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Effect of Some Postharvest Treatments on Quality Attributes Of Sweet Pepper Fruits During Cold Storage

Shehata, S.A.[1];Emam, M.S.[2]; El-Helaly, M.A.[1]and Gad-ELrab, N.A.[2]
[1]Vegetable Corps Department, Faculty of Agriculture, Cairo University, Giza, Egypt.
[2]Postharvest and Handling of Vegetable Crops Research Department. HorticultureResearchInstitute, Agricultural Research Center, Giza, Egypt.

Abstract

This study was carried out on sweet pepper fruits (Monist F1 hybrid) harvested at 3/4 yellowing color stage obtained from private farm, at Ismailia Governorate, during 2010-2011 and 2011-2012 seasons to study the effect of active and passive modified atmosphere packaging (MAP),packaging in perforated polypropylene bags (Pppb),hydrogen peroxide (H_2O_2) at 0.12 % and vapor gard(VG) at 0.1% treatments compared with untreated fruits(control) on the quality maintenance of sweet pepper fruits during storage at 10ºC. All studied treatments reduced weight loss, decay, firmness loss and color changes compared with untreated control.

Sweet pepper fruits packed in sealed polypropylene bags (active or passive MAP) was the most effective treatment in reducing weight loss percentage as compared with the other treatments and untreated control. Hydrogen peroxide or Pppb rated good appearance after 21 days at 10ºC.On the otherhand, untreated fruits having poorest appearance at the end of storage at10ºC.

No decay was observed in sweet pepper fruits exposed to active MAP during storage. Furthermore, it is also reduced weight loss, maintained fruits firmness and retarded the loss of TSS, ascorbic acid and carotenoids and gave good appearance for 28 days at 10ºC, (28 days).

The results suggested that active MAP at 5% O2 + 10% CO2 followed by H_2O_2 treatments were the promising technique for maintaining quality and extending storage period of sweet pepper fruits.

Keywords: sweet pepper, postharvest, storage period, modified atmosphere packaging,hydrogen peroxide,vapor gard.

Introduction

Sweet pepper (*Capsicum annuum*, L.) is one of the most important vegetable crops in the world. It is one of the vegetables that have excellent nutritive value, higher content of ascorbic acid, This research was supported by development of Postharvest Treatments Project which required for human nutrient (Davey *et al*., 2000). Nevertheless, it is very perishable vegetable with a short shelf life and high susceptibility to fungal diseases (Hardenburg*et al*., 1990). 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, which limits storage to temperature below 7ºC (Paull, 1990). Therefore, maintaining freshness of pepper fruits has been a challenge in keeping its postharvest quality such as reducing water loss, delaying softening and extending shelf life period (Gonzalez *et al*., 1999;Xie*et al*., 2004). Refrigeration (8-10ºC) is the major tool to maintain quality and controlling decay of peppers (Hardenburg*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). In addition to refrigeration, modified atmosphere packaging (MAP) is commonly used to maintain the quality and improve the shelf life of sweet pepper fruits (Akbudak, 2008). Moreover packaging and low temperature storage has been shown to increase shelf life by slowing the growth of spoilage organisms (Miller *et al*., 1986). The MAP of sweet pepper which elevated CO_2 and reduced O_2 levels has been shown to inhibit fruit respiration, delay ripening, decrease ethylene production , retarding softening, maintains color and extending shelf life of pepper fruits (Ben-Yehoshua *et al*., 1983; Gonzalez and Tiznado, 1993; Akbudak, 2008 ;Shehata *et al*., 2013).

Postharvest treatments, with hydrogen peroxide (H_2O_2) have been proposed as alternative to chemical treatments. It is a compound allowed for use in organic crop production according to National Organic Program (NOP, 2003). The use of H_2O_2 for disinfecting of fruits and vegetables appeared to reduce microbial populations on fresh products and extend the shelf life without leaving significant residues or causing loss of quality (Sapers and Simmons, 1998; Sapers*et al*., 2001). In this concern, Bayoumi (2008) found that the use of H_2O_2 in postharvest treatments have a good potential strategy to improve the postharvest quality, extend shelf life period and maintained some nutritional quality as well as inhibiting decay development of peppers.

Waxy compounds have been applied widely in fruits and vegetables to prevent moisture losses, such as Vapor Gard (VG). In this concern, Shabana *et al*. (1985) found that date fruits treated with V.G. were superior in keeping quality and reduced the percentage of the defected and shrinked fruits when compared with untreated fruits. Also, Collie Graddick*et al*. (1986) stated that blueberry fruits dipped in V.G. at 2% for 10 min maintained their fresh appearance and marketable qualities when compared with untreated fruits.

The objective of this present work was to determine the potential benefits of modified atmosphere packaging, H_2O_2 and Vapor Gard treatments on the quality maintenance of sweet pepper fruits during storage at 10ºC and shelf life conditions at 20ºC.

Material and methods

Seeds of sweet pepper (*Capsicum annuum*, L.) Monist F1 hybrid were sown in the nursery on 11th and13th of September in 2010 and 2011 seasons, respectively, and the seedling were transplanted on 25th of October in both seasons, in green house conditions at Fayed district, Ismailia Governorate.

Sweet pepper fruits were harvested at 3/4 yellowing color stage on February 27th and 29th in 2011 and 2012 seasons, respectively, then transported to the laboratory of Handling of Vegetable Crops Research Department, Giza Governorate, uniform size each fruit about 280 ± 10g. and color, all fruit has short calyx (1cm long).Sound and healthy fruits free from each blemishes were selected to postharvest treatments experiments as follow:

1- Packaging in sealed polypropylene bags (40µ thickness, 20 × 30 cm size), then flushed with a gas mixture at 5% O_2 + 10% CO_2 (active MAP). T1
2- Packaging in sealed polypropylene bags (40µ thickness, 20 × 30 cm size), (passive MAP). T2
3- Packaging in perforated polypropylene bags(Pppb),(40µ thickness, 20 × 30 cm size with 4 holes (each 5 mm in diameter).T3
4- Dipping in solution of Hydrogen peroxide(H_2O_2) at 0.12 %for 30 min. T4
5- Dipping in solution of Vapor Gard (VG) at 0.1% for 3 min. T5
6- Untreated fruits (Control). T6

Twelve replicates were prepared from each treatment. Each replicate consisted of 3 fruits; and then placed in carton box. The samples were taken as random in 3 replicates and the samples were arranged in a complete randomized design and stored at 10ºC and 90-95% relative humidity for 28 days. The treatments were examined immediately after harvest and every 7 days for the following properties:

1. Weight loss percentage.
2. General appearance was measured on scale of9 = excellent, 7 = good, 5 = fair, 3 = poor,1 =unsalable and fruits rating (5) or below were considered un marketable.
3. Decay was measured on scale of1= non, 2= slight, 3= moderate, 4=sever, 5=extreme.
4. Firmness (kg/cm^2) it was measured by a hand pressure tester (Italian model) expressed in kg/ cm^2 (Abbott,1999).
5. Total soluble solids percentages (T.S.S), determined by using referactometer as described in A.O.A.C. (1990).
6. Ascorbic acid content (mg/100g fruit fresh weight), determined by titration method using 2.6 dichloro-phenole-end-phenole as described in A.O.A.C. (1990).
7. Total carotenoids content (mg/100g fresh weight) determined according to (A.O.A.C., 1990).

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

Results and disicussion

Weight loss

Data in Table1 show that, weight loss percentage of sweet pepper fruits was increased considerably and consistently with the prolongation of storage period. These results were agreement with those obtained by Akbudak (2008). Normally, the weight loss occurs during fruit storage due to its respiratory processes, the transference of humidity and other senescence related metabolic processes during storage (Neill*et al*., 2002).

Concerning the effect of postharvest treatments on weight loss percentage, data reveal that there were significant differences between treatments in weight loss percentage during storage.However, all treatments retained their weight during storage as compared with the control (untreated fruits). Moreover, sweet pepper fruits packed in active MAP at 5% O_2 + 10% CO_2 or passive MAPresulted in prominent reduction in weight loss percentage with non-significant differences between them. These results were agreement with those obtained by Nyanjage*et al*. (2005). In this respect, the highest values of weight loss percent were recorded with untreated fruits (control). This result was true in the two seasons of study.

Lowest weight loss from active or passive MAP is due to the confinement of moisture around the product by polypropylene bags. This increases the relative humidity and reduces vapor pressure deficit and transpiration. In addition, packaging creates a modified atmosphere with higher concentration of carbon dioxide and reduced oxygen around the product which slows down the metabolic processes and transpiration (Thompson, 1996), which diminished the weight loss during storage (Wang and Qi, 1997). Also, MAP reduced the water loss by minimizing the contact of fruits with the surrounding air or by inhibiting the diffusion of water vapor with permeability of vapors of the films (Akbudak, 2008). The highest weight loss observed in untreated fruits throughout the storage period can be attributed to air movement, which tends to sweep away the unstirred layer of air (at aquibrium vapor pressure with the tissues) adjacent to the surface of the product, thus increasing the vapor pressure deficit (Wills *et al*, 1998).

Hydrogen peroxide (H_2O_2) and Vapor gard treatments significantly reduced fresh weight loss of pepper fruits as compared with untreated fruits (control) during storage, this agreement with the results obtained by Du *et al*. (2007) for H_2O_2 and Shabana*et al*. (1985) for Vapor gard.The reduction of weight loss percentage by using H_2O_2 may be attributed to reducing the respiration process rates during postharvest storage (Du *et al*., 2007; Bayoumi, 2008). In this concern, Neill *et al*. (2002) and Desikan*et al*. (2004) demonstrated that absicic acid (ABA) induced stomatal closure of guard cells in Arabidopsis and it requires H_2O_2 to induced stomatal closure.

The favorable effect of Vapor gard treatment in reduction of weight loss may be due to the formation of thin layer covering the fruits which prevent moisture losses and also reduce gas exchange and subsequently inhibit metabolic activities (Shabana*et al*. 1985).

As for the interaction between the used postharvest treatments and storage period, data in Table1 show that sweet pepper fruits exposed to active or passive MAP had the lowest weight loss percentage during all storage period. Studies have been shown that MAP has been beneficial for sweet pepper fruits (Nyanjage*et al*. 2005). These results were true in the two seasons.

Table 1. Effect of some postharvest treatments on weight loss (%) of sweet pepperfruits during storage at 10°C in 2010 - 2011 and 2011- 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	0.00	0.04	0.08	0.13	0.17	**0.08**	0.00	0.07	0.12	0.16	0.20	**0.11**
Passive MAP	0.00	0.06	0.12	0.16	0.19	**0.11**	0.00	0.05	0.10	0.17	0.21	**0.10**
Pppb	0.00	0.39	1.89	2.45	3.72	**1.69**	0.00	0.73	1.76	2.47	3.53	**1.70**
Hydrogen peroxide	0.00	0.93	2.11	2.85	4.44	**2.07**	0.00	0.80	2.11	2.94	4.92	**2.16**
Vapor gard	0.00	1.07	2.68	3.69	4.91	**2.47**	0.00	1.00	2.55	3.68	5.27	**2.50**
Control	0.00	2.12	3.78	4.87	6.17	**3.39**	0.00	2.77	5.02	6.45	8.39	**4.52**
Mean	0.00	0.77	1.78	2.36	3.27		0.00	0.90	1.94	2.64	3.75	
L.S.D. at 5%												
Treatments (T)	0.11						0.18					
Storage period (S)	0.10						0.16					
T×S	0.24						0.40					

General appearance (GA)

Data in Table2 show that, general appearance of sweet pepper fruits decreased with the prolongation of storage at 10ºCin both seasons. Similar results were reported by (Gonzalez-Aguilar *et al*., 1999). The decrease of GA during storage period might be due to shriveling, wilting, color change and decay (Banaras *et al*., 2005).

Significant differences in appearance were found between postharvest treatments on pepper fruits during storage. All treatments were better than the control, however, sweet pepper stored in active MAP at 5% O_2 + 10% CO_2orPppb and H_2O_2 was the most effective treatments for maintained general appearance during storage, this agreement with the results obtained by Akbudak, (2008) for MAP and Bayoumi, (2008) for H_2O_2. Previous studies showed that MAP delayed senescence of pepper (Gonzalez and Tiznado, 1993). MAP made a significant contribution on extending the postharvest longevity of pepper fruits having a high rate of postharvest water loss (Lownds and Bosland, 1988). Water saturated atmosphere within the packages controlled water loss due to transpiration delayed senescence in the absence of water stress and thereby extended postharvest longevity of fruits (Nawa*et al*., 2001).

The keeping quality of GA was improved by using H_2O_2 attributed to the effect of H_2O_2 on the reduction of weight loss and rot rate of pepper fruits (Bayoumi, 2008). H_2O_2 treatments have beneficial effects on fruit physiology such as delaying ripening of tomato by the increasing antioxidants content in fruits (Saltveit and Sharaf, 1992). In the same time, ethylene production by fruits can be reduced by H_2O_2 and this reduction keeps the appearance of fruits in the best condition.

The interaction between postharvest treatments and storage period revealed that sweet pepper fruits packed in polypropylene film and exposed to active MAP at 5% O_2 + 10% CO_2 showed the best appearance, it does not exhibit any changes in their appearance till the 21 days at 10ºC and gave good appearance at the end of storage. Meanwhile using H_2O_2 or Pppb rated good appearance till 21 days at 10ºC. On the other hand, untreated fruits (control) having the poorest appearance at the end of storage. These results were true in both seasons.

Table 2. Effect of some postharvest treatments on general appearance (score) of sweet pepper fruits during storage at 10 °C in 2010 - 2011 and 2011 - 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	9.00	9.00	9.00	9.00	8.33	**8.87**	9.00	9.00	9.00	9.00	7.67	**8.73**
Passive MAP	9.00	9.00	8.33	7.67	5.00	**7.80**	9.00	9.00	8.33	7.67	4.33	**7.67**
Pppb	9.00	9.00	9.00	9.00	7.67	**8.73**	9.00	9.00	9.00	8.33	7.00	**8.47**
Hydrogen peroxide	9.00	9.00	9.00	8.33	7.00	**8.47**	9.00	9.00	9.00	7.67	7.00	**8.33**
Vapor gard	9.00	9.00	7.67	6.33	5.00	**7.40**	9.00	9.00	7.67	5.67	4.33	**7.13**
Control	9.00	7.67	6.33	3.67	1.00	**5.53**	9.00	7.67	5.67	3.00	1.00	**5.27**
Mean	**9.00**	**8.78**	**8.22**	**7.33**	**5.67**		**9.00**	**8.78**	**8.11**	**6.89**	**5.22**	
L.S.D. at 5%												
Treatments (T)			0.49						0.51			
Storage period (S)			0.44						0.47			
T×S			1.09						1.14			

Decay

Data in Table3 showthat, there were significant increases in decay score with the prolongation of storage period. This finding may be due to the continuous chemical and biochemical changes in the fruits such as transformation of complex compounds to it simple forms that more liable to fungal infection (Wills *et al*., 1998). These results are similar to those obtained by Gonzalez-Aguilar *et al*.(1999). However, all postharvest treatments were much better in reducing decay and thus longer storage periods were gained.Sweet pepper fruit packed in active MAP was the most effective treatments on decay incidence during all storage period. Similar results were obtained by Gonzalez-Aguilar *et al*. (2004) who found that decay development of fresh-cut pepper stored at 5ºC was retarded at high CO_2 MAP. The decayed fruits started to be shown after 14 days of storage at 10ºC for the untreated control, while, no decay was observed in fruits treated with active MAP at 5%O_2 + 10% CO_2,H_2O_2 and Pppbtreatments during storage. Passive MAPwas effective up to 21 days at 10ºC. These fruits were scored with slight symptoms of decay after 28 days of storage, whereas untreated control showed severe decay symptoms at the end of storagein both seasons. Vapor gard treatment was less effective in reducing the decay symptoms.

Bayomi(2008) found that H_2O_2treatment was highly decreased the extension of rot in pepper fruits. The reduction of decay by usingH_2O_2 treatment may be attributed to that H_2O_2as a reactive oxygen species (ROS) play important and manifold role in plant disease resistance to infection with pathogens.

In postharvest application, Simmons *et al*. (1997) stated that H_2O_2treatment have been shown to decrease microbial loads of plums. Moreover, (Ukuku*et al*.2005) found that washing with H_2O_2solution can markedly reduce the human pathogens.

The highest decay observed at the end of storage with passive MAP may be due to high relative humidity and water condensation around the product, which promote the development of postharvest decay (Coates *et al*. 1995).

The favorable effect of Pppb could be attributed to the continuous ventilation, less moisturecondensation and suppression of off-flavor development (Abd El-Rahman,1990). Also, Conesa*etal*.2007 found that MAP of pepper was avoid fermentation and inhibit growth of spoilage microorganisms. Moreover, (Jobling, 2001; Lee *et al*., 2006a and Lee *et al*., 2006b) stated that elevated CO_2 levels can reduce the products sensitivity to C_2H_4; it can also slow the growth of many of the postharvest fungi that cause rots.

The interaction between the used treatments and storage period was non-significant between all treatments and storage period until 14 days and significant during the last period in both seasons. Active MAP, H_2O_2 and packaging in perforated polypropylene bag were the best treatments to minimizing decay score as the interaction with storage period.

Fruit firmness

Date in Table4 show 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*., 1998).

Concerning the effect of postharvest treatments on fruit firmness during storage, data revealed that various applied treatments had significantly greater fruit firmness as compared with the untreated control. However, sweet pepper fruits packed in sealed polypropylene bags (active or passive MAP) or packed in perforatedpolypropylene bagswere the most effective treatment in reducing the loss of firmness with non-significant differences between them during storage at 10ºC, followed by H_2O_2treatment. Vapor gard treatment was less effective in reducing firmness loss during storage as compared with the other treatments.These findings agreewith (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. Results of firmness showed similarities to weight loss which had strong relationship between firmness and weight loss in bell pepper was reported by Lurie *et al*. (1986).

Vapor gard is an anti-transpirant which forms a coating on the fruit and prevents evaporative water loss thus retaining fruit turgidity Le Lagadec and Moruda (2002), also Vapor gard inhibits the increase in polygalacturonase (the enzyme responsible) levels for pectin breakdown in ripening fruits (Lazan*et al*., 1990).

The interaction between postharvest treatments and storage period was significant in the two seasons. Sweet pepper fruits packed in sealed polypropylene bags with active MAP at 5%O_2 +10% CO_2had the highest value of fruit firmness during all storage period.

Table 3. Effect of some postharvest treatments on decay (score) of sweet pepper fruits during storage at 10°C in 2010 - 2011 and 2011 - 2012 seasons.

Treatments	**2010/2011 seasons**						**2011/2012 seasons**					
	Storage period in days					**Mean**	**Storage period in days**					**Mean**
	0	7	14	21	28		0	7	14	21	28	
Active MAP	1.00	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00	1.00	1.00	**1.00**
Passive MAP	1.00	1.00	1.00	1.00	2.00	**1.20**	1.00	1.00	1.00	1.33	2.33	**1.33**
Pppb	1.00	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00	1.00	1.00	**1.00**
Hydrogen peroxide	1.00	1.00	1.00	1.00	1.00	**1.00**	1.00	1.00	1.00	1.00	1.33	**1.07**
Vapor gard	1.00	1.00	1.00	1.67	2.00	**1.33**	1.00	1.00	1.00	2.00	2.67	**1.53**
Control	1.00	1.00	2.00	3.33	4.67	**2.40**	1.00	1.00	2.33	4.00	4.33	**2.53**
Mean	**1.00**	**1.00**	**1.17**	**1.50**	**1.94**		**1.00**	**1.00**	**1.22**	**1.72**	**2.11**	
L.S.D. at 5%												
Treatments (T)		0.13						0.19				
Storage period (S)		0.12						0.17				
T×S		0.30						0.42				

Table 4. Effect of some postharvest treatments on firmness (kg/cm^2) of sweet pepper fruits during storage at 10°C in 2010 - 2011 and 2011 - 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	220.00	218.33	216.67	213.33	210.00	215.67	218.33	215.00	213.33	210.00	203.33	212.00
Passive MAP	220.00	216.67	213.33	210.00	207.00	213.40	218.33	213.33	210.00	206.67	201.67	210.00
Pppb	220.00	213.33	210.00	206.67	201.67	210.33	218.33	211.67	208.33	201.67	193.33	206.67
Hydrogen peroxide	220.00	210.00	205.00	200.00	195.00	206.00	218.33	208.33	201.67	198.33	190.00	203.33
Vapor gard	220.00	210.00	199.00	192.33	180.00	200.27	218.33	206.67	198.33	188.33	178.33	198.00
Control	220.00	200.00	190.00	182.33	170.00	192.47	218.33	201.67	188.33	181.67	166.67	191.33
Mean	220.00	211.39	205.67	200.78	193.94		218.33	209.44	203.33	197.78	188.89	
L.S.D. at 5%												
Treatments (T)			5.44						7.14			
Storage period (S)			4.97						6.52			
T×S			12.17						15.97			

Total soluble solids

Data in Table5 demonstrate that total soluble solids (T.S.S) of sweet pepper fruits were significantly increased at the beginning of storage and then decreased with the prolongation of the storage period. Similar results were obtained by El-Sheikh *et al*. (1997). The increase in T.S.S in the first period might owe much to the higher rate of moisture loss through transpiration. However, the reduction in T.S.S during the last period of storage might owe much to the higher rate of sugar loss through respiration than water loss through transpiration (Wills *et al*., 1998).

Concerning the effect of postharvest treatments on T.S.S, data revealed that there were significant differences between treatments in T.S.S percentages during storage, however, in general, sweet pepper fruits packed in active MAP at 5% O_2 +10% CO_2 and Pppb and dipping in H_2O_2 were significantly higher in fruit total soluble solids than other treatments. The lowest values of T.S.S % were resulted in untreated fruits (control) in both seasons. Similar results were obtained by Akbudak (2008) who found that in pepper, MAP slowed down the changes in T.S.S values, and in this way, T.S.S changes in plastic material treated were suppressed, thus the ripening of fruits was inhibited.

For the effect of H_2O_2treatment similar results were obtained by Peng*et al*. (2003) who found that H_2O_2treatment tended to maintain T.S.S values significantly better than the control.These treatments had superior positive effects, which might be at least partially attributed to this inhibition of phenolic metabolism.

The interaction between postharvest treatments and storage period was significant in the two seasons. After 28 days of storage at 10ºC, sweet pepper fruits packed in active MAP at 5% O_2 +10% CO_2 or fruits treated with H_2O_2had the highest values of T.S.S % with non-significant differences between them.

Table 5. Effect of some postharvest treatments on total soluble solids (%) of sweet pepper fruits during storage at 10°C in 2010 - 2011 and 2011 - 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	7.83	8.07	8.13	8.17	8.00	**8.04**	7.70	8.07	8.20	8.13	7.93	**8.01**
Passive MAP	7.83	8.03	8.10	7.83	7.57	**7.87**	7.70	7.90	8.13	7.90	7.50	**7.83**
Pppb	7.83	8.07	8.20	8.07	7.83	**8.00**	7.70	8.03	8.20	8.00	7.87	**7.96**
Hydrogen peroxide	7.83	8.00	8.10	8.13	8.00	**8.01**	7.70	8.00	8.20	8.10	7.97	**7.99**
Vapor gard	7.83	7.90	8.00	7.87	7.23	**7.77**	7.70	7.90	8.00	7.80	7.30	**7.74**
Control	7.83	8.00	8.20	7.53	6.93	**7.70**	7.70	8.10	8.23	7.17	6.87	**7.61**
Mean	**7.83**	**8.01**	**8.12**	**7.93**	**7.59**		**7.70**	**8.00**	**8.16**	**7.85**	**7.57**	
L.S.D. at 5%												
Treatments (T)			0.15						0.13			
Storage period (S)			0.14						0.12			
T×S			0.35						0.29			

Ascorbic acid content

Data in Table 6 show that ascorbic acid content was increased with prolongation of storage period increased until 14 days of storage at 10ºC and then was decreased till the end of storage period in both seasons. This increase might be due to the lower rate of sugar loss through respiration; however, the decrease in ascorbic acid might be due to the higher rate of sugar loss through respiration than water loss through transpiration (Wills*et al*., 1998), these results are similar with those obtained by (Sakaldas and Kaynas, 2010).

Concerning the effect of postharvest treatments on ascorbic acid, data reveal that all treatments were effective on preventing ascorbic acid degradation during storage as compared with the untreated fruits (control), Moreover, in general active MAP at 5% O_2 +10% CO_2, Pppb and H_2O_2 resulted in maintaining ascorbic acid content. Vapor gard treatment had slight effects on ascorbic acid preservation.

Modified atmosphere packages prevent ascorbic acid degradation caused by low O_2 concentration it has been previously reported that in storage atmosphere of O_2 the ascorbic acid level is preserve (Arvanitoyannis *et al*., 2005). Moreover, high CO_2treatment retarded the change in ascorbic acid content of pepper fruits during storage (Akbudak, 2008).

The increment of ascorbic acid content related to H_2O_2 treatments because it can be regenerated by two enzymes namely monodehydro ascorbate reductase and dehydro ascorbate reductase (Nishikawa *et al*., 2003) which could explain the increase by H_2O_2treatment during storage period. The stability of ascorbic acid directly increased in the presence of H_2O_2 during storage of orange and grape fruit juices (Ozkan*et al*., 2004).

As for the interaction between postharvest treatments and storage period, data in Table 6 show that sweet pepper treated with active MAP at 5% O_2 +10% CO_2 was the most effective treatment in reducing ascorbic acid loss at the end of storage.

Total carotenoid (TC)

Data in Table 7 show that total carotenoid contents in sweet pepper fruits were increased at the beginning of storage until 21 days of storage at 10ºC and then decreased till the end of storage in both season. The increase in TC in the first period of storage may be due to the destruction of chlorophyll and accumulation of carotenoid, however, the decrease in TC at the last period of storage could be attributed to the gradually destruction by polyphenol oxidase enzymes (Mayer and Harel, 1991).

Concerning the effect of postharvest treatments on TC content, data show that, in general active MAP at 5% O_2 + 10% CO_2, Pppb and H_2O_2 treatments resulted in maintaining TC contents during storage. These results were agreement with those obtained by Akbudak(2008) who found that changes in fruit color at the end of storage preceded more slowly in MAP treatment, however, the colors of untreated fruits, changed rapidly.

For the interaction between postharvest treatments and storage period on TC, data in Table 7 reveal that sweet pepper fruits treated with active MAP and H_2O_2 were the most effective treatments in maintaining TC content at the end of storage. These results were true in both seasons.

Conclusion

From the previous results it could be concluded that active MAP at 5% O_2 + 10% CO_2 followed by H_2O_2 treatments is the promising technique for maintaining quality and extending the storage period of sweet pepper fruits.

Table 6. Effect of some postharvest treatments on ascorbic acid (mg/100g fresh weight) of sweet pepper fruits during storage at 10°C in 2010 - 2011 and 2011- 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	122.00	134.10	138.77	139.43	131.60	**133.18**	121.27	130.73	139.00	137.00	133.07	**132.21**
Passive MAP	122.00	134.93	135.57	130.37	125.47	**129.67**	121.27	131.87	134.67	129.00	121.93	**127.75**
Pppb	122.00	136.33	137.57	130.23	125.87	**130.40**	121.27	133.07	139.67	130.33	125.17	**129.90**
Hydrogen peroxide	122.00	134.57	135.47	139.57	129.33	**132.19**	121.27	130.63	136.33	131.67	129.00	**129.78**
Vapor gard	122.00	134.00	140.50	130.17	117.30	**128.79**	121.27	130.33	135.33	125.30	118.67	**126.18**
Control	122.00	135.23	138.40	120.33	103.33	**123.86**	121.27	129.67	140.00	118.67	110.00	**123.92**
Mean	**122.00**	**134.86**	**137.71**	**131.68**	**122.15**		**121.27**	**131.05**	**137.50**	**128.66**	**122.97**	
L.S.D. at 5%												
Treatments (T)		4.60							2.66			
Storage period (S)		4.20							2.43			
T×S		10.28							5.94			

Table 7. Effect of some postharvest treatments on carotenoids (mg/100g fresh weight) of sweet pepper fruitssduring storage at 10°C in 2010 - 2011 and 2011 - 2012 seasons.

Treatments	2010/2011 seasons						2011/2012 seasons					
	Storage period in days					Mean	Storage period in days					Mean
	0	7	14	21	28		0	7	14	21	28	
Active MAP	3.77	3.82	3.93	4.19	4.02	**3.95**	3.68	3.77	3.91	4.12	4.00	**3.90**
Passive MAP	3.77	3.84	3.90	3.99	3.70	**3.84**	3.68	3.75	3.83	3.85	3.77	**3.78**
Pppb	3.77	3.89	3.96	4.08	3.74	**3.89**	3.68	3.80	3.86	4.00	3.88	**3.84**
Hydrogen peroxide	3.77	3.80	3.91	4.16	4.00	**3.93**	3.68	3.74	3.83	4.07	3.97	**3.86**
Vapor gard	3.77	3.82	3.95	4.07	3.62	**3.86**	3.68	3.74	3.88	4.00	3.75	**3.81**
Control	3.77	3.94	4.15	3.71	3.50	**3.82**	3.68	3.86	4.05	3.69	3.46	**3.75**
Mean	**3.77**	**3.85**	**3.97**	**4.03**	**3.76**		**3.68**	**3.78**	**3.89**	**3.95**	**3.81**	
L.S.D. at 5%												
Treatments (T)			0.06						0.07			
Storage period (S)			0.06						0.07			
T×S			0.14						0.16			

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تأثير بعض معاملات ما بعد الحصاد على صفات الجوده لثمار الفلفل الحلو خلال التخزين المبرد

سعيد عبدالله شحاتة [1] , مصطفى صالح إمام [2] , مصطفى عبد الفتاح الهلالى [1] , نوره على جاد الرب[2]

[1]كلية الزراعة – جامعة القاهرة – جيزة – مصر .

[2]قسم بحوث تداول الخضر – معهد بحوث البساتين – جيزة – مصر .

أجريت الدراسة على هجين الفلفل الحلو (مونست) حيث تم جمع الثمار فى مرحلة 4/3 تلوين (أصفر) من مزرعة خاصة بمركز فايد بمحافظة الإسماعيلية خلال موسمى 2010 – 2011 , 2011 – 2012 لدراسة تأثير تعبئة ثمار الفلفل فى جو هوائى معدل (بالحقن الغازى داخل العبوة (موجب) او الذى تحدثه الثمار نفسها (سالب) و التعبئة فى اكياس بولى بروبلين مثقب وغمر الثمار فى محلول فوق اكسيد الهيدروجين تركيز 0,12 % لمدة 30 دقيقة ومحلول Vapor Gard (مضاد للنتح) بتركيز 0,1 % لمدة 3 دقائق تعطى الاحتفاظ بالجودة خلال التخزين المبرد على درجة 10°م .

وقد أوضحت النتائج ان كل المعاملات المستخدمة قد أدت الى تقليل فقد الوزن والتالف وفقد الصلابة والتغير فى اللون مقارنة بالثمار الغير معاملة (كنترول).وأدى تخزين ثمار الفلفل تحت ظروف الجو الهوائى المعدل (الموجب والسالب) الى تقليل فقد الوزن اثناء التخزين المبرد وفترة العرض مقارنة بالمعاملات الاخرى والكنترول.وأعطت المعاملة بفوق اكسيد الهيدروجين والتعبئة فى الاكياس المثقبة من البولى بروبلين مظهر جيد بعد 21 يوم على درجة 10°م, بينما اعطت الثمار الغير معاملة (كنترول) مظهراً فقير عند نهاية فترة التخزين على 10°م, (28 يوم).

لم يظهر أى تلف فى الثمار المعبأة تحت ظروف الجو الهوائى المعدل (5% أكسجين + 10% ثانى اكسيد الكربون) طوال فترة التخزين على درجه 10°م, كما أدت المعاملة الى تقليل فقد الوزن مع الاحتفاظ بصلابة الثمار وتأخير فقد نسبة المواد الصلبة الذائبة وحمض الاسكوربيك والكاروتينات كما أعطت مظهر جيد بعد 28 يوم على درجة 10°م.

لذا يمكن اعتبار تعبئة ثمار الفلفل تحت ظروف الجو الهوائى المعدل (الموجب) يليها المعاملة بفوق اكسيد الهيدروجين طريقة واعده فى المحافظة على صفات الجودة واطالة فترة حياة الثمار طوال فترة التخزين.

مشروع تطوير معاملات ما بعد الحصاد للمحاصيل التصديرية