ISSN 1110-0419

Annals Of Agric. Sci., Moshtohor,
Vol. 47(3): Ho. 431-444, (2009).

EFFECT OF HOT WATER TREATMENT, MODIFIED ATMOSPHERE PACKAGING AND STORAGE PERIODS ON ALLEVIATING CHILLING INJURY IN CUCUMBER FRUITS

BY

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ABSTRACT

This study was carried out at Kaha Experimental Farm, Qalyoubia Governorate during 2007 and 2008 seasons, to study the effect of hot water treatment and modified atmosphere packaging on fruit quality and chilling injury of cucumber (*Cucmus sativus* L.) cv. Beta Alpha during storage at 5°C and retail shelf life condition at 20°C.

Hot water treatment at 43°C for 20 min and packaging in perforated (PPB) or non perforated polypropylene bags (NPPB) did not exhibit any sign of chilling injury during storage at 5°C for 12 days plus 2days at 20 °C.

Immersion of cucumber fruits in 43°C water for 20 min, then packed in NPPB maintained fruit firmness, delayed the losses of chlorophyll and reduced decay during storage and shelf life condition.

Cucumber fruits packed in PPB or NPPB, immersed in 43°C for 20 min alone or combined with PPB or NPPB did not exhibit any changes in their appearance till the six days of storage at 5°C and gave fruit with good appearance at the end of storage, while using hot water at 38°C for 30 min. as well as untreated fruits control resulted in poor fruit appearance at the same period.

Cucumber fruits immersed in hot water at 43°C for 20 min. and then packed in NPPB could induce accumulation of cucumber fruits to low temperature and without chilling injury symptoms during storage at 5°C.

INTRODUCTION

Refrigeration is the major tool to maintain fruit and vegetable quality, where it decreases temperature, lowers metabolism, thus it prolongs shelf life. Cucumber fruits, being of tropical origin, are susceptible to chilling injury (CI), if held at low temperature (Kader 1986). The optimal storage temperature recommended in literature ranged between 10-13°C (Hardenburg *et al.*, 1986). So, cucumber fruits are injured if held at temperature lower than 10°C for more than 3 days (Eaks and Morries, 1956).

Chilling sensitive crops can develop symptoms of CI either during storage at chilling temperature or subsequently during marketing condition at non chilling temperature. Chilling injury symptoms include surface pitting, the formation of sunken, dark colored watery areas, rapid chlorophyll breakdown and increased susceptibility to decay and fungal growth (Ryall and Lipton, 1979; Cabrera and Saltveit, 1990). Thus, for this reason, this work has been done including heat treatment, and modified atmosphere packaging as well as the combination between them to reduce symptoms of chilling injury in cucumber fruits.

Post harvest heat treatment is a non contamination physical treatment that reduces chilling injury and controls activity of pathogens.

* This research was supported by Development of Postharvest treatments project

The use of hot water treatment (HWT) is an accurate method to reduce the development of CI (Ali *et al.*, 2004). Thus, it has been used as a supplement to refrigeration to extend storage and shelf life of cucumber fruits (Hardenburg *et al.*, 1986). The efficiency of hot water treatment that reduces symptoms of CI has been demonstrated by several researchers (Wang, 1993) on zucchini squash, (Saltveit *et al.*, 1987) on tomato and (Hirose, 1985) on cucumber.

Modified atmosphere packaging (MAP) is another technique that has been used to prevent the development of chilling injury symptoms of cucumber fruits (Forney and Lipton., 1990). Wrapping cucumber fruit in sealed polyethylene film reduced weight loss, maintained fruit firmness and prevent CI symptoms during storage at 5°C and 95% RH (Wang and Qi, 1997). However, packaging cucumber fruits in plastic film resulted in reduced chlorophyll loss and chilling injury in cucumber fruits compared with non packaged fruits when stored at 5°C (Eaks and Morries 1956). Wrapping cucumber fruits in polyethylene film is very important to protect the marketability of the fruits (Forney and Lipton 1990). Moreover, the increase in humidity and reduction in O_2 concentration and accumulation of Co_2 within the package often are beneficial for preventing the development of CI symptoms (Wang and Qi, 1997)

MATERIAL AND METHODS

Cucumber (*Cucumus sativus* L.) cv Beta Alpha. was grown under open field conditions at Kaha Experimental Farm. Horticultural Research Institute during two successive seasons of 2007 and 2008 .Seeds were sown on September 5th and 7th in the first and second seasons, respectively. Normal cultural practices were carried out whenever it was needed according to the recommendation of Ministry of Agricultural. Fruits were harvested at the proper stage on November 5th and 10th in the first and second season, respectively, then transported to the laboratory of Post harvest and Handling of Vegetable Crops department at Giza governorate within 1.5 hours after harvesting.

Fruits of the same size (12-14cm in length), shape and free from injury were selected for the following treatments:

1- Packaging in micro-perforated polypropylene bags (18×25cm in size) (PPB) with 9 μm thickness.
2- Packaging in non- perforated polypropylene bags (18×25cm in size) (NPPB) with 9 μm thickness.
3- Dipping in hot water at 38°C for 30 min.
4- Dipping in hot water at 43°C for 20 min.
5- Dipping in hot water at 38°C for 30 min + Treatment (1).
6- Dipping in hot water at 38°C for 30 min + Treatment (2).
7- Dipping in hot water at 43°C for 20 min + Treatment (1).
8- Dipping in hot water at 43°C for 20 min + Treatment (2).
9- Untreated fruits (control).

Twenty four replicates were prepared for each treatment. Each replicate consisted of a bag containing 6 fruits. The samples were arranged in a complete randomized design and stored at 5°C and 95% relative humidity for 3, 6, 9 and 12 days. At each interval, samples were taken from 3 replicates for each treatment and examined for general appearance, weight loss (%), decay (%), chilling injury (CI), firmness, total soluble solids (T.S.S) and chlorophyll. Other 3 replicates from each treatment removed from 5°C and placed into 20°C for two subsequent days to simulate marketing condition. The following quality measurements were recorded:

General appearance: It was evaluated using a scale from "1-9" with 9= Excellent, 7= good, 5=fair 3= poor, 1=unsalable, and fruits rating "5" or below were considered unmarketable.

Weight loss and decay: They were expressed as percentages.

Chilling injury: The degree of chilling injury, was judged by the extent of surface pitting, was evaluated five hours after transferring of cucumber fruits from

storage chambers to room temperature (20°C) by rating scale of 1 to 5, where 1= no pitting, 2= 10% of the surface area pitted, 3= 11-25% of the surface area pitted, 4= 26-50% of the surface area pitted 5= ≥ 50% of the surface area pitted (as describe by Wang and Qi, 1997).

Fruit firmness: It was measured in Lb/in^2 by Magness and Ballouf pressure tester equipped with 3/16 inch plunger and adjusted in Newton (as recommended by ASHS post harvest working Group).

Total soluble solids percentage: It was determined by digital refractometer of Model Abbe Leica.

Total chlorophyll: It was measured by using Minolta chlorophyll meter 501and expressed as" SPAD".

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

RESULTS AND DISCUSSION

General appearance

Data in Table (1) indicate that general appearance of the fruit packed in non-perforated polypropylene bags, immersed in 43°C for 20min alone or combined with perforated or non-perforated bags did not exhibit any changes in their appearance till the 6th days of storage at 5°C and gave fruits with good appearance at the end of the storage. Mean while fruits immersed in hot water at 38°C for 30 min and then packed in non perforated bags. As well as cucumber fruits packed in (PPB) alone reflected fair appearance. On the other hand, immersion cucumber fruits in hot water at 38°C for 30 min. as well as untreated fruits control resulted in poor fruit appearance at the end of storage periods.

General appearance of cucumber fruits decreased with the prolongation of storage period .Similar results were reported by Abd El-Rahman (2001) on cucumber.

The interaction between treatments and storage period appeared significant during storage and shelf life condition. So, cucumber fruits immersion in hot water at 43°C for 20 min. and packed in NPPB performed good appearance after 9 days at 5°C +2 days at 20°C.

Weight loss (%)

Data in Table (2) show that the lowest values of weight loss were obtained in cucumber fruits packed in non perforated polypropylene bags alone or combined with hot water treatments. Packaging in non perforated polypropylene bags effectively retarded evaporative water loss, thus enabling the fruits to maintain high water content during storage (Abd-EL-Rahman, 2001). The lower amount of air movement around the wrapped fruits, compared with the non wrapped fruits, would also help to maintain a microclimate with a very high humidity around the fruits (Forney *et al.*, 1989).Also, modification of the atmosphere around the fruits, in other words, decreasing O_2 and increasing CO_2 in the storage atmosphere of fruit, decreases the rate of respiration (Wang and Qi, 1997).

On the contrary, dipping cucumber fruits in hot water led to increasing the percentage of weight loss as compared with the other treatments or untreated fruit control. In this respect, dipping cucumber fruits in hot water of 43°C for 20min gave the highest value of weight loss during storage at 5°C or shelf life condition at 20°C. These results are similar to those reported by (McCollum *et al.*, 1995) who found that dipping cucumber fruits in hot water increased respiration rate following treatment then decreased it after 48 hours and there were no differences among the treatments.

Weight loss percentage of cucumber fruits increased considerably and consistently with the prolongation of storage period. The weight loss is a natural consequence of the catabolism of horticultural products, the loss in weight may be attributed to respiration and other senescence related metabolic processes during storage (Watada and Qi, 1999). Similar results were reported by Abd El-Rahman, (2001) on cucumber.

Table (1): Effect of hot water treatment, modified atmosphere packaging and storage period on general appearance of cucumber fruit during storage at 5°C and Additional 2 days at 20°C (storage and marketing simulation).

Treatments*	2007						2008					
	Storage period (days)						Storage period (days)					
	At harvest	3 days	6 days	9 days	12 days	Mean	At harvest	3 days	6 days	9 days	12 days	Mean
1	9.0	8.9	8.5	7.5	5.5	7.9	9.0	9.0	8.6	7.3	6.3	8.0
2	9.0	9.0	8.9	7.9	6.9	8.3	9.0	9.0	8.7	7.7	7.0	8.3
3	9.0	8.0	6.5	5.5	4.0	6.6	9.0	8.3	7.1	7.0	4.0	7.1
4	9.0	8.8	8.6	7.9	6.9	8.2	9.0	8.9	8.8	8.0	7.0	8.3
5	9.0	8.9	7.7	7.0	6.0	7.7	9.0	8.3	8.0	7.7	6.9	8.0
6	9.0	8.5	7.4	7.0	5.5	7.5	9.0	8.7	8.3	7.3	5.5	7.8
7	9.0	9.0	8.9	7.9	6.9	8.3	9.0	9.0	8.6	7.8	7.0	8.3
8	9.0	9.0	8.9	7.9	7.0	8.4	9.0	9.0	8.7	8.0	7.0	8.3
9	9.0	7.7	6.8	5.0	3.5	6.4	9.0	8.0	7.2	6.1	4.0	6.9
Mean	9.0	8.6	8.0	7.1	5.8		9.0	8.7	8.2	7.4	6.1	
L.S.D. at 0.05%												
Treatments(T)				0.3						0.6		
Storage period(SP)				0.7						0.8		
(T * SP)				1.6						1.7		
Shelf life												
	6 days at 5°C+2 days at 20°C		9 days at 5°C+2 days at 20°C		12 days at 5°C+2 days at 20°C	Mean	6 days at 5°C+2 days at 20°C		9 days at 5°C+2 days at 20°C		12 days at 5°C+2 days at 20°C	Mean
1	7.7		6.0		4.0	6.9	7.3		6.3		4.0	5.9
2	7.7		6.3		5.7	6.6	7.7		6.7		6.0	6.8
3	5.7		4.0		3.0	4.2	6.7		4.0		3.0	4.6
4	5.7		5.0		3.7	4.8	6.7		6.0		5.3	6.0
5	7.7		6.3		5.0	6.3	7.0		6.0		5.0	6.0
6	7.7		6.3		5.7	6.6	7.3		6.7		6.0	6.7
7	7.0		6.3		5.0	6.1	7.3		6.3		5.7	6.4
8	7.7		7.0		5.7	6.8	7.7		7.1		5.3	6.7
9	7.0		3.5		3.0	4.5	6.7		4.0		3.0	4.6
Mean	7.1		5.6		4.6		7.2		5.9		4.8	
L.S.D. at 0.05%												
Treatments(T)				0.3						0.3		
Storage period(SP)				0.4						0.6		
(T * SP)				0.6						0.9		

(1) Perforated polypropylene bags.* (2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min. (4) Hot-water dips at 43°C/20 min.
(5) 38°C/30 min + Treat. (1). (6) 38°C/30 min + Treat. (2).
(7) 43°C/20 min + Treat. (1). (8) 43°C/20 min +Treat. (2).
(9) Control

Table (2): Effect of hot water treatment, modified atmosphere packaging and storage period on weight loss (%) of cucumber fruit during storage at 5°C and additional 2 days at 20°C (storage and marketing simulation).

Treatments*	2007					2008				
	Storage period (days)					Storage period (days)				
	3days	6day	9 days	12 days	Mean	3day	6day	9 days	12days	Mean
1	1.6	3.1	4.1	6.3	**3.8**	1.6	2.7	3.1	5.7	**3.3**
2	0.0	0.1	0.2	0.3	**0.1**	0.0	0.1	0.2	0.3	**0.1**
3	3.6	7.8	10.0	13.8	**8.8**	3.3	5.3	8.4	10.7	**6.9**
4	4.3	8.2	9.6	14.3	**9.1**	3.7	6.2	8.7	11.7	**7.6**
5	1.7	3.8	4.6	6.0	**4.0**	1.5	2.9	3.9	5.4	**3.4**
6	0.1	0.1	0.1	0.2	**0.1**	0.0	0.1	0.1	0.2	**0.1**
7	1.9	4.1	4..	5.0	**3.9**	1.8	3.7	4.5	5.6	**3.9**
8	0.0	0.1	0.1	0.2	**0.1**	0.1	0.1	0.1	0.2	**0.1**
9	2.6	6.8	8.4	11.6	**7.3**	2.2	6.3	7.9	10.8	**6.8**
Mean	**1.7**	**3.8**	**4.6**	**6.4**	**4.1**	**1.6**	**3.0**	**4.1**	**5.6**	**3.6**
L.S.D. at 0.05%										
Treatments(T)			**0.8**					**0.9**		
Storage period(SP)			**0.9**					**1.0**		
(T * SP)			**1.1**					**1.2**		
	Shelf life									
	6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean		6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean	
1	4.0	5.0	7.2	**5.4**		3.7	4.1	6.8	**4.8**	
2	0.2	0.3	0.4	**0.3**		0.2	0.3	0.4	**0.3**	
3	9.7	12.0	15.9	**12.5**		7.4	10.5	12.8	**10.2**	
4	10.1	11.5	16.4	**12.7**		8.4	10.8	13.8	**11.0**	
5	4.7	5.5	6.9	**5.7**		3.8	4.8	6.4	**5.0**	
6	0.2	0.2	0.3	**0.3**		0.2	0.2	0.3	**0.2**	
7	5.0	5.5	6.0	**5.5**		4.6	5.4	6.5	**5.5**	
8	0.2	0.2	0.3	**0.2**		0.2	0.3	0.3	**0.3**	
9	8.7	10.3	13.6	**10.9**		8.3	9.3	12.7	**10.1**	
Mean	**4.0**	**5.0**	**7.2**			**3.7**	**4.1**	**6.8**		
L.S.D. at 0.05%										
Treatments(T)		**0.3**					**0.7**			
Storage period(SP)		**0.5**					**0.6**			
(T * SP)		**0.9**					**1.1**			

(1) Perforated polypropylene bags.* (2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min. (4) Hot-water dips at 43°C/20 min.
(5) 38°C/30min +Treat. (1). (6) 38°C/30min +Treat. (2).
(7) 43°C/20min +Treat. (1). (8) 43°C/20min +Treat. (2).
(9) Control

The interaction between treatments and storage period appeared significant during storage and shelf life condition, and packaging in non perforated polypropylene bags showed the lowest values of weight loss compared to the other treatments.

Decay%

Results in Table (3) show that all various treatments were much better in reducing decay and thus longer storage periods were gained. The decayed fruits started to be shown early after 6 days of storage for the control treatment. However, no decay was observed in fruit packed in PPB or NPPB, fruit immersed in hot water at 43°C for 20 min. alone or combined with PPB and NPPB during storage at 5°C.The reduction in decay and fungal development by the hot water treatment may be related to washing off the natural pathogenic spore population from the surface of fruit (Cantwell and Nie, 1992) on tomato.

Table (3): Effect of hot water treatment, modified atmosphere packaging and storage period on decay (%) of cucumber fruit during storage at 5°C and additional 2 days at 20°C (storage and marketing simulation).* *

Treatments*	2007					2008				
	Storage period (days)					Storage period (days)				
	3day	6day	9 days	12days	Mean	3day	6day	9 days	12days	Mean
1	0	0	0	0	**0.0**	0.0	0.0	0.0	0.0	**0.0**
2	0	0	0	0	**0.0**	0.0	0.0	0.0	0.0	**0.0**
3	0	0	6.6	16.6	**5.8**	0.0	0.0	6.7	16.7	**5.9**
4	0	0	0	0	**0.0**	0.0	0.0	0.0	0.0	**0.0**
5	0	0	0	6.6	**1.7**	0.0	0.0	0.0	6.7	**1.7**
6	0	0	0	3.3	**0.8**	0.0	0.0	0.0	3.3	**0.8**
7	0	0	0	0	**0.0**	0.0	0.0	0.0	0.0	**0.0**
8	0	0	0	0	**0.0**	0.0	0.0	0.0	0.0	**0.0**
9	0	10	20	36	**16.5**	0.0	13.3	20.0	26.7	**15.0**
Mean	**0.0**	**1.1**	**3.0**	**6.9**		**0.0**	**1.5**	**3.0**	**5.9**	
	Shelf life									
	6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean		6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean	
1	0.0	6.6	10.0	**5.5**		0.0	11.1	14.4	**8.5**	
2	0.0	1.1	3.3	**1.5**		0.0	2.2	4.4	**2.2**	
3	6.6	10.0	16.6	**11.1**		3.3	13.3	16.7	**11.1**	
4	0.0	0.0	3.3	**1.1**		0.0	0.0	4.4	**1.5**	
5	3.3	10.0	16.6	**10.0**		1.1	12.2	16.6	**10.0**	
6	0.0	3.3	6.6	**3.3**		0.0	2.2	4.4	**2.2**	
7	0.0	3.3	3.3	**2.2**		0.0	3.3	7.8	**3.7**	
8	0.0	0.0	3.3	**1.1**		0.0	0.0	4.4	**1.1**	
9	13.3	26.7	37.3	**25.8**		17.8	24.4	28.9	**23.2**	
Mean	**2.6**	**6.8**	**11.1**			**2.5**	**8.0**	**11.3**		

**Not statistically analyses

(1) Perforated polypropylene bags.*
(2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min.
(4) Hot-water dips at 43°C/20 min.
(5) 38°C/30min +Treat. (1).
(6) 38°C/30min +Treat. (2).
(7) 43°C/20min +Treat. (1).
(8) 43°C/20min +Treat. (2).
(9) Control

Data in Table (3) indicate that decay percentage started slowly and increased at the end of storage. This finding may be due to the continuous chemical and biochemical changes happened in the fruits such as transformation of complex compounds to simple forms of a more liability to fungal infection. These results are similar to those found by Abd El-Rahman (2001) on cucumber.

The interaction between treatments and storage period was significant during storage and shelf life condition, where fruit immersion in hot water at 43°C for 20 min. and packed in NPPB did not show any decay till the 9th day at 5°C + 2 days at 20°C.

Chilling injury (CI):

Dipping in hot water at 43°C for 20 min and or packaging in perforated or non perforated polypropylene bags significantly decreased chilling injury symptoms (Table 4). On the contrary, untreated fruits control was suffered from higher CI symptoms.

The symptoms first appeared as numerous tiny pits then advanced to large sunken spots and scattered water soaked area. These symptoms progressed rapidly in untreated fruits control with increasing duration of storage. Symptoms became more pronounced after the fruits were transferred from 5 °C to 20 °C.

Fruits from hot water treatment (43°C for 20 min) and packaging in perforated or non perforated polypropylene bags did not exhibit any sign of CI during storage at 5°C or after 2 days at 20°C.

Chilling stress induced increases in putrescence levels in cucumber fruits which were packed in perforated or sealed polyethylene bags. Moreover, the sealed bag had the higher levels of putrescence, while perforated bags had higher content of spermidine than non wrapped fruits (Wang and Qi, 1997). Also, Mirdehghan *et al.* (2007) found that heat treatment which showed beneficial effect in alleviating chilling injury on pomegranate were accompanied by increasing in polyamines concentration (putrescine, spermiddine and spermine), they proposed particular role for endogenous polyamines in increasing fruit tolerance to cold

High polyamine levels have been correlated with increasing chilling resistance, so it has been hypothesized that polyamine may protect the integrity of membranes which in turn alleviates chilling injury (Wang and Qi, 1997).

Fruit firmness:

Data presented in Table (5) show that various applied treatments had significantly greater fruit firmness as compared with untreated fruit control. However, the highest value of fruits firmness were obtained from cucumber fruits packing in non perforated polypropylene bags (NPPB) followed by combination of hot water treatment at 43°C for 20 min. with subsequent packing in NPPB during storage at 5°C or shelf life condition at 20°C.

Moreover, significant reduction in fruit firmness had occurred by prolongation of the storage period (Abd El-Rahman, 2001).

The postharvest storage of fruit is accompanied by loss of cell wall integrity due to breakdown of peptic substances, which led to an increase in soluble pectin and decrease in fruit firmness (Mirdehghan *et al.*, 2007).

The interaction between various treatments and storage period was significant in the two seasons. In this concern, cucumber fruits packed in "NPPB" or dipped in hot water at 43°C for 20 min. and packed in "NPPB" deleted the rate of softening during the first 6th days of storage at 5°C and the decrease became more pronounced as the storage progressed.

The mechanism by which pre- storage heating may affect the cell wall structure and thus maintain fruit firmness could be explained by Conway *et al.* (1994) on apples, possibly that heat treatment would activate endogenous Ca form calcium-pectat from low methoxyl pectin generated by the activation of pectin esterase by heat and thus delaying the action of cell wall degrading enzymes. Recently, heat treated strawberry (45°C for

3h) showed delay in softening by reduction of endo-1,4 B-D glucanase, B-xylosidase poly-galactoronase and B-glactosidase activities, while pictinmethyl esterase activity was enhanced (Vicente *et al.*, 2006). This broad effect of heat treatments on cell wall degrading enzymes could slow down pectin solubilisation by reducing pectin cleavage and by increasing the amount of putative sites for calcium bridge formation in the cell wall.

Table (4): Effect of hot water treatment, modified atmosphere packaging and storage period on chilling injury of cucumber fruit during storage at 5°C and additional 2 days at 20°C (storage and marketing simulation).

Treatments*	2007						2008					
	Storage period (days)						Storage period (days)					
	At harvest	3 days	6 days	9 days	12 days	Mean	At harvest	3 days	6 days	9 days	12 days	Mean
1	1.0	1.0	1.0	2.0	3.0	**1.6**	1.0	1.0	1.0	1.0	2.0	**1.2**
2	1.0	1.0	1.0	1.0	2.0	**1.2**	1.0	1.0	1.0	1.0	1.0	**1.0**
3	1.0	1.0	2.0	3.0	4.0	**2.2**	1.0	1.0	1.0	2.0	3.0	**1.6**
4	1.0	1.0	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	1.0	2.0	**1.2**
5	1.0	1.0	1.0	2.0	3.0	**1.6**	1.0	1.0	1.0	1.0	2.0	**1.2**
6	1.0	1.0	1.0	1.0	2.0	**1.2**	1.0	1.0	1.0	1.0	2.0	**1.2**
7	1.0	1.0	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	1.0	1.0	**1.0**
8	1.0	1.0	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	1.0	1.0	**1.0**
9	1.0	1.0	2.0	3.0	4.0	**2.2**	1.0	1.0	2.0	3.0	4.0	**2.2**
Mean	**0.9**	**1.0**	**1.2**	**1.7**	**2.3**		**1.0**	**1.0**	**1.1**	**1.3**	**2.0**	
L.S.D. at 0.05%												
Treatments(T)				**0.1**						**0.1**		
Storage period(SP)				**0.1**						**0.2**		
(T * SP)				**0.2**						**0.3**		

	Shelf life							
	6 days at 5°C+2 day at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean	6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean
1	1.0	3.0	4.0	**2.7**	1.0	1.0	3.0	**1.7**
2	1.0	2.0	2.0	**1.7**	1.0	1.0	2.0	**1.3**
3	3.0	3.0	5.0	**3.7**	1.0	3.0	4.0	**2.7**
4	1.0	1.0	2.0	**1.3**	1.0	1.0	3.0	**1.7**
5	1.0	2.0	4.0	**2.3**	1.0	1.0	3.0	**1.7**
6	1.0	1.0	3.0	**1.7**	1.0	1.0	1.0	**1.0**
7	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	**1.0**
8	1.0	1.0	1.0	**1.0**	1.0	1.0	1.0	**1.0**
9	3.0	4.0	5.0	**4.0**	3.0	4.0	5.0	**4.0**
Mean	**1.4**	**2.0**	**3.0**		**1.2**	**1.6**	**2.6**	
L.S.D. at 0.05%								
Treatments(T)			**0.2**				**0.2**	
Storage period(SP)			**0.3**				**0.3**	
(T * SP)			**0.4**				**0.3**	

(1) Perforated polypropylene bags.*
(2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min.
(4) Hot-water dips at 43°C/20 min.
(5) 38°C/30 min +Treat. (1).
(6) 38°C/30 min +Treat. (2).
(7) 43°C/20 min +Treat. (1).
(8) 43°C/20 min +Treat. (2).
(9) Control

Table (5): Effect of hot water treatment, modified atmosphere packaging and storage period on firmness of cucumber fruit (pound/inch)^2 during storage at 5°C and additional 2 days at 20°C (storage and marketing simulation).

Treatments*	2007						2008					
	Storage period (days)						Storage period (days)					
	At harvest	3 days	6 days	9 days	12 days	Mean	At harvest	3 days	6 days	9 days	12 days	Mean
1	67.7	66.4	65.7	62.8	59.7	**64.5**	71.8	70.4	69.9	66.5	63.3	**68.4**
2	67.7	67.0	66.5	63.8	61.0	**65.2**	71.8	71.0	71.0	67.2	64.7	**69.1**
3	67.7	65.8	64.5	61.0	57.5	**63.3**	71.8	69.7	68.4	65.3	61.8	**67.4**
4	67.7	65.4	64.1	60.6	57.1	**63.0**	71.8	69.2	68.1	65.0	60.5	**66.9**
5	67.7	66.7	66.0	63.1	60.0	**64.7**	71.8	70.6	69.3	66.5	63.7	**68.4**
6	67.7	66.5	66.0	63.3	60.5	**64.8**	71.8	71.2	69.0	67.1	64.2	**68.7**
7	67.7	66.0	65.3	62.4	59.3	**64.0**	71.8	70.3	68.7	65.2	62.7	**67.7**
8	67.7	66.3	65.8	63.1	60.3	**65.0**	71.8	71.2	69.1	66.3	63.6	**68.4**
9	67.7	64.6	60.8	57.6	53.1	**61.8**	71.8	68.7	67.5	63.1	59.3	**66.1**
Mean	**67.7**	**66.1**	**65.5**	**62.0**	**58.7**		**71.8**	**70.3**	**69.0**	**65.8**	**62.6**	
L.S.D. at 0.05%												
Treatments(T)				**0.7**					**0.5**			
Storage period(SP)				**0.8**					**0.7**			
(T * SP)				**1.2**					**1.1**			
Shelf life												
	6 days at 5°C+2 day at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean			6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean		
1	63.1	60.9	58.6	**60.9**			66.4	64.3	61.8	**64.2**		
2	64.0	62.1	60.1	**62.1**			67.0	65.7	62.4	**65.0**		
3	61.2	58.5	56.0	**58.6**			64.9	63.0	60.3	**62.7**		
4	60.7	58.1	55.6	**58.1**			65.0	62.2	58.1	**61.8**		
5	63.4	61.0	58.9	**61.1**			66.5	64.7	62.4	**64.5**		
6	63.5	61.6	59.6	**61.6**			67.1	65.2	62.7	**65.0**		
7	61.7	60.5	58.2	**60.1**			66.2	64.7	62.2	**64.4**		
8	63.3	61.4	59.4	**61.4**			66.4	64.5	62.1	**64.3**		
9	57.5	54.2	50.6	**54.1**			64.3	60.3	56.9	**60.5**		
Mean	**62.0**	**59.8**	**57.5**	**59.8**			**66.0**	**63.8**	**61.0**	**63.6**		
L.S.D. at 0.05%												
Treatments(T)				**0.8**					**1.0**			
Storage period(SP)				**1.4**					**1.5**			
(T * SP)				**1.3**					**1.6**			

(1) Perforated polypropylene bags.* (2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min. (4) Hot-water dips at 43°C/20 min.
(5) 38°C/30min +Treat. (1). (6) 38°C/30min +Treat. (2).
(7) 43°C/20min +Treat. (1). (8) 43°C/20min +Treat. (2).
(9) Control

Total soluble solids (TSS)

Data in Table (6) reveal that there were no significant differences among treatments used.

Total soluble solids of cucumber fruits were significantly increased with prolongation of storage period until 9 day of storage at 5°C, and then they began to decrease as the storage period prolongation.

The increase in TSS in the first period of storage might owe much to the higher rate moisture loss through transpiration than the rate of dry matter loss through respiration. Also, the reduction in TSS during storage might owe much to the higher rate of sugar loss through respiration than water loss through transpiration (Wills *et al.*, 1981).

Interaction effect between applied treatments and storage period was insignificant during cold storage and shelf life condition.

Total chlorophyll content:

Data in Table (7) show that immersion of cucumber fruit in 43°C water for 20 min. then packing in "NPPB" retained more chlorophyll contents followed by fruits packed in "NPPB" compared to untreated fruits control.

Chlorophyll content in cucumber fruits decreased gradually with the prolongation of storage period. This decrement in chlorophyll content could be attributed to the gradually destruction by chlorophyllase activity and transformation of chloroplasts to chromoplasts. These results agree with those obtained by El- Sheikh and El-Doweny., (1997) and Abd El-Rahman, (2001).

These results were true during storage at 5°C and shelf life condition at 20°C and hot water treatments may be inhibited chlorophyllase enzyme (Kazami *et al.*, 1991 a).

The interaction among various treatments and storage periods appeared significant in both seasons. So, immersion of cucumber fruit in 43°C water for 20min, with subsequent packing in "NPPB" had higher chlorophyll content after 12 days of cold storage at 5°C or after shelf life condition at 20°C. The combined mechanism by which hot water treatment and modified atmosphere inhibit color development more than that of their individual effects can be explained as was reported by Ali *et al.*, (2004) on cherry tomato. They could suppose that this may be a substantial effect that results from the combination of HWT and lower O_2.

For individual effects, Goodwin and Jamikon (1952) reported that lycopene pigment in tomato fruits is inhibited by heat stress. On the other hand, comparatively lower O_2 (12.5 k Pa) modified atmosphere might be the cause, at least in part for color delay. Delayed ripening and extended postharvest life has been observed in tomatoes inside polyethylene film (Hobson, 1980).

Salunkhe and Wu (1973) found that the degradation of chlorophyll and biosynthesis of lycopene from mature green tomatoes was completely inhibited for 1 month under 1.2 k Pa and 10days under 10.2 k Pa O_2 atmosphere. For the CO_2 effects, Thompson (1998) showed that higher CO_2 atmosphere did not by themselves inhibit the color development of tomato fruit, unless the atmosphere were 9.1 k Pa or more. They therefore suppose that the modified O_2 might be the dominant factor and/or 3.4-3.7 K Pa CO_2 had no effect on the color development of cherry tomatoes in the films. The combination of lower O_2 in MAP and HWT may affect the color development of cherry tomato in several ways = (a) (HWT) may partially inhibit the color development and lower O_2 becomes established more strongly and completely;(b) lower O_2 may be favored after heat treatment and (c) the combination with lower O_2 and HWT may provide an extra effect.

Table (6): Effect of hot water treatment, modified atmosphere packaging and storage period on T.S.S (%) of cucumber fruit during storage at 5°C and additional 2 days at 20°C (storage and marketing simulation).

Treatments*	2007						2008					
	Storage period (days)						Storage period (days)					
	At harvest	3 days	6 days	9 days	12 days	Mean	At harvest	3 days	6 days	9 days	12 days	Mean
1	4.3	4.4	4.4	4.5	4.4	**4.4**	3.9	3.9	3.9	4.2	3.9	**4.0**
2	4.3	4.3	4.3	4.4	4.3	**4.3**	3.9	3.9	3.9	3.9	3.9	**3.9**
3	4.3	4.4	4.5	4.7	4.2	**4.4**	3.9	4.2	4.4	4.1	4.0	**4.1**
4	4.3	4.4	4.4	4.5	4.3	**4.4**	3.9	4.3	4.3	4.2	4.0	**4.1**
5	4.3	4.4	4.4	4.5	4.4	**4.4**	3.9	4.0	4.1	4.3	4.1	**4.1**
6	4.3	4.3	4.3	4.4	4.3	**4.3**	3.9	3.9	3.9	3.9	3.9	**3.9**
7	4.3	4.4	4.4	4.5	4.4	**4.4**	3.9	4.0	4.1	4.3	4.1	**4.1**
8	4.3	4.3	4.4	4.4	4.3	**4.3**	3.9	3.9	3.9	4.0	4.0	**3.9**
9	4.3	4.4	4.4	4.5	4.4	**4.4**	3.9	4.2	4.3	4.1	3.5	**4.0**
Mean	**4.3**	**4.3**	**4.4**	**4.5**	**4.3**		**3.9**	**4.0**	**4.1**	**4.1**	**3.9**	
L.S.D. at 0.05%												
Treatments(T)				**N.S**						**N.S**		
Storage period(SP)				**N.S**						**N.S**		
(T * SP)				**N.S**						**N.S**		
	Shelf life											
	6 days at 5°C+2 day at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean			6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean		
1	4.2	4.1	3.9	**4.1**			3.7	3.9	3.5	**3.7**		
2	4.1	4.0	3.9	**4.0**			3.7	3.6	3.5	**3.6**		
3	4.2	4.3	3.8	**4.1**			4.4	3.8	3.6	**3.9**		
4	4.2	4.2	3.9	**4.1**			4.3	3.9	3.6	**3.9**		
5	4.2	4.1	3.9	**4.1**			3.9	3.9	3.7	**3.8**		
6	4.2	4.0	3.9	**4.0**			3.7	3.6	3.4	**3.6**		
7	4.2	4.1	3.9	**4.1**			3.9	3.9	3.6	**3.8**		
8	4.1	4.0	3.8	**3.9**			3.7	3.6	3.6	**3.4**		
9	4.2	4.2	4.0	**4.1**			4.1	3.8	3.1	**3.6**		
Mean	**4.2**	**4.1**	**3.9**				**3.9**	**3.8**	**3.5**			
L.S.D. at 0.05%												
Treatments(T)			**N.S**						**N.S**			
Storage period(SP)			**N.S**						**N.S**			
(T * SP)			**N.S**						**N.S**			

(1) Perforated polypropylene bags.* (2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min. (4) Hot-water dips at 43°C/20 min.
(5) 38°C/30min +Treat. (1). (6) 38°C/30min +Treat. (2).
(7) 43°C/20min +Treat. (1). (8) 43°C/20min +Treat. (2).
(9) Control

Table (7): Effect of hot water treatment, modified atmosphere packaging and storage period on total chlorophyll (reading) of cucumber fruit during storage at 5°C and additional 2days at 20°C (storage and marketing simulation).

Treatments*	2007						2008					
	Storage period (days)						Storage period (days)					
	At harvest	3 days	6 days	9 days	12 days	Mean	At harvest	3 days	6 days	9 days	12 days	Mean
1	53.6	53.0	51.7	50.0	48.8	**51.4**	58.8	56.7	55.7	54.1	52.1	**55.5**
2	53.6	53.6	52.1	51.1	50.1	**52.1**	58.8	57.3	56.5	54.4	52.8	**56.0**
3	53.6	52.7	51.7	50.1	48.9	**51.4**	58.8	55.0	55.7	54.5	52.8	**55.4**
4	53.6	53.2	52.0	51.0	50.2	**52.0**	58.8	56.1	55.4	54.1	53.2	**55.5**
5	53.6	52.9	51.7	50.1	48.2	**51.3**	58.8	56.8	55.8	54.7	52.8	**55.8**
6	53.6	53.0	52.3	51.4	50.3	**52.1**	58.8	57.5	56.0	54.1	52.6	**55.8**
7	53.6	53.1	51.9	50.5	48.3	**51.5**	58.8	57.1	55.8	54.9	53.0	**55.9**
8	53.6	53.6	52.4	51.7	50.5	**52.3**	58.8	57.8	56.5	54.7	53.1	**56.2**
9	53.6	51.5	49.7	47.2	45.6	**49.5**	58.8	56.0	54.7	52.8	51.3	**54.7**
Mean	**53.6**	**52.9**	**51.7**	**50.3**	**49.0**		**58.8**	**56.7**	**55.8**	**54.3**	**52.6**	
L.S.D. at 0.05%												
Treatments(T)			**0.1**						**0.1**			
Storage period(SP)			**0.7**						**0.4**			
(T * SP)			**1.2**						**1.4**			

	Shelf life							
	6 days at 5°C+2 day at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean	6 days at 5°C+2 days at 20°C	9 days at 5°C+2 days at 20°C	12 days at 5°C+2 days at 20°C	Mean
1	49.2	47.5	46.3	**47.7**	50.2	47.6	46.1	**48.0**
2	50.6	49.5	48.5	**49.5**	51.0	46.8	41.4	**46.4**
3	49.1	47.5	46.3	**47.6**	49.8	46.6	44.3	**46.9**
4	49.3	48.3	47.5	**48.4**	49.1	45.2	43.4	**45.9**
5	49.2	47.6	45.7	**47.5**	50.9	45.2	42.1	**46.1**
6	50.7	49.8	48.8	**49.8**	51.3	48.5	44.5	**48.1**
7	49.4	48.0	45.8	**47.7**	50.2	46.1	42.6	**46.3**
8	50.8	50.1	48.9	**49.9**	50.7	45.5	41.1	**45.8**
9	46.6	44.1	42.5	**44.4**	49.3	46.3	43.4	**46.3**
Mean	**49.4**	**48.1**	**46.7**		**50.3**	**46.4**	**43.2**	
L.S.D. at 0.05%								
Treatments(T)			**0.5**				**0.3**	
Storage period(SP)			**0.6**				**0.4**	
(T * SP)			**1.1**				**1.6**	

(1) Perforated polypropylene bags.* (2) Non-Perforated polypropylene bags
(3) Hot-water dips at 38°C/30 min. (4) Hot-water dips at 43°C/20 min.
(5) 38°C/30min +Treat. (1). (6) 38°C/30min +Treat. (2).
(7) 43°C/20min +Treat. (1). (8) 43°C/20min +Treat. (2).
(9) Control

CONCLUSION

Cucumber fruits immersed in hot water at 43°C for 20 min. and then packed in NPPB could be stored for 9 days at 5°C + 2 days at 20°C with good appearance and without decay and chilling injury symptoms.

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*تأثير الماء الساخن والجو الهوائى المعدل وفترات التخزين على تقليل ضرر البرودة فى ثمار الخيار

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أجريت هذه الدراسة فى محطة بحوث الخضر بقها. محافظة القليوبية خلال موسمى ٢٠٠٧ – ٢٠٠٨ لدراسة تأثير استخدام الماء الساخن والتعبئة فى جو هوائى معدل على جودة ثمار الخيار وأضرار البرودة للصنف بيتا الفا أثناء التخزين المبرد على درجة ٥°م والعرض بالاسواق على درجة ٢٠° م أدت المعاملة بالماء الساخن ٤٣° م لمدة ٢٠ دقيقة والتعبئة فى أكياس بولى بروبلين مثقب وغير مثقب إلى عدم ظهور أى علامات لأضرار البرودة أثناء التخزين المبرد على درجة ٥ ° م لمدة ١٢ يوما بالإضافة إلى يومين على درجة ٢٠° م .

أدى غمس ثمار الخيار فى الماء الساخن على درجة حرارة ٤٣° م لمدة ٢٠ دقيقة ثم التعبئة فى أكياس بولى بروبلين غير مثقب إلى المحافظة على صلابة الثمار، وتأخير فقد الكلوروفيل وتقليل التالف أثناء التخزين والعرض بالأسواق. كما أدى تعبئة ثمار الخيار فى أكياس بولى بروبلين مثقب أو غير مثقب وغمس الثمار فى الماء الساخن على درجة ٤٣° م لمدة ٢٠ دقيقة منفرداً أو مع التعبئة فى أكياس مثقبة أو غير مثقبة لم تظهر بها أي تغير فى المظهر العام للثمار حتى ٦ أيام من التخزين على درجة ٥° م كما أعطت نفس المعاملات مظهر جيد للثمار بعد٩ أيام من التخزين على درجة ٥° م + ٢ يوم على درجة ٢٠° م . بينما كان مظهر الثمار غير مقبول عند المعاملة بالماء الساخن على درجة ٣٨° م لمدة ٣٠ دقيقة ومعاملة الكنترول لنفس فترة التخزين .

* مشروع تطوير معاملات ما بعد الحصاد للمحاصيل التصديرية