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Effect of Dipping Sweet Pepper Fruits in Some Safe Materials on Postharvest Quality and Storability

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Abstract: This study was carried out under plastic house conditions during the two seasons of 2016-2017 and 2017-2018 at protective cultivation directory, Dokki site and laboratory of Handling Vegetables Crops Department, Horticulture Research Institute, Giza Governorate to study the effect of dipping sweet pepper fruits in some safe materials on postharvest quality ½ Lareka F1 hybrid½, these treatments were Chitosan at 0.5percent, Ozonated water (O3) at 15ppm, hydrogen peroxide at 0.12percent (H_2O_2), Carboxy methyl cellulose at 1percent and control fruits on keeping the quality parameters and prolong the shelf life of fruits. Samples were stored at refrigerated storage for 28 days (10°C additional shelf life at 20°C additional 95% RH) and were checked every week. In general, tested treatments were effective for reducing wight loss, general appearance, decay, firmness and ascorbic acid loss compare with control fruits during cold storage. Sweet pepper fruits treated with H_2O_2 at .012% or chitosan at 0.5% inhibit the weight loss and decay percentage, preserved fruit firmness and delayed the loss of ascorbic acid and carotenoids content during storage and shelf life. Control fruits gave the highest values of weight loss and decay percentage and the lowest values of firmness and poor appearance after 21 days of storage at 10°C + 2 days at 20°C. Finally, hydrogen peroxide at .012% or Chitosan at 0.5% improved storability, maintained fruit quality and gave fruits with good appearance till of 28 days without decay.

Key words: Sweet pepper · Chitosan · Hydrogen peroxide Ozonated water · Carboxy methyl cellulose · Storage

INTRODUCTION

One of the most important and popular vegetable crops grown for both export and import is a sweet pepper. Bell peppers contains magnificent list of plant nutrient that are found to have disease prohibition and health promoting [1]. After harvest, the main biochemical and physiological changes come in pepper due to metabolic activities, which result in quality and nutritional value degeneration as well as accelerating senescence and decay. Moisture loss results not only in appreciable weight loss but also in less attractive fruit due to poorer firmness and wilted tissues, which reduce the fruit quality, where it decreases metabolism and water loss, thus it extending shelf life [2, 3].

Inhibits respiration of fruits, maintains color and prolongs the shelf life [4]. Chitosan has been applied successfully as coating on food surface to increase the shelf life constructively without compromising the natural tastes of product. The films made of chitosan are used to cover fresh fruits and vegetable such as tomato, pepper, cantaloupe, apples and orange; Because they are elastic offering invaluable properties such as elasticity selective permeability and act as antimicrobial bulkhead against pathogens [5]. Addition to interest of chitosan coating is concerning to its capacity to prolonged the storability of vegetables and fruits. Chitosan creates a coating that is semipermeable and regulates the gas exchange, decreases transpiration losses and fruit ripening is slowed down. Also, the rate of respiration and therefore water loss is decreased [6].

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Postharvest treatment, with hydrogen peroxide (H_2O_2) has propose as alternate to chemical treatments. The National Organic Program permits the use of this compound in the cultivation of organic crops [7]. Fruit and vegetable disinfection using h_2o_2 seemed to lower microbial populations on fresh products and extand shelf life without leaving substantial residue [8]. In this context, Bayoumi [3] detected that the use of H_2O_2 in postharvest treatments has a good potential strategy to improve the postharvest quality, Shelf life period and preserved some nutritional value as well as impeding development of peppers decay.

One of the polysaccharides used as an edible coating is Carboxy methyl cellulose (CMC). CMC is translucent and flexible and it can serve as a barrier to oxygen and moisture. Several studies have recommended the use of carboxy CMC as a suitable coating material for several products. Ayranci and Tunc [9] demonstrated that adding methylcellulose to apricot and green pepper reduced the loss of water and vitamin C. Additionally, Nadim *et al*., [10] revealed that the methyl cellulose coatings are efficient for strawberries shelf life extending and delayed the senescence process compared with control. The addition coatings had afavourable effect on reducing weight loss, decay, color change, loss of firmness and retarded the softening of fruit.

Ozone maintaining postharvest quality of fruits by oxidizing ethylene produced and decreased the respiration rate during the ripening process. Reducing the ethylene level prolongation, the shelf life of many ethylene sensitive fruits and vegetables and reduces the shrinking of product during storage [11]. In this concern, Shalluf *et al*. [12] found that the use of ozone treatment significantly decreased respiration rate that retarded deterioration and preserved the keeping quality characteristics for an extended time.

The objective of this present work was to determine the potential benefits of H_2O_2, chitosan, ozonated water, carboxy methyl cellulose treatments on the preservation of sweet pepper fruits quality under storage at 10°C and at 20°C shelf life conditions.

MATERIALS AND METHODS

On February 27th and 29th in the first and second seasons, respectively, sweet pepper fruits were harvested at 3/4 yellow color stage; then transported to the laboratory of Handling of Vegetable Crops Department, at Giza. Uniform fruits in size (about 280 ± 10gm each fruit) and color, with short calyx (1 cm long) that were sound, healthy and free from blemishes were selected for postharvest experiment as follow:

- Dipping in solution of Chitosan at 0.5 % for 3 min.
- Dipping in solution of Hydrogen peroxide (H_2O_2) at 0.12 % for 3 min.
- Dipping in solution of Ozonated water at 15ppm for 3 min.
- Dipping in solution of Carboxymethyl cellulose at 1% for 3 min.
- Dipping in tap water fruits for 3 min. (control).

Twenty-four Eus were prepared from each treatment. Each Eu consisted of 3 fruits; the samples arranged in a complete randomized design and stored at 10°C and 90-95% relative humidity for 28 days. The treatments were examined immediately after harvest and every 7 days intervals in addition to 2 days at 20°C (shelf life conditions) for the following properties:

(weight loss %, general appearance score, decay score, firmness, total soluble solids %, ascorbic acid and total carotenoids content).

Carboxymethyl cellulose solutions were prepared by dissolving 10 g of Carboxymethyl cellulose (CMC) powder in 1000 ml of water and ethyl alcohol (2:1) at 75°C under the high speed mixer (900 rpm) for 15 min. then, glycerol has been added (1.5% w/v) and the solution was stirred for another 10 min under the same conditions [13].

The following properties were examined:

Weight Loss Percentage: Was estimated according to the following equation:

$$\text{Weight loss\%} = \frac{\text{Initial weight of fruits} - \text{weight of fruits at sampling data}}{\text{Initial weight loss}} \times 100$$

General Appearance: Was measured on a scale from 9 to 1 where 9= excellent, 7= good, 5= fair, 3= poor, 1=unsalable. Fruits rating (5) or below were considered as unmarketable.

Decay Percentage: Was measured on a scale of 1= none, 2= slight, 3= moderate, 4= severe, 5= extreme.

Fruit Firmness: Was measured by a hand pressure tester (Italian model) expressed in kg/cm^2 [14].

Total Soluble Solids Percentage (TSS): Was determined by using refractometer as described in A.O.A.C. [15].

Ascorbic Acid Content: Was determined as mg/100g fruit fresh weight by titration method using 2, 6 dichloro-phenol indo-phenol the dye as described in A.O.A.C. [15].

Total Carotenoids Content: Was determined as mg/100g fresh weight according to A.O.A.C. [15].

Statistical Analysis: The obtained data were statistically analyzed as the method of Snedecor and Cochran [16].

RESULTS AND DISCUSSIONS

Weight Loss: Data in Table 1 prove that, weight loss percentage of bell pepper fruits was increased significantly and consistently with the extending of storage period. These findings agreed with those obtained by akbudak [17]. Generally, the weight loss during storage is caused by the fruits's senescence-related metabolic activities, respiratory processes and humidity transference during storage [18].

Concerning the effect of postharvest treatments on weight loss percentage, data show 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. Moreover, sweet pepper fruits treated with H_2O_2 at 0.12% or chitosan 0.5% at resulted in prominent reduction in weight loss percentage with non-significant differences between them. These results agree with those obtained by Kibar and Sabir [19]. In this respect, the highest values of weight loss percent were recorded with control. This result was true in the two seasons of study. The highest weight loss noticed in control fruits through the storage period can be attributed to air motion which tends to removal 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 [20]. The decreasing of weight loss percentage by using H_2O_2 may be attributed to lowering the respiration process rates during postharvest storage [3]. The favorable effect of chitosan treatment in reduction of weight loss possibly because chitosan can be utilised to provide a barrier of protection due to its film-forming property, thus allowing control of the biochemical changes in the metabolism of sweet pepper by preventing water loss or creating a modified atmosphere surrounding the fruits [21].

In both seasons, the interaction between postharvest treatments and storage periods plus shelf life was significant. Fruits of the bell pepper treated with H_2O_2 showed the lowest value of weight loss percentage. On the other side, the highest values of weight loss percent were recorded from control. These results were achieved in the two seasons.

General Appearance: According to data in Table 2, general appearance of sweet pepper fruits decreased with the prolongation of storage at 10°C in two seasons. According to similar outcomes reported by Gonzalez-Aguilar *et al*. [22]. The decrease of GA during storage period might be due to shriveling, wilting, color change and decay [23].

Significant differences in appearance were found between postharvest treatments on pepper fruits during storage. All treatments were better than the control, however, sweet pepper dipping in H_2O_2 or chitosan and ozonated water were the most significant effect treatments for maintained good general appearance during storage and shelf life, this concurs with the results obtained by Bayoumi, [3]. The maintenance quality of GA was improved by the use of H_2O_2 attributed to the effect of H_2O_2 on the decreasing of weight loss and rot rate of pepper fruits [3]. Saltveit and Sharaf [24] reported that H_2O_2 treatments have a beneficial effect on physiology of fruit, such as retardation the ripening of tomatoes by the increasing antioxidants content in fruits.

The chitosan covering on vegetables and fruits serves as a semipermeable barrier against carbon dioxide and moisture, which lowers respiration, water loss, respiratory activity and microbial rot of fruits, preventing dehydration and fruit shrinkage, ethylene production and maintaining overall quality and prolonging shelf life [25]. Chitosan coatings can also inhibit the increase of oxidative enzymes activity. An increase in antioxidant enzymes activity 767 and the ability to neutralise free radicals of fruits during storage would reduce the physiological deterioration and improve the resistance of tissue to prevent microbial invasion and lessen fruit deterioration [26].

Ozone maintaining fruit postharvest quality by oxidizing ethylene produced and reduced the respiration rate during the ripening process. Reducing the ethylene level prolongation the shelf life of many ethylene sensitive fruits and vegetables and reduces the shrinking of product during storage [11]. Also, ozone treatment markedly reduction in respiration rate that retarded deterioration and maintained the keeping quality attributes for a longer period [12].

Table 1: Effect of some postharvest treatments on weight loss (%) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	Weight loss (%)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	0.00k	1.88gh	3.87cd	5.12b	7.54a	3.68A
Chitosan	0.00k	0.97ij	2.09g	3.31ef	4.40c	2.15D
CMC*	0.00k	1.50hi	2.92f	4.12cd	5.23b	2.76B
Ozonated water	0.00k	1.25ij	2.29g	3.71de	5.17b	2.48C
Hydrogen peroxide	0.00k	0.80j	1.94gh	3.24ef	4.23cd	2.04D
Mean	0.00E	1.28D	2.62C	3.9B	5.31A	
			2017-2018			
Control	0.00m	2.06hi	3.50ef	4.89b	7.67a	3.62A
Chitosan	0.00m	0.90l	1.91hj	3.33f	4.87bc	2.20C
CMC*	0.00m	1.36jl	2.53gh	4.07de	5.30b	2.65B
Ozonated water	0.00m	1.15kl	2.10hi	3.55df	5.08b	2.38C
Hydrogen peroxide	0.00m	0.73l	1.79ik	2.87fg	4.20cd	1.92D
Mean	0.00E	1.37D	2.51C	3.96B	5.73A	

Values followed with the same capital letters in the same column or row are not statistically different. Small letters for the interaction, according to Duncan·s multiple range test.

*Carboxymethyl-cellulose.

Table 2: Effect of some postharvest treatments on general appearance (score) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	General appearance (score)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	9.00a	7.00ac	4.33de	2.33df	1.00f	4.73D
Chitosan	9.00a	9.00a	7.67ac	7.00ac	6.33bd	7.80B
CMC*	9.00a	7.67ac	7.00ac	5.67cd	4.33de	6.73C
Ozonated water	9.00a	9.00a	7.67ac	7.00ac	6.33bd	7.80B
Hydrogen peroxide	9.00a	9.00a	9.00a	8.33ab	7.67ac	8.60A
Mean	9.00A	8.33A	7.13B	6.07C	5.13D	
			2017-2018			
Control	9.00a	7.00bc	5.00d	2.33e	1.00f	4.87D
Chitosan	9.00a	9.00a	7.67ab	7.00bc	6.33bd	7.80B
CMC*	9.00a	9.00a	6.33bd	5.67cd	5.00d	7.00C
Ozonated water	9.00a	9.00a	7.67ab	7.00bc	6.33bd	7.80B
Hydrogen peroxide	9.00a	9.00a	9.00a	9.00a	7.67ab	8.73A
Mean	9.00A	8.50A	6.67B	5.50C	4.67D	

Values followed with the same capital letters in the same column or row are not statistically different. Small letters for the interaction, according to Duncan·s multiple range test.

*Carboxymethyl-cellulose.

General appearance (score) 9= excellent, 7= good, 5= fair, 3= poor and 1= unusable

The interaction between postharvest treatments and storage period discovered that sweet pepper fruits treated with H_2O_2 showed the best appearance, till the 21st day, it does not show any changes in appearance at 10°C in the second season and gave good appearance at the end of storage and shef life. Meanwhile using chitosan or ozonated water rated good appearance till 21 days at 10°C. Whereas on the other hand, control having the poorest appearance at the end of storage. These results were true in both seasons.

Table 3: Effect of some postharvest treatments on decay (score) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	Decay (score)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	1.00d	1.00d	1.67bd	2.33ab	2.67a	1.73A
Chitosan	1.00d	1.00d	1.00d	1.00d	1.00d	1.00C
CMC*	1.00d	1.00d	1.33cd	1.67bd	2.00ac	1.40B
Ozonated water	1.00d	1.00d	1.00d	1.33cd	1.67bd	1.20BC
Hydrogen peroxide	1.00d	1.00d	1.00d	1.00d	1.00d	1.00C
Mean	1.00C	1.00C	1.20BC	1.47AB	1.67A	
	2017-2018					
Control	1.00c	1.00c	1.67ac	2.00ac	2.67a	1.67A
Chitosan	1.00c	1.00c	1.00c	1.00c	1.00c	1.00C
CMC*	1.00c	1.00c	1.33bc	1.67ac	2.33ab	1.47AB
Ozonated water	1.00c	1.00c	1.00c	1.33bc	1.67ac	1.20BC
Hydrogen peroxide	1.00c	1.00c	1.00c	1.00c	1.00c	1.00C
Mean	1.00C	1.00C	1.25BC	1.50AB	1.92A	

Values followed with the same capital letters in the same column or row are not statistically different.

Small letters for the interaction, according to Duncan, s multiple range test.

*Carboxymethyl-cellulose.

Decay (score) 1=none, 2=slight 3=moderate, 4=severe and 5=extreme

Decay: The data in Table 3 reveal that, there were significant increases in decay score with the prolongation of storage period. This finding possibly as a result of 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 [20]. These findings concur with those of Gonzalez-Aguilar, *et al*. [22].

However, all postharvest treatments were much better in decreasing decay and thus longer storage periods were gained. The decayed fruits began to be appeared after two weeks of storage at 10°C plus 2 days at 20°C for the control, while, no decay was observed in fruits treated with H_2O_2 or chitosan treatments during storage and shelf life. Ozonated water was effective up to 21 days at 10°C additional to 2 days at 20°C. These fruits were scored with slight symptoms of decay after 28 days of storage, whereas control fruits showed severe decay signs at the end of storage in both seasons. Treatment with Carboxy methyl cellulose was less effective in decreasing the decay symptoms.

Bayomi [3] show that H_2O_2 treatment was highly reduced the extension of rot in pepper fruits. The reduction of decay by using H_2O_2 treatment may be attributed to that H_2O_2 as a reactive oxygen species (ROS) play important and manifold role in plant disease resistance to infection with pathogens. In postharvest application, Simmons et al. [27] stated that H_2O_2 treatment have been demonstrate to reduce microbial loads of plums. Moreover, Ukuku et al. [28] found that washing with H_2O_2 solution significantly lowers the human pathogens.

The impact of chitosan treatment in lowering decay may be caused by the positively charged amino acids in chitosan interacting with the negatively charged cell membranes of microorganisms, causing the leaking of proteinaceous and other intracellular components [29].

Chitosan is an antimicrobial agent against many plants pathogenic and bacteria. additionally, chitosan causes systemic resistance in plant [30]. biostimulant effect and disease resistance in horticultural crops by chitosan and potential mechanisms of action have recently been examined [31].

Fruit shelf life and general visual quality have been shown to correlated with increased activity of phenylalanine ammonia lyase [32]. Loaiza-Velarde and Saltveit [33] found that product treated with ozone inhibited the increase in PAL activity; so, increased the storability of product.

The interaction between the used treatments and storage period was non-significant between all treatments and storage period until 7 days and significant during the last period in both seasons. H_2O_2 or chitosan treatments were the best techniques to maintaining fruits without decay as the interaction with storage period.

Fruit Firmness: Date in Table 4 show that there was a significant reduction in fruit firmness by the increasing storage time in the two seasons. Considering the same outcomes reported by Fallik *et al*., [34]. The decline in fruit firmness possibly because 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 [20].

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 control fruits. However, sweet pepper fruits treated with H_2O_2 or chitosan were the most effective treatment in reducing the loss of firmness with non-significant differences between them during storage, then ozonated water treatment. Carboxy methyl cellulose treatment was less effective in reducing firmness loss during storage as compared with the other treatments. These findings agree with Ben-Yahoshua *et al*. [35].

As for the interaction between period of the storage and postharvest treatments was significant through the two seasons. fruits of the sweet pepper treated with H_2O_2 or chitosan had the highest value of fruit firmness during all storage period.

Total soluble solids:

Significant reduction in TSS% of sweet pepper fruits during storage and shelf life was observed in the two seasons of study (Table 5). However, the lower TSS during storage may be mostly attributable to the higher rate of sugar respiration loss than water transpiration loss [20].

Concerning the impact of postharvest treatments, data reveal that sweet pepper fruits dipped in H_2O_2 gave the highest values of TSS% of fruits compared with the other treatments during storage and life shelf. Moreover, sweet pepper fruits treated with Chitosan were significantly higher in TSS% during storage and shelf life than ozonated water and Carboxy methyl cellules in both seasons. However, significantly the lowest value of TSS% resulted from control during storage and shelf life in both seasons.

For the effect of H_2O_2 treatment similar findings were achieved by Peng *et al*. [36] who found that H_2O_2 treatment tended to maintain T.S.S values significantly better than the control fruits.

As for the interaction between postharvest treatments and storage period, data reveal that sweet pepper fruits treated with Hydrogen peroxide were significantly superior in maintaining TSS compared with untreated control after 28 days at 10°C + 2 days at 20°C in both seasons.

Ascorbic Acid Content: It is obvious from data in Table 6 clearly that ascorbic acid contents of bell pepper fruits were decreased with the prolongation of storage period or shelf life in the two seasons. however, the reduce in ascorbic acid might result from the higher rate of sugar loss through respiration than water loss through transpiration. According to Sakaldas and Kaynas [37], similar results were reported.

Concerning the impact of postharvest treatments on ascorbic acid content, data revealed that all treatments were effective on preventing ascorbic acid degradation during storage as compared with the control fruits. In general, H_2O_2, chitosan or ozonated water resulted in maintaining ascorbic acid content. Carboxy methyl cellulose treatment had slight effects on ascorbic acid preservation in both seasons.

The preserving of ascorbic acid content is correlated to H_2O_2 treatments because it can be renovated by two enzymes namely monodehydroascorbate reductase and dehydroascorbate reductase [38].

The higher level of ascorbic acid in chitosan treated fruits might reflect the low oxygen permeability, slowing down the respiration rate, which delays the deteriorative oxidation reaction of ascorbic acid of fruits [39].

Klopotek *et al*. [40] found that changes in vitamin C of fruits treated with ozone can be attributed to the activation of an antioxidative system that promotes the biosynthesis of vitamin C from the carbohydrate pool.

The interaction between storage period and postharvest treatments was significant for ascorbic acid contents of bell pepper fruits in both seasons, the results showed that after 28 days at 10°C or 2 days at 20°C, H_2O_2 was the most effective treatment in reducing ascorbic acid loss at the end of storage. However, the lowest one was obtained from control fruits.

Total Carotenoids: Results in Table 7 demonstrate that carotenoids values of sweet pepper fruits increased during storage or shelf life. These results were true in the two seasons. after 7 days of storage, no significant differences were found in total carotenoids contents among treatments including the control. However, the differences were significant after storage for 28 days plus shelf life. Hydrogen peroxide gave the lowest value of carotenoids at storage period 28 days at 10°C additional 2 days at 20°C in the two seasons. The fruits treated with H_2O_2 or chitosan or ozonated water resulted in prominent reduction in weight loss percentage with non-significant differences between them during storage in the two seasons.

Table 4: Effect of some postharvest treatments on firmness (kg/cm^2) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	Firmness (kg/cm^2)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	4.77ab	4.45af	4.05eh	3.70gh	3.07h	4.01D
Chitosan	4.85ab	4.78ab	4.65ad	4.40af	4.20dg	4.58AB
CMC*	4.75ab	4.55ae	4.22cf	4.02fh	3.67i	4.24C
Ozonated water	4.73ac	4.63ad	4.47af	4.23df	4.02fh	4.42B
Hydrogen peroxide	4.92a	4.82ab	4.75ab	4.68ad	4.55ab	4.74A
Mean	4.80A	4.65A	4.43B	4.21C	3.90D	
			2017-2018			
Control	4.90ab	4.67be	4.15hi	3.67j	3.15k	4.11E
Chitosan	4.92a	4.80ac	4.68be	4.52eg	4.30gh	4.64B
CMC*	4.90ab	4.67be	4.38fh	4.02i	3.55j	4.30D
Ozonated water	4.88ab	4.77ad	4.57cf	4.28gh	4.03i	4.51C
Hydrogen peroxide	4.92a	4.85ab	4.77ad	4.73ae	4.55df	4.76A
Mean	4.90A	4.73B	4.45C	4.12D	3.76E	

Values followed with the same capital letters in the same column or row are not statistically different. Small letters for the interaction, according to Duncan's multiple range test.

*Carboxymethyl-cellulose.

Table 5: Effect of some postharvest treatments on TSS (%) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	TSS (%)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	7.20a	7.00ac	6.50fh	6.30hj	5.50l	6.50C
Chitosan	7.20a	7.15a	6.80de	6.50fh	6.10jk	6.75AB
CMC*	7.21a	7.10ab	6.70df	6.40gi	6.00k	6.68B
Ozonated water	7.22a	7.10ab	6.80de	6.50fh	6.00k	6.72B
Hydrogen peroxide	7.22a	7.16a	6.89bd	6.59eg	6.20ik	6.81A
Mean	7.21A	7.10B	6.74C	6.46D	5.96E	
			2017-2018			
Control	7.20ab	7.00ac	6.70de	6.30fh	5.90l	6.62C
Chitosan	7.50a	7.30ab	7.10bd	6.80de	6.40fh	7.02AB
CMC*	7.50a	7.20ac	7.00bd	6.70df	6.10k	6.88B
Ozonated water	7.30ab	7.30ab	7.10bd	6.80de	6.20ik	6.92B
Hydrogen peroxide	7.60a	7.50a	7.20ac	6.90bd	6.50fh	7.14A
Mean	7.38A	7.20B	6.98C	6.65D	6.10E	

Values followed with the same capital letters in the same column or row are not statistically different. Small letters for the interaction, according to Duncan's multiple range test.

*Carboxymethyl-cellulose

Table 6: Effect of some postharvest treatments on ascorbic acid (mg/100 g fresh weight) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	Ascorbic acid (mg/100 g fresh weight)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	121.87ab	119.47ad	114.68ad	112.83ad	108.81d	115.53D
Chitosan	121.90ab	120.97ac	118.70ad	116.17ad	112.37bd	118.02AB
CMC*	121.97ab	120.52ac	116.57ad	114.84ad	109.63cd	116.71C
Ozonated water	122.00a	120.70ac	117.63ad	114.88ad	111.40bd	117.32AB
Hydrogen peroxide	121.98a	121.03ac	119.03ad	117.70ad	114.10ad	118.75A
Mean	121.94A	120.54AB	117.32BC	115.28D	111.24E	
			2017-2018			
Control	123.20ab	119.43ef	115.99ij	113.38k	108.27n	116.05E
Chitosan	123.38a	121.77bd	118.57fg	116.80hj	113.03kl	118.71B
CMC*	123.40a	120.50de	116.63hj	115.32i	110.53m	117.28D
Ozonated water	123.06ac	121.50cd	117.87fh	115.68j	111.48lm	117.92C
Hydrogen peroxide	123.06ac	121.82ad	119.17ef	117.47gi	115.53j	119.41A
Mean	123.26A	120.80B	117.26C	115.30D	110.83A	

Values followed with the same capital letters in the same column or row are not statistically different.

Small letters for the interaction, according to Duncan, s multiple range test.

*Carboxymethyl-cellulose

Table 7: Effect of some postharvest treatments on total carotenoids (mg/100 g fresh weight) of sweet pepper fruits during storage at 10°C, with an additional 2 days at 20°C in 2016 / 2017 and 2017/ 2018 seasons

	Total carotenoids (mg/100 g fresh weight)					
	Storage period (day)					
	2016-2017					
Treatments	Start	7+2	14+2	21+2	28+2	Mean
Control	2.49e	2.65de	2.96cd	3.46b	4.09a	3.13A
Chitosan	2.46e	2.52e	2.62de	2.79ce	2.92cd	2.62C
CMC*	2.50e	2.60de	2.81ce	3.10bc	3.40b	2.88B
Ozonated water	2.48e	2.53e	2.65de	2.80ce	3.10bc	2.71C
Hydrogen peroxide	2.49e	2.62fe	2.69de	2.78ce	2.90cd	2.70C
Mean	2.48D	2.58D	2.75C	2.99B	3.24A	
			2017-2018			
Control	2.70g	2.77e	2.95cd	3.55b	4.20a	3.23A
Chitosan	2.75g	2.81e	2.92de	3.07ce	3.10cd	2.96C
CMC*	2.73g	2.77e	2.95de	3.06bc	3.95b	2.87B
Ozonated water	2.70g	2.77e	2.92de	3.07ce	3.69bc	3.03C
Hydrogen peroxide	2.67g	2.71g	2.76e	2.90ce	3.00cd	2.81C
Mean	2.72D	2.78D	2.91C	3.16B	3.55A	

Values followed with the same capital letters in the same column or row are not statistically different. Small letters for the interaction, according to Duncan, s multiple range test.

*Carboxymethyl-cellulose.

For the interaction between postharvest treatments and storage period on carotenoids, data revealed that sweet pepper fruits treated with H_2O_2 or chitosan were the most effective treatments in maintaining carotenoids content at the end of storage and shelf life conditions. These results are true in both seasons.

CONCLUSION

From the previous results, it could be concluded that sweet pepper fruits dipped in hydrogen peroxide at .012% or Chitosan at 0.5% improved storability of fruits, maintained fruit quality and gave fruits with good appearance till of 28 days without decay.

REFERENCES

1. Howard, L.R., S.T. Talcott, C. H. Brenes and B. Villalon, 2000. Changes in physicochemical and antioxidant activity of selected pepper cultivars (*Capsicum species*) as influenced by maturity. Journal of Agricultural and Food Chemistry, 48: 1713-1720.
2. Kader, A.A., 2002. Postharvest technology of horticultural crops. University of California, Division of Agriculture and Natural Resources Publication, 3: 311:535.
3. Bayoumi, Y.A., 2008. Improvement of postharvest keeping quality of white pepper fruits (*Capsicum annum* L.) by hydrogen peroxide treatment under storage conditions. Acta Biologica Szegediensis, 52(1): 7-15.
4. Xing, Y.G., X.H. Li, Q.L. Xu, J. Yung, Y.Q. Lu and Y. Tang, 2011. Effect of chitosan coating enriched with cinnamon oil on qualitative properties of sweet pepper (*Capsicum annum* L.) Food Chem., 124: 1443-1450.
5. Zhelyazkov, S., G. Zsivanovits, B. Brashlyanova and M. Marudova- Zsivanovits, 2014. Shelf-life Extension of Fresh-cut Apple Cubes with Chitosan Coating. Bulgarian Journal of Agricultural Science Bulgarian Journal of Agricultural Science, 20(3): 536-540.
6. Bautista-Ban¡os, S., A.N. Hernández-Lauzardo, M.G. Velázquez-del Valle, M. Hernández-López, E. Ait Barka and E. Bosquez-Molina, 2006. Chitosan as a potential natural compound to control pre and postharvest diseases of horticultural commodities. Crop Protection, 25: 108-118.
7. NOP, 2003. National Organic Program, 31 October 2003, Federal Register, Rules and Regulations, 68: (211).
8. Sapers, G.M., R.L. Miller, V. Pilizota and F. Kamp, 2001. Shelf life extension of fresh mushrooms (*Agaricus bisporus*) by application of hydrogen peroxide and browning inhibitors. J. Food Sci., 66: 362-366.
9. Ayranci, E. and S. Tunc, 2004. A method for the measurement of the oxygen permeability and the development of edible films to reduce the rate of oxidative reactions in fresh foods. Food Chemistry, 80: 423-431.
10. Nadim, Z., A. Ebrahim, S. Hassan and A. C. Reza, 2015. Effect of methylcellulose-based edible coating on strawberry fruit's quality maintenance during storage. Journal of Food Processing and Preservation, 39: 80-90.
11. Jaksch, D., R. Margesin, T. Mikoviny, J.D. Skalny, E. Hartungen, F. Schinner, N.J. Mason and T.D. Mark, 2004. The effect of ozone treatment on the microbial contamination of pork meat measured by detecting the emissions using PTR-MS and by enumeration of microorganisms. Int. J. Mass Spectrom., 239: 209-214.
12. Shalluf, M.A., C. Tizaoui and N. Karodia, 2007. Controlled atmosphere storage technique using ozone for delay ripening and extend the shelf life of tomato fruit. IOA Conference and Exhibition Valencia, Spain, pp: 7.
13. Haffez, M.M., 2016. Effect of postharvest treatments on quality and storability of fresh cut cantaloupe. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Cairo, Egypt, pp: 138.
14. Abbott, J.A., 1999. Quality measurements of fruits and vegetable postharvest. Biol. Technol., 15: 207-225.
15. A.O.A.C. 1990. Quality of Official Analytical Chemists, Washington. DC. USA.
16. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 8^{th} Ed., Iowa State Univ. Press, Ames, Iowa, USA., pp: 476.
17. Akbudak, B. 2008. Effect of polypropylene and polyvinyl chloride plastic film packaging materials on the quality of yalova charleston pepper (*Capsicum annuum* L.) during storage. Food Sci. Technol. Res., 14(1): 5-11.
18. Neill, S.J., R. Desikan, A. Clarke, R.D. Hurst and J. Hancock, 2002. Hydrogen peroxide and nitric oxide as signalling molecules in plants. J. Exp. Bot., 53(372): 1237-1247.
19. Kibar, H. F. and F. Sabir, 2018. Chitosan coating for extending postharvest quality of tomatoes (*Lycopersicon esculentum* Mill.) maintained at different storage temperatures. Agriculture and Food, 3(2): 97-108.

20. Wills R., B. McGlasson, D. Graham and D. Oyce, 1998. Postharvest: An introduction to the physiology and Handling of fruit, vegetables and ornamentals (4th end n).CAB international, New York, pp: 77-96.
21. Qiu, M., H.G. Jiang, G.R. Ren, J.Y. Huang and X.Y. Wang, 2013. Effect of chitosan coatings on postharvest green asparagus quality. Carbohydr. Polym., 92: 2027-2032.
22. Gonzalez-Aguilar, G., R. Cruz, R. Baez and C.Y. Wang, 1999. Storage quality of bell peppers pretreated with hot water and polyethylene packaging. J. Food Qual., 22(3): 287-299.
23. Banaras, M., P.W. Bosland and N.K. Lownds, 2005. Effect of harvest time and growth conditions on storage and post-storage quality of fresh peppers (*Capsicum annuum* L.). Horticultural Research Institute, National Agricultural Research Centre, Park Road, Islamabad, Pakistan. Pak. J. Bot., 37(2): 337-344.
24. Saltveit, M.E. and A.R. Sharaf, 1992. Ethanol inhibitors ripening of tomato fruit harvested at various degrees of ripeness without affecting subsequent quality. J. Am. Soc. Hort. Sci., 117: 793-798.
25. Velickova, E., E. Winkelhausen, S. Kuzmanona, V.D. Alvesand and M.M. Martins, 2013. Impact of chitosan-beeswax edible coatings on the quality of fresh strawberries (*Fragaria ananassa* cv Camarosa) under commercial storage conditions. Food Science and Technology, 52: 80-92.
26. Wang, S.Y. and G. Haiyan, 2013. Effect of chitosan-based edible coating on antioxidants, antioxidant enzyme system and postharvest fruit quality of strawberries (*Fragaria x aranassa* Duch.). Food Science and Technology, 52: 71-79.
27. Simmons, G.E., J.L. Semilanick, S. John and D.A. Margosan, 1997. Reduction of microbial populations on prunes by vapor phase hydrogen peroxide. J. Food Protect., 60: 188-191.
28. Ukuku, D.O., M.L. Bari, S. Kawamoto and K. Isshiki, 2005. Use of hydrogen peroxide in combination with nisin, sodium lactate and citric acid for reducing transfer of bacterial pathogens from whole melon surfaces to fresh-cut pieces. Int. J. Food Microbiol., 104: 225-233.
29. Dutta, P.K., S. Tripathi, G.K. Mehrotra and J. Dutta, 2009. Perspectives for chitosan based antimicrobial films in food applications. Food Chemistry, 114: 1173-1182.
30. Terry, L.A. and D. Joyce, 2004. Elicitors of induced disease resistance in postharvest horticultural crops: a brief review. Postharvest Biology and Technology, 32: 1-13.
31. Pichyangkura, R. and S. Chadchawan, 2015. Biostimulant activity of chitosan in horticulture. Sci Hortic., 196: 49-65.
32. Lopez-Galvez, G., M. Saltveit and M. Cantwell, 1996. Wound-induced phenylalanine ammonia lyase activity: factors affecting its induction and correlation with the quality of minimally processed lettuces. Postharvest Biology and Technology, 9: 223-233.
33. Loaiza-Velarde, G.J. and M.E. Saltveit, 2001. Heat shocks applied either before or after wounding reduce browning of lettuce leaf tissue. Journal of the American Society for Horticultural Science, 12: 227-234.
34. Fallik, E., S. Grinberg, O. Yekutieli, A. Wiseblum, R. Regev, H. Beres and E. Bar-Lev, 1999. A unique hot water treatment to improve storage quality of sweet pepper. Postharvest Biology and Technology, 15: 25-32.
35. Ben-Yahoshua, S., B. Shapiro, Z.E. Chen and S. Lurie, 1983. Mode of action of plastic film in extending life of lemon and bell pepper fruits by alleviation of water stress. Plant Physiology, 73: 87-93.
36. Peng, L.T. and Y.M. Jiang, 2003. Effects of chitosan coating on shelf life and quality of fresh-cut Chinese water chestnut. Lebensm. Wiss. U. Technol., 36: 359-364.
37. Sakaldaş, M. and K. Kaynaş, 2010. Biochemical and quality parameters changes of green sweet bell peppers as affected by different postharvest treatments. Journal of Biotechnology, 9(48): 8174-8181.
38. Nishikawa, F., M. Kato, H. Hyodo, Y. Ikoma, M. Sugiura and M. Yano, 2003. Ascorbate metabolism in harvested broccoli. J. Exp. Bot., 54: 2439-2448.
39. Dang Q.F., J.Q. Yan, Y. Li, X.J. Cheng, C.S. Liu and X.G. Chen, 2010. Chitosan acetate as an active coating material and its effects on the storing of Prunus avium L. J. Food Sci., 75(2): 125-131.
40. Klopotek, Y. and V. Böhm, 2005. Processing Strawberries to Different Products Alters Contents of Vitamin C, Total Phenolics, Total Anthocyanins and Antioxidant Capacity. Journal of Agriculture and Food Chemistry, 53: 5640-5646.