the efficacy of it was reduced afterwards. These fruits were scored with slight symptoms of decay, whereas control fruits showed moderate to severe decay symptoms at the end of storage period.
Dipping bell pepper fruits in hot water resulted in reduction in fungal development and this may be related to washing off the fruit (Sakaldas and Kaynas, 2010). Various metabolic reactions can be controlled by short-term heat shock treatments (Loaiza-Velarde et al, 1997). The interaction between various treatments and storage period was significant in the two seasons.

Table (1): Effect of hot water treatment and modified atmosphere packaging on weight loss percentage of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treatments	2007/2008 season					2008/2009 season				
	Storage period in days				Mean	Storage period in days				Mean
	7	14	21	28		7	14	21	28	
T1	3.24	7.18	10.23	12.90	8.39	4.12	8.06	10.53	13.14	8.96
T2	3.94	7.87	11.04	13.56	9.10	4.32	8.67	10.85	13.67	9.38
T1 + PEB	0.68	0.92	1.14	1.36	1.03	0.74	0.82	1.34	1.58	1.12
T2 + PEB	0.72	0.98	1.22	1.41	1.08	0.82	0.96	1.53	1.72	1.26
T1 + PPB	0.42	0.65	0.94	1.10	0.78	0.53	0.70	0.95	1.23	0.85
T2 + PPB	0.50	0.72	0.98	1.21	0.85	0.60	0.74	1.06	1.32	0.93
Control	3.02	6.56	9.41	12.12	7.78	3.92	8.06	10.25	13.06	8.82
Mean	1.79	3.55	4.99	6.24		2.15	4.00	5.22	6.53	
L.S.D. at 5%										
Treatments			0.16					0.18		
Storage period			0.26					0.27		
Treatments × S. period			0.32					0.30		

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB)

Table (2): Effect of hot water treatment and modified atmosphere packaging on general appearance (score) of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treatments	2007/2008 season						2008/2009 season					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
T1	9.0	9.0	8.3	7.6	5.0	7.79	9.0	9.0	7.6	7.0	6.3	7.8
T2	9.0	9.0	7.6	7.0	6.3	7.80	9.0	9.0	8.3	7.0	5.6	7.8
T1 + PEB	9.0	9.0	9.0	8.3	7.0	8.47	9.0	9.0	9.0	7.6	7.0	8.3
T2 + PEB	9.0	9.0	9.0	7.6	6.3	8.20	9.0	9.0	9.0	7.6	7.0	8.3
T1 + PPB	9.0	9.0	9.0	9.0	8.3	8.87	9.0	9.0	9.0	9.0	8.3	8.8
T2 + PPB	9.0	9.0	9.0	9.0	8.3	8.87	9.0	9.0	9.0	9.0	8.3	8.8
Control	9.0	9.0	7.6	6.3	4.3	7.26	9.0	9.0	7.0	6.3	4.3	7.1
Mean	9.0	9.0	8.5	7.8	6.5		9.0	9.0	8.4	7.6	6.7	
L.S.D. at 5%												
Treatments			0.26					0.20				
Storage period			0.29					0.22				
Treatments × S. period			0.34					0.31				

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).

Table (3): Effect of hot water treatment and modified atmosphere packaging on decay (score) of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treatments	2007/2008 season					2008/2009 season				
	Storage period in days				Mean	Storage period in days				Mean
	7	14	21	28		7	14	21	28	
T1	1.00	1.00	1.00	1.92	1.23	1.00	1.00	1.00	1.83	1.21
T2	1.00	1.00	1.00	1.84	1.21	1.00	1.00	1.00	1.72	1.18
T1 + PEB	1.00	1.00	1.00	2.08	1.27	1.00	1.00	1.00	2.24	1.31
T2 + PEB	1.00	1.00	1.00	2.04	1.26	1.00	1.00	1.00	2.07	1.27
T1 + PPB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T2 + PPB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Control	1.00	1.00	2.15	3.32	1.87	1.00	1.00	2.58	3.64	2.06
Mean	1.00	1.00	1.16	1.89		1.00	1.00	1.23	1.93	

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB)

Fruit firmness

Date in Table (4) showed that there was a significant reduction in fruit firmness by the prolongation of storage period in both seasons. Similar results were reported by Fallik et al, (1999). The decline in fruit firmness may be due to the gradually breakdown of proto-pectin to lower molecular fractions which are more soluble in water and this was directly correlated with the rate of softening of the fruits (Wills et al, 1981).

In general, all treatments were firmer than control fruits. However, hot water alone didn't prevent firmness loss, while fruit dipped in hot water and packed in PPB maintained fruit firmness and good visual characteristics. This finding agree with several other authors (Ben-Yahoshua et al, 1983; Gonzalez-Aguilar et al, 1999) who found that the main benefit of film packaging of peppers was the reduction in fruit water and firmness loss.

The interaction between various treatments and storage period was significant in the two seasons. Pepper fruits dipped in hot water and then packed in polypropylene bags maintained the fruit firmness for 28 days at 8 ºC whereas fruits treated with hot water alone maintained its firmness for 14 days, then rapidly lost firmness with extending the period of storage.

Ascorbic acid

Data in Table (5) showed that ascorbic acid content significantly decreased with prolongation of storage period in both seasons. This reduction might be due to the higher rate of sugar loss through respiration. These results are similar with those obtained by (Sakaldas and Kaynas, 2010). In addition postharvest treatments were found effective on preventing ascorbic acid degradation during storage with significant difference determined after 28 days storage. Thus sweet pepper fruits treated with hot water at 50 ºC for 3 min or 55ºC for 1 min combined with PPB preserved vitamin C during the whole storage period with no significant differences between these treatments. Hot water at 50 ºC for 3 min alone had slight effects on ascorbic acid preservation.

Modified atmosphere packaging prevented vitamin C degradation caused by low O_2 concentration. It has been previously reported that in storage atmosphere of O_2 the vitamin C level is preserve (Arvanitoyannis et al, 2005).

Table (4): Effect of hot water treatment and modified atmosphere packaging on firmness (N) of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treat.	2007/2008 season						2008/2009 season					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
T1	48.2	44.1	42.2	37.7	31.2	40.7	53.1	51.0	49.3	42.3	38.2	46.8
T2	48.2	44.2	43.1	36.1	31.2	40.6	53.1	51.2	48.8	41.7	37.1	46.4
T1 + PEB	48.2	46.4	44.2	40.3	38.1	43.5	53.1	51.3	49.2	44.2	41.4	47.8
T2 + PEB	48.2	46.9	44.6	41.2	39.1	44.0	53.1	52.1	49.3	45.1	42.3	48.4
T1 + PPB	48.2	47.1	45.1	43.7	41.7	45.1	53.1	52.1	50.3	48.3	45.1	49.8
T2 + PPB	48.2	47.2	46.3	43.5	41.2	45.3	53.1	53.0	51.4	47.2	45.7	50.1
Control	48.2	42.2	42.2	37.1	31.0	40.5	53.1	49.2	46.2	44.31	39.3	46.4
Mean	48.2	52.9	43.8	39.9	36.2		53.1	51.4	49.1	44.7	41.2	
L.S.D. at 5%												
Treatments			0.44					0.46				
Storage period			0.48					0.49				
Treatments × S. period			0.52					0.55				

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).

Table (5): Effect of hot water treatment and modified atmosphere packaging on ascorbic acid content (mg/100g F.W.) of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treat.	2007/2008 season						2008/2009 season					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
T1	88.4	80.4	72.9	68.7	61.2	74.3	76.2	70.4	67.2	61.4	58.4	66.7
T2	88.4	77.4	69.3	60.2	49.7	69.0	76.2	70.3	65.2	59.4	52.2	64.7
T1 + PEB	88.4	84.2	78.7	74.2	69.2	79.0	76.2	73.2	70.4	65.2	60.7	69.2
T2 + PEB	88.4	83.1	75.2	72.3	68.1	77.4	76.2	71.3	67.8	63.1	59.2	67.5
T1 + PPB	88.4	86.1	80.2	76.0	72.3	80.6	76.2	75.3	72.1	70.5	63.3	71.5
T2 + PPB	88.4	85.6	80.2	75.8	71.9	80.5	76.2	74.2	71.4	69.9	64.8	71.3
Control	88.4	75.1	64.2	55.1	45.7	65.7	76.2	68.2	62.7	56.3	47.1	62.1
Mean	88.4	81.7	74.4	68.7	62.4		76.2	71.9	67.9	63.2	58.0	

L.S.D. at 5%		
Treatments	0.46	0.49
Storage period	0.52	0.51
Treatments × S. period	0.59	0.57

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).

Carotenoids

Data in Table (6) showed that carotenoid contents in sweet pepper fruits decreased gradually with the prolongation of storage period in both seasons. This decrement could be attributed to the gradually destruction by polyphenol oxidase enzymes (Mayer and Harel, 1991). Immersion of bell peppers in hot water at 50 ºC for 3 min or 55 ºC for 1 min, followed by packaging, resulted significantly reducing the changes in carotenoids content compared with fruits treated with hot water alone and untreated control. However, hot water treatment combined with PPB was the most effective treatment in reducing carotenoids loss during storage. These results are in agreement with those obtained by Gonzalez-Aguilar et al. (1999) who found that hot water treatment followed by packaging with polyethylene film was effective in inhibit color development of sweet pepper fruits during storage at 8 ºC. The interaction between various treatments and storage period was significant in both seasons.

Conclusion

Sweet pepper fruits dipped in hot water at 50ºC for 3 min or 55ºC for 1 min and then packed in sealed polypropylene bags could be stored for 28 days at 8ºC with good appearance and without decay and maintained fruit firmness, ascorbic acid and carotenoids.

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Table (6): Effect of hot water treatment and modified atmosphere packaging on caroteniods content (mg/100g F.W.) of sweet pepper fruits during storage at 8 ºC and 95 % RH in 2007/2008 and 2008/2009 seasons.

Treat.	2007/2008 season						2008/2009 season					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
T1	3.84	3.70	3.52	3.05	3.02	3.43	4.18	4.00	3.71	3.33	3.06	3.65
T2	3.84	3.64	3.45	3.03	2.94	3.38	4.18	3.94	3.70	3.32	3.01	3.63
T1 + PEB	3.84	3.74	3.68	3.52	3.25	3.61	4.18	4.10	3.96	3.70	3.41	3.87
T2 + PEB	3.84	3.72	3.60	3.51	3.18	3.57	4.18	4.02	3.85	3.61	3.32	3.79
T1 + PPB	3.84	3.73	3.64	3.58	3.41	3.64	4.18	4.11	3.94	3.90	3.76	3.98
T2 + PPB	3.84	3.72	3.65	3.52	3.38	3.62	4.18	3.98	3.82	3.72	3.47	3.83
Control	3.84	3.68	3.52	3.20	3.10	3.47	4.18	3.92	3.84	3.33	3.11	3.68
Mean	3.84	3.70	3.72	3.34	3.17		4.18	4.02	3.85	3.57	3.30	
L.S.D. at 5%												
Treatments			0.11						0.09			
Storage period			0.17						0.11			
Treatments × S. period			0.21						0.13			

Dipping in hot water at 50ºC for 3 minute (T1)
Dipping in hot water at 55ºC for 1 minute (T2).
Packaging in sealed polyethylene bags (18 × 25 cm in size) with 20 µm thickness (PEB).
Packaging in sealed polypropylene bags (18 × 25 cm in size) with 20 µm thickness (PPB).

References

Barkai-Golan R. (1981). An annotated check-list of fungi causing postharvest diseases of fruit and vegetables in Israel. ARO SPEC. PUBL. 194, 36pp. Volcani Centre, Bet Degan.

Ben-Yahoshua S., Shapiro B., Chen Z.E., & Lurie S. (1983). Mode of action of plastic film in extending life of lemon and bell pepper fruits by alleviation of water stress. Plant Physioloy, 73: 87-93.

Ceponis M.J., Cappellini R.A. & Lightner R.A. (1987). Disorders in fresh pepper shipments to the New York market. Plant Dis, 71: 380-382.

Fallik E., Grinberg S., Alkalai S. & Lurie S. (1996). The effectiveness of postharvest hot water dips on the control of gray and black moulds in sweet red pepper (*Capsicum annuum*). Plant Path, 45, 644-649.

Fallik E., Grinberg S., Alkalai S., Yekutieli O., Wiseblum A., Regev R., Beres H. & Bar-Lev E. (1999). A unique hot water treatment to improve storage quality of sweet pepper. Postharvest Biology and Technology, 15: 25-32.

Forney C.F., Rij R.E. & Ross S.R. (1989). Measurements of broccoli respiration rate in film wrapping packages. Hort. Science, 24:111-113.

Gonzalez G. & Tiznado M. (1993). Postharvest physiology of bell peppers stored in low density polyethylene bags. Lebensm. Wiss. U. Technol, 26: 450-455.

Gonzalez-Aguilar G., Mulas M., Zacarias l. & Lafuente M.T. (1997). Temperature and duration of water dips influence chilling injury, decay and ploymine content of "Fortune" mandarins. Postharvest Biology and Technology, 12: 61-69.

Gonzalez-Aguilar G., Cruz R., Baez R. & Wang C.Y. (1999). Storage quality of bell pepper pretreated with hot water and polyethylene packaging. J. FOOD Qual., 22: 287-299.

Hadenburg R.E., Watada A.E. & Wang C.Y. (1986). The commercial storage of fruits, vegetables and florist and nursery stocks. Pp, 23-25, U.S. Dept. Agric. Handbook No. 66, Washington, DC.

Loaiza-Velarde, J.G., Toma´s-Barbera´n, F.A., Saltveit, M.E. (1997). Effect of intensity and duration of heat-shock treatments on wound-induced phenolic metabolism in iceberg lettuce. J. Am. Soc. Hort. Sci. 122, 873–877.

Luo Y. & Makitzel L.J. (1996). Extension of postharvest life of bell peppers with low oxygen. J. Sci. Food Agr, 70: 115-119.

Maalekuu K., Elkind Z., Tuvia-Alkalai S., Shalom Y. & Fallik E. (2003). Quality evaluation of three sweet pepper cultivars after prolonged storage. Adv. Hort. Sci, 17: 187-191.

Mayer A.M. & Harel E. (1991). Polyphenoloxidase and their significance in fruit and vegetables. In P.F. Fox, ed., Food Enzymology, v.1, Elsevier, London, pp. 373-398.

Miller W.R., Rosse L.A. & McDonald R.E. (1986). Deterioration of individually wrapped and non-wrapped bell peppers during long term storage. Trop. Sci. 26, 1-8.

Paull R.E. (1990). Chilling injury of crops of tropical and subtropical origin. In: Wang C.Y. (ed.) chilling injury of horticultural crops. CRC Press, Boca Raton, FL. Pp. 17-36.

Sakaldas M. & Kaynas K. (2010). Biochemical and quality changes of green sweet bell pepper as affected by different postharvest treatments. African J. of Biotech, 9(48): 8174-8181.

Sendecor G.W. & Cochran W.G. (1980). Statistical methods. Iowa State Univ. Press. U.S.A.

Wang C.Y. & Qi L. (1997). Modified atmosphere package alleviates chilling injury in cucumbers. Postharvest Biology and Technology, 10: 195-200.

Wills R.B.H., Lee T.H., Graham D., McGlasson W.B. & Hall E.G. (1981). Physiology and biochemistry, p. 17-37. In: Postharvest: An introduction to the physiology and handling of fruit and vegetables. AVI, Westport, Conn.