J. Plant Production, Mansoura Univ., Vol. 3 (7): 2139 - 2151, 2012

EFFECT OF ACTIVE AND PASSIVE MODIFIED ATMOSPHERE PACKAGING ON QUALITY ATTRIBUTES OF BROCCOLI FLORETS

Mohamed, M. E.[1] ; M. E. Ragab[2] ; S. M. El-miniawy[2] and Rawia E. I. El-Bassiouny[1]

1-Postharvest and Handling of Vegetable Crops Dept., Hort. Res. Inst., Agric. Res. Center, Dokki, Giza, Egypt.

2- Dept. of Horticulture, Fac. of Agric., Ain Shams Univ., Shoubra El-Kheima, Cairo, Egypt.

ABSTRACT

The experiment was carried out during the two seasons of 2008 and 2009 on broccoli F_1 Hybrid Sakura to study the effect of two packaging materials and modified atmosphere packaging (MAP) on quality attributes of broccoli florets stored at 0°C and 95% RH for 16 days.

Broccoli florets packed in polypropylene film showed the highest intensities of freshness, greenness, and compactness and had less off-odor as compared with those stored in polyethylene bags. There were no differences in weight loss between broccoli florets stored in the different packaging materials.

Florets packed in active MAP retained their weight during storage as compared to those in passive MAP. The optimum gas composition of MAP tests for maintaining quality of broccoli florets during storage was 5% O_2 + 10% Co_2.

Off-odor was not observed in broccoli florets packed in polypropylene film and exposed to 5% O_2 + 5% Co_2, while at 5% O_2 + 10% Co_2 gave a slight off-odor at the end of storage with non significant differences between them.

Packing broccoli florets packed in polypropylene film and exposing to active MAP (5% O_2 + 10% Co_2) was the most effective treatment for reducing weight loss and color change and maintaining high content of chlorophyll and gave florets with good appearance for 16 days at 0°C and 95% RH.

INTRODUCTION

Broccoli has a relatively high respiration and transpiration rates and a short shelf life it is also, extremely sensitive to ethylene and loss water rapidly (Brennan and Shewfelt, 1989). The shelf life of florets was 1-3 days at 20 °C (Wang and Hruschka, 1977). Refrigeration is the primary means that maintaining broccoli in good condition for 3 weeks of storage when held at 0-2 °C (Ryall and Lipton, 1979). In addition to refrigeration, modified atmosphere packaging (MAP) is commonly used to maintain the quality and improve the shelf life of broccoli florets (Charles *et al*., 1991).The MAP of broccoli at elevated Co_2 and reduced O_2 levels has been shown to retard deterioration , i.e. yellowing and softening , and preserve the market quality of broccoli during storage (Barth *et al*., 1993, Elkashif *et al*., 1993 and Jacobsson *et al*., 2004) The low O_2 and high Co_2 levels that are modified through the product's respiration and the permeability of the film slow down

This research was supported by Development of Postharvest Treatments Project.

respiration and have an effect on inhibiting microbial growth in MAP (Hu *et al*., 2007). Broccoli can be stored at 1 to 2% O_2 and 5 to 10% Co_2 atmospheres at low temperatures (Jacobsson *et al*., 2003). However, a low oxygen level (0.5-2 %) or carbon dioxide concentration in excess of 10 %, combined with temperature fluctuations, may results in the production of off-odors, thus reducing the shelf life of the broccoli (Ballantyne *et al.,* 1988 and Makhlouf *et al*., 1989).

The main benefit, however, of using MAP is to inhibit decay and generation of C_2H_4 because it can influence the enzymes activity, thus the permeability of cell membranes does not increase quickly (Ballantyne *et al*., 1988). Furthermore MAP can prevent microbial growth, discoloration and cell destruction and can reduce the risk of infection (Barth *et al*., 1993)

The objective of this present work was to evaluate the potential of active and passive modified atmosphere packaging in preserving the quality and extend the shelf life of broccoli florets during storage at 0°C.

MATERIALS AND METHODS

Seeds of broccoli **(***Brassica Oleracea var.* italica) F_1 Hybrid Sakura (seeds from Tokita Co, Japan) were sown at the nursery in transplanting trays on September 5th and 8th 2009 and 2010 respectively. The transplants were set up in the field on October 4th and 8th in the first and the second seasons, respectively, at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University. The soil was loamy clay. The agriculture practices took place wherever necessary according to the recommendations of Ministry of Agriculture.

Broccoli heads were harvested at the proper stage of marketing on 2nd and 5th of December 2009 and 2010, respectively, and then transported immediately to the laboratory of postharvest center, Horticulture Research Institute, Giza. Heads were separated to florets which were rinsed in chlorinated water (1000 ppm as sodium hypo chloride) for 10 min.

Two commercially available polymeric films/ bags were used as packaging materials. The investigated polymer materials were polypropylene and polyethylene (15x20 cm) of 40 µm thickness. Broccoli florets were packaged, each package contained 200 grams as one replicate. The packages were all heat sealed and treated as follows:

1- Passive MAP (A)
2- Flushed with a gas mixture (active MAP) 5 %O_2 + 5 %$C0_2$ (B)
3- Flushed with a gas mixture (active MAP) 5 %O_2 +10%$C0_2$ (C)

Twenty four replicate were prepared for each treatment. The samples were arranged in a complete randomized design and stored at 0°C and 95 % R.H. for 16 days. The treatments were examined immediately after harvest and every 4 days intervals for and the following parameters were determined:

1) Weight loss percentage.
2) General appearance (GA):

GA was determined according to the following score system: 9= excellent, 7= good, 5= fair, 3= poor and 1= unusable. The scale depends on morphological

defects such as shriveling fresh appearance, color change of florets and decay. Florets rating (5) or below considered unmarketable.

3) Off odor:

Off odor was evaluated on a scale of 1 to 5 where 1= none,2= slight, 3= moderate, 4= sever and 5= extremely sever.

4) External surface color:

Color was evaluated by a color difference meter (Minolta CR400) to measure the L and hue angle value.

5) Total chlorophyll:

Total chlorophyll was determined according to A.O.A.C. (1990).

6) Gas composition inside the packages: the concentration of O_2 and Co_2 inside the packages were monitored using Dual Trak model 902 D gas analyzer and expressed by percentage. By inserting the test probe through a rubber seal attached to the outside of the packaging.

All obtained data were statically analyzed according to the method described by Snedecor and Cochran (980).

RESULTS AND DISCUSSION

Weight loss:

Data in Table (1) show that weight loss percentage of broccoli florets increased considerably and consistently with the prolongation of storage period. The loss in weight may be attributed to respiration and other senescence related metabolic processes during storage (Charles *et al*., 1991).

As to packaging material, no significant differences were found in weight loss percentage between polypropylene and polyethylene packages. However, there were significant differences among MAP treatments. Broccoli florets held in active MAP retained their weight during storage as compared with passive MAP. Moreover, active MAP of 5% O_2 + 10% Co_2 resulted in prominent reduction in weight loss percentage. Joseph and Mishael (1992) found that reducing 0_2 concentration to 2% and increasing Co_2 to 5% resulted in more than 10 fold decline in the rate respiration and reduce sensitivity of ethylene of broccoli which diminished the weight loss in the florets during storage (Jacobsson and Nielsen, 2003).

As for the interaction between packaging materials, MAP treatments and storage period, data in Table (1) show that broccoli florets packed in polypropylene or polyethylene bags with active MAP at 5% O_2 + 10% Co_2 had the lowest weight loss percent during all storage period.

Table(1): Effect of active and passive modified atmosphere packages (MAP) on weight loss percentage of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)				
		4	8	12	16	Mean
		2009 season				
	A	0.12 E-H	0.16 EF	0.24 C	0.55 A	**0.27 A**
Polyethylene	B	0.1 G-J	0.12 F-H	0.17 DE	0.40 B	**0.20 B**
	C	0.08 J	0.09 H-J	0.12 F-H	0.25 C	**0.14 C**
	Mean	**0.10 E**	**0.12 D**	**0.18 C**	**0.40 A**	**0.20 A**
	A	0.11 FG-I	0.15 E-G	0.22 CD	0.51 A	**0.25 A**
Polypropylene	B	0.09 H-J	0.11 FG-I	0.16 EF	0.36 B	**0.18 B**
	C	0.07 IJ	0.09 H-J	0.13 E-H	0.23 C	**0.13C**
	Mean	**0.09 E**	**0.12 DE**	**0.17 C**	**0.37 B**	**0.19 A**
	A	0.12 EF	0.16 DE	0.23 C	0.53 A	**0.26 A**
Mean	B	0.10 FG	0.12 F	0.17 D	0.38 B	**0.19 B**
of (MAP)	C	0.08 G	0.09 FG	0.13 EF	0.24 C	**0.13 C**
	Mean	**0.10 D**	**0.12 C**	**0.17 B**	**0.38 A**	
		2010 season				
	A	0.14 F-J	0.17 E-I	0.27 D	0.60 A	**0.30 A**
Polyethylene	B	0.10 IJ	0.14 F-J	0.19 E-G	0.40 C	**0.21 B**
	C	0.08 J	0.11 H-J	0.14 F-J	0.22 DE	**0.14 C**
	Mean	**0.11 D**	**0.14 D**	**0.20 C**	**0.41 A**	**0.21 A**
	A	0.13 G-J	0.17 E-I	0.22 DE	0.52 B	**0.26 A**
Polypropylene	B	0.11 I	0.13 G-J	0.18 E-H	0.35 C	**0.19 B**
	C	0.08 J	0.10 IJ	0.15 F-J	0.20 D-F	**0.13 C**
	Mean	**0.11 D**	**0.13 CD**	**0.18 C**	**0.36 B**	**0.20 A**
	A	0.14 E-G	0.17 D-F	0.25 C	0.56 A	**0.28 A**
Mean	B	0.11 GH	0.14 F-H	0.19 DE	0.38 B	**0.20 B**
of (MAP)	C	0.08 H	0.11 GH	0.15 E-G	0.21 CD	**0.14 C**
	Mean	**0.11 C**	**0.14 C**	**0.19 B**	**0.38 A**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

General appearance:

Data in Table (2) show that general appearance (GA) of broccoli florets decreased with the prolongation of storage period. Similar results were reported by Jacobsson *et al.* (2004). The decrease of GA during storage period might be due to shrivelling, color change and less compact (Forney and Rij, 1991).

Significant differences in appearance were found between the two packaging materials on the broccoli. Broccoli florets stored in polypropylene bags were perceived the higher intensities of freshness, greenness and compactness as compared with those stored in polyethylene bags.

Concerning MAP effect the general appearance of broccoli florets exposed to active MAP was better than passive MAP. Active MAP for 5% O_2 + 10% Co_2 showed the best appearance because it does not exhibit any changes in their appearance till the 12^{th} days at 0^oC and gave product with good appearance at the end of storage (16 days). While using 5% O_2 + 5%

Co_2 rated good appearance after 12 days from storage. On the other hand, passive MAP rated excellent appearance after 4 days and dropped to poor appearance at the end of storage.

The interaction among packaging materials, MAP treatments and storage period revealed that broccoli florets packed in polypropylene or polyethylene film and exposed to active MAP at 5% O_2 + 10% Co_2 performed good appearance after 16 days of storage at 0°C.

Table(2): Effect of active and passive modified atmosphere packages (MAP) on general appearance(score) of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)				Mean	
		0	4	8	12	16	
		2009 season					
	A	9.00 A	9.00 A	6.33 DE	5.67 E	4.33 F	**6.87E**
Polyethylene	B	9.00 A	9.00 A	7.67 CD	7.00 DE	5.33 F	**7.6 CD**
	C	9.00 A	9.00 A	8.33 BC	7.67 CD	7.00 EF	**8.2 AB**
	Mean	**9.00 A**	**9.00 A**	**7.44 BC**	**6.78 CD**	**5.55 E**	**7.56 B**
	A	9.00 A	9.00 A	7.00 AB	6.33 BC	4.33 DE	**7.13 DE**
Polypropylene	B	9.00 A	9.00 A	8.33 AB	7.67 BC	6.33 CD	**8.07 BC**
	C	9.00 A	9.00 A	9.00 A	8.67 AB	7.67 BC	**8.67 A**
	Mean	**9.00 A**	**9.00 A**	**8.11 B**	**7.56 B**	**6.11 DE**	**7.96 A**
	A	9.00 A	9.00 A	6.67 DE	6.00 E	4.33 F	**7.00 C**
Mean	B	9.00 A	9.00 A	8.00 BC	7.34 CD	5.83 E	**7.83 B**
of (MAP)	C	9.00 A	9.00 A	8.67 AB	8.17 A-C	7.34 CD	**8.43 A**
	Mean	**9.00 A**	**9.00 A**	**7.78 B**	**7.17 C**	**5.83 D**	
		2010 season					
	A	9.00 A	9.00 A	5.67 EF	5.00 FG	4.33 G	**6.60 D**
Polyethylene	B	9.00 A	9.00 A	7.33 BCD	7.00 CD	6.33 DE	**7.73 B**
	C	9.00 A	9.00 A	8.33 AB	7.67 BC	7.00 CD	**8.20 AB**
	Mean	**9.00 A**	**9.00 A**	**7.11 CD**	**6.56 DE**	**5.89 F**	**7.51 B**
	A	9.00 A	9.00 A	7.00 CD	6.33 DE	4.33 G	**7.13 C**
Polypropylene	B	9.00 A	9.00 A	7.67 BC	7.00 CD	6.33 DE	**7.80 B**
	C	9.00 A	9.00 A	9.00 A	8.33 AB	7.33 B-D	**8.53 A**
	Mean	**9.00 A**	**9.00 A**	**7.89 B**	**7.22 C**	**6.00 G**	**7.82 A**
	A	9.00 A	9.00 A	6.34 EF	5.67 F	4.33 G	**6.87 C**
Mean	B	9.00 A	9.00 A	7.50 CD	7.00 DE	6.33 EF	**7.77 B**
of (MAP)	C	9.00 A	9.00 A	8.67 AB	8.00 BC	7.17 D	**8.37 A**
	Mean	**9.0 A**	**9.0 A**	**7.50 B**	**6.89 C**	**5.94 D**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Off-odor:

Data in Table (3) show that off-odor inside the different packaging materials started to be observed after 8 days of storage, and then increased till the end of storage period.

These strong off-odors have mainly been associated with sulphur volatile compound, for example, methanethiol, hydrogen sulphide, dimethyl disulphide

and dimethyl trisulphide (Hansen *et al*., 1992) However, off-odor was not observed in broccoli florets packed in polypropylene film and exposed to 5% O_2 + 5% Co_2, while those exposed to 5% O_2+ 10% Co_2 or passive MAP gave a slight off-odor at the end of storage. However, no significant differences were detected between both active MAP treatments Broccoli florets packed in polyethylene film with MAP gave the highest score of off-odor especially at 5% O_2 + 10% Co_2 after 16 days of storage. These results agree with those obtained by Hansen *et al*.(1993) who found that the off-odor developed when the storage atmosphere contained a high level of Co_2 in combination with very low O_2 concentration.

Table(3): Effect of active and passive modified atmosphere packages (MAP) on off-odor (score) of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	1.00 D	1.00 D	1.33 CD	1.67 CD	2.00 BC	**1.40 B**
Polyethylene	**B**	1.00 D	1.00 D	1.00 D	2.00 BC	3.67 A	**1.73 A**
	C	1.00 D	1.00 D	1.67 CD	2.67 B	3.67 A	**2.00 A**
	Mean	**1.00 D**	**1.00 D**	**1.33 CD**	**2.11 B**	**3.11 A**	**1.71 A**
	A	1.00 D	1.00 D	1.00 D	1.33 CD	1.67 CD	**1.20 BC**
Polypropylene	**B**	1.00 D	1.00 D	1.00 D	1.00 D	1.00 D	**1.00 C**
	C	1.00 D	1.00 D	1.00 D	1.00 D	1.67 CD	**1.13 BC**
	Mean	**1.00 D**	**1.00 D**	**1.00 D**	**1.11 CD**	**1.45 C**	**1.11 B**
	A	1.00 D	1.00 D	1.17 CD	1.50 BC	1.84 B	**1.30 B**
Mean	**B**	1.00 D	1.00 D	1.00 D	1.50 DC	2.34 A	**1.37 AB**
of (MAP)	**C**	1.00 D	1.00 D	1.34 CD	1.84 B	2.67 A	**1.57 A**
	Mean	**1.00 D**	**1.00 D**	**1.17 CD**	**1.61 B**	**2.28 A**	
		2010 season					
	A	1.00 F	1.00 F	1.67 D-F	2.00 C-E	2.33 CD	**1.60 BC**
Polyethylene	**B**	1.00 F	1.00 F	1.00 F	2.67 BC	3.33 AB	**1.80 AB**
	C	1.00 F	1.00 F	1.33 EF	2.67 BC	3.67 A	**1.93 A**
	Mean	**1.00 D**	**1.00 D**	**1.33 CD**	**2.45 B**	**3.11 A**	**1.78 A**
	A	1.00 F	1.00 F	1.00 F	1.67 D-F	2.00 C-E	**1.33 CD**
Polypropylene	**B**	1.00 F	1.00 F	1.00 F	1.00 F	1.00 F	**1.00 E**
	C	1.00 F	1.00 F	1.00 F	1.33 EF	1.67 D-F	**1.20 DE**
	Mean	**1.00 D**	**1.00 D**	**1.00 D**	**1.33 CD**	**1.56 C**	**1.18 B**
	A	1.00 C	1.00 C	1.34 C	1.84 B	2.17 B	**1.47 A**
Mean	**B**	1.00 C	1.00 C	1.00 C	1.84 B	2.17 B	**1.40 A**
of (MAP)	**C**	1.00 C	1.00 C	1.17 C	2.00 B	2.67 A	**1.57 A**
	Mean	**1.0 C**	**1.00 C**	**1.17 C**	**1.89 B**	**2.33 A**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Color:

The color of the homogenized samples was measured recording L value and hue angle. The L value is measure of the lightness of the florets, while the hue angle represents acoordinat in a standardized color space.

Changes in lightness (L) and hue angle (h^o) values were observed during storage compared to initial values (Table 4). Lightness of broccoli florets was affected by storage time. An increment in L value was detected during by prolonging the storage period. Broccoli backed in the two packaging material, in addition to active MAP at 5% O_2 + 10% Co_2 reduced this increases in L value and remained very close to the initial value during storage, resulted in darker color (lower L value). These results are in agreement with those obtained by Charles *et al*. (1991).

Table(4): Effect of active and passive modified atmosphere packages (MAP) on color (L.Value) of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	/ storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	41.00 N	41.58 H-M	42.47 DEF	43.67 B	45.73 A	**42.89 A**
Polyethylene	B	41.00 N	41.31 MN	41.93 F-K	42.15 E-H	42.85 D	**41.85 B**
	C	41.00 N	41.18 MN	41.60 H-M	41.88 G-L	42.23 E-G	**41.58 CD**
	Mean	**41.00 G**	**41.36 F**	**42.00 DE**	**42.57 C**	**43.60 A**	**42.11 A**
	A	41.00 N	41.44 J-N	42.61 DE	43.19 BC	45.26 A	**42.70 A**
Polypropylene	B	41.00 N	41.21 MN	41.53 I-N	42.03 F-I	42.48 DEF	**41.65 BC**
	C	41.00 N	41.07 MN	41.23 MN	41.40 K-N	42.00 F-J	**41.34 D**
	Mean	**41.00 G**	**41.24 FG**	**41.79 E**	**42.21 D**	**43.25 B**	**41.90 B**
	A	41.00 H	41.51 E-G	42.54 C	43.43 B	54.50 A	**42.80 A**
Mean	B	41.00 H	41.26 F-H	41.73 BE	42.09 D	42.67 C	**41.75 B**
of (MAP)	C	41.00 H	41.13 GH	41.42 EFG	41.64 EF	42.12 D	**41.46 C**
	Mean	**41.00 E**	**41.30 D**	**41.90 C**	**42.39 B**	**43.43 A**	
		2010 season					
	A	41.32 N	42.61 H-M	43.52 DE	44.72 B	46.87 A	**43.81 A**
Polyethylene	B	41.32 N	42.33 J-M	42.98 E-I	43.20 E-G	43.91 CD	**42.75 B**
	C	41.32 N	42.20 LM	42.64 G-M	42.91 F-J	43.25 E-G	**42.46 C**
	Mean	**41.32 G**	**42.38 F**	**43.05 DE**	**43.61 C**	**44.68 A**	**43.01 A**
	A	41.32 N	42.34 J-M	43.11 E-H	44.12 C	47.00 A	**43.58 A**
Polypropylene	B	41.32 N	42.23 K-M	42.74 F-L	43.07 E-H	43.20 E-G	**42.51 BC**
	C	41.32 N	42.10 M	42.44 I-M	42.30 KLM	42.81 F-K	**42.19 D**
	Mean	**41.32 G**	**42.22 F**	**42.76 E**	**43.16 D**	**44.34 B**	**42.76 B**
	A	41.32 I	42.48 FGH	43.32 CD	44.42 B	46.94 A	**43.69 A**
Mean	B	41.32 I	42.28 GH	42.86 EF	43.14 DE	43.56 C	**42.63 B**
of (MAP)	C	41.32 I	42.15 H	42.547 F-H	42.61 FG	43.03 DE	**42.33 C**
	Mean	**41.32 E**	**42.30 D**	**42.91 C**	**43.39 B**	**44.15 A**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Hue angle (h^o) gave the best indication of greenness. Data in Table (5) indicate that there was a decrease in hue angle value during storage, however, broccoli florets packed in polypropylene film were more green (higher hue angle value) as compared with polyethylene film. On the other hand, broccoli stored at passive MAP gave the lower value of hue angle as an

important degreening or intense yellowing compared to active MAP. In addition active MAP at 5% O_2 + 10% Co_2 did no show the same behavior and maintained high hue angle values during storage. The treatments that showed most retention of green color (high hue angle) were performed with broccoli florets packed in polypropylene film plus active MAP at 5%O_2 + 10% Co_2. These results agree with those obtained by Jacobsson and Nielsen (2003) who found that MAP maintain the quality and extend the shelf life of broccoli florets by delaying softening and color changes.

Table(5): Effect of active and passive modified atmosphere packages (MAP) on color (hue angle h^o) of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	125.22 A	121.24 EFC	116.12 KL	110.33 N	106.43 P	**115.87 E**
Polyethylene	B	125.22 A	123.24 CD	120.43 FG	117.04 K	115.30 LM	**120.25 C**
	C	125.22 A	123.90 B-D	122.15 E	119.43 HI	116.65 K	**121.47 B**
	Mean	**125.22 A**	**122.79 B**	**119.57 D**	**115.60 F**	**112.79 G**	**119.19 B**
	A	125.22 A	121.24 EF	118.75 IJ	114.65 M	109.03 0	**117.78 D**
Polypropylene	B	125.22 A	124.14 BC	122.15 E	119.72 GH	118.27 J	**121.90 B**
	C	125.22 A	125.22 AB	123.14 D	121.74 E	120.46 FG	**123.16 A**
	Mean	**125.22 A**	**123.53 B**	**121.35 C**	**118.70 E**	**115.92 F**	**120.94 A**
	A	125.22 A	121.24 DE	117.44 G	112.49 H	107.73 I	**116.82 C**
Mean	B	125.22 A	123.69 B	121.29 D	118.38 F	116.79 G	**121.07 B**
of (MAP)	C	125.22 A	124.56 B	122.65 C	120.59 E	118.56 F	**122.31 A**
	Mean	**125.22 A**	**123.16 B**	**120.46 C**	**117.15 D**	**114.36 E**	
		2010 season					
	A	123.24 A	118.73 EF	113.79 KL	108.11 N	104.30 P	**113.63 E**
Polyethylene	B	123.24 A	120.75 C	118.00 FG	114.68 K	112.98 LM	**117.93 C**
	C	123.24 A	121.42 BC	119.70 D	117.02 HI	114.33 K	**119.14 B**
	Mean	**123.24 A**	**120.30 B**	**117.16 D**	**113.27 F**	**110.54 G**	**116.90 B**
	A	123.24 A	118.82 DEF	116.35 IJ	112.33 M	106.83 0	**115.51 D**
Polypropylene	B	123.24 A	121.60 BC	119.70 D	117.33 GH	115.90 J	**119.55 B**
	C	123.24 A	121.73 B	120.66 C	119.31 DE	118.05 FG	**120.60 A**
	Mean	**123.24 A**	**120.72 B**	**118.90 C**	**116.32 E**	**113.59 F**	**118.56 A**
	A	123.24 A	118.78 DE	115.07 G	110.22 H	105.57 I	**114.57 C**
Mean	B	123.24 A	121.18 B	118.85 D	116.01 F	114.44 G	**118.74 B**
of (MAP)	C	123.24 A	121.58 B	120.18 C	118.17 E	116.19 F	**119.87 A**
	Mean	**123.24 A**	**120.51 B**	**118.03 C**	**114.80 D**	**112.07 E**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Total chlorophyll:

Data in Table (6) showed that chlorophyll content in broccoli florets decreased gradually during storage. This decrement could be attributed to the gradual increase of destruction by chlorophyll degrading peroxide (POD) activity which is t transformation of chloroplasts to chromplasts (Charles *et al*., 1991).

Concerning the effect of packaging materials, data revealed that the highest content of chlorophyll was obtained from broccoli florets packed in polypropylene film.

Table(6): Effect of active and passive modified atmosphere packages (MAP) on total chlorophyll(mg/100mg f.w) of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	103.25 A	100.08 D	96.75 G	93.29 J	89.24 M	**96.52 F**
Polyethylene	B	103.25 A	101.23 C	99.27 E	95.41 H	91.27 K	**98.09 D**
	C	103.25 A	101.98 B	101.10 C	97.43 F	94.35 I	**99.62 B**
	Mean	**103.25 A**	**101.10 C**	**99.04 E**	**95.38 G**	**91.63 I**	**98.08 B**
	A	103.25 A	100.24 D	97.42 F	95.19 H	90.37 L	**97.29 E**
Polypropylene	B	103.25 A	102.27 B	100.22 D	97.27 F	93.31 J	**99.26 C**
	C	103.25 A	102.14 B	101.26 C	99.4 E	97.32 F	**100.68 A**
	Mean	**103.25 A**	**101.55 B**	**99.63 D**	**97.39 F**	**93.67 H**	**99.08 A**
	A	103.25 A	100.16 E	97.09 H	94.24 K	89.81 M	**96.91 C**
Mean	B	103.25 A	101.75 C	99.75 F	96.34 I	92.29 L	**98.68 B**
of (MAP)	C	103.25 A	102.60 B	101.18 D	98.42 G	95.84 J	**100.15 A**
	Mean	**103.25 A**	**101.32 B**	**99.34 C**	**96.33 D**	**92.64 E**	
		2010 season					
	A	101.82 A	98.05 FG	95.30 J	92.39 M	89.24 0	**95.36 E**
Polyethylene	B	101.82 A	99.98 D	97.78 G	94.55 K	91.28 N	**97.08 C**
	C	101.82 A	100.73 C	99.59 DE	96.46 I	93.43 L	**98.41 B**
	Mean	**101.82 A**	**99.59 C**	**97.56 E**	**94.47 G**	**91.32 I**	**96.95 B**
	A	101.82 A	99.31 E	96.93 H	93.05 L	89.37 0	**96.10 D**
Polypropylene	B	101.82 A	101.33 B	99.72 D	96.12 I	93.31 L	**98.46 B**
	C	101.82 A	101.53 AB	100.73 C	98.28 F	96.37 I	**99.75 A**
	Mean	**101.82 A**	**100.72 B**	**99.13 D**	**95.82 F**	**93.02 H**	**98.10 A**
	A	101.82 A	98.68 E	96.12 G	92.72 J	89.31 L	**95.73 C**
Mean	B	101.82 A	100.66 C	98.75 E	95.34 H	92.30 K	**97.77 B**
of (MAP)	C	101.82 A	101.13 B	100.16 D	97.37 F	94.90 I	**99.08 A**
	Mean	**101.82 A**	**100.16 B**	**98.34 C**	**95.14 D**	**92.17 E**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Florets packed in active MAP retained more chlorophyll content compared with those of passive MAP which gave the lowest ones. The most important delay in chlorophyll degradation was observed in florets exposed to 5% O_2 + 10 Co_2.

The interaction of packaging material, MAP and storage period was significant after 16 days of storage. The lowest value of chlorophyll contents was noted in broccoli florets packed in polyethylene film plus passive MAP, while the highest one was found in broccoli packed in polypropylene film plus active MAP at 5% O_2 + 10% Co_2 during the same period.

Gas composition inside the packages:

Since broccoli is still alive after harvest it also respires. It is necessary to achieve proper gas composition in the packages, so it is very important to study the gas changes inside the package of MAP.

Moreover, the atmosphere analysis showed that, in two packages, the atmosphere had been modified (Tables 7&8). The O_2 and Co_2 inside the packages differed significantly between packaging materials. Broccoli florets packed in polyethylene film had low O_2 and high Co_2 as comported with those in polypropylene ones. The O_2 concentration was above the critical concentration (0.5-2.5%) for developing off-odor (Ballantyne *et al*., 1988; Makhlouf *et al*., 1989).

Table(7): Effect of active and passive modified atmosphere packages (MAP) on O_2 concentration inside the packages of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	20.80 A	19.00 C	15.45 E	12.37 F	10.00 G	**15.52 B**
Polyethylene	**B**	5.00 H	3.60 L	3.00 M	2.80 M	2.20 N	**3.32 E**
	C	5.00 H	4.60 HI	4.40 IJ	4.00 J-L	2.00 N	**4.00 D**
	Mean	**10.27 A**	**9.07 D**	**7.62 F**	**6.39 G**	**4.73 H**	**7.61 B**
	A	20.80 A	20.37 A	19.60 B	17.87 D	15.07 E	**18.74 A**
Polypropylene	**B**	5.00 H	4.63 HI	4.43 IJ	4.00 J-L	3.70 KL	**4.35 C**
	C	5.00 H	4.70 HI	4.60 HI	4.13 JK	3.93 KL	**4.47 C**
	Mean	**10.27 A**	**9.90 B**	**9.54 C**	**8.67 E**	**7.57 F**	**9.19 A**
	A	20.80 A	19.69 B	17.53 C	15.12 D	12.54 E	**17.13 A**
Mean	**B**	5.00 F	4.12 H	3.72 I	3.40 I	2.95 J	**3.84 C**
of (MAP)	**C**	5.00 F	4.65 G	4.50 G	4.07 H	2.97 J	**4.24 B**
	Mean	**10.27 A**	**9.48 B**	**8.58 C**	**7.53 D**	**6.15 E**	
		2010 season					
	A	20.80 A	18.83 D	14.50 F	11.30 G	10.20 H	**15.13 B**
Polyethylene	**B**	5.00 I	4.30 KL	4.13 L-N	3.57 0	2.10 P	**3.82 D**
	C	5.00 I	4.47 JKL	4.30 KL	3.70 0	1.87 P	**3.87 D**
	Mean	**10.27 A**	**9.20 C**	**7.64 E**	**6.19 G**	**4.72 H**	**7.60 B**
	A	20.80 A	20.20 B	19.30 C	17.17 E	14.70 F	**18.43 A**
Polypropylene	**B**	5.00 I	4.63 I-K	4.23 LM	3.77 N0	3.50 0	**4.23 C**
	C	5.00 I	4.70 IJ	4.37 J-L	3.87 M-0	3.73 0	**4.33 C**
	Mean	**10.27 A**	**9.84 B**	**9.30 C**	**8.27 D**	**7.31 F**	**9.00 A**
	A	20.80 A	19.52 B	16.90 C	14.24 D	12.45 E	**16.78 A**
Mean	**B**	5.00 F	4.47 G	4.18 H	3.67 I	2.80 J	**4.02 B**
of (MAP)	**C**	5.00 F	4.59 G	4.34 GH	3.79 I	2.80 J	**4.10 B**
	Mean	**10.27 A**	**9.52 B**	**8.47 C**	**7.23 D**	**6.02 E**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

Table(8): Effect of active and passive modified atmosphere packages (MAP) on Co_2 concentration inside the packages of broccoli florets during storage in 2009 and 2010 seasons.

Packaging materials	MAP	storage period (days)					Mean
		0	4	8	12	16	
		2009 season					
	A	0.03 T	2.20 R	3.57 Q	5.73 M	7.20 K	**3.75 E**
Polyethylene	B	5.00 N	6.00 M	10.00 I	12.07 E	15.27 C	**9.67 C**
	C	10.00 I	11.40 F	13.07 D	16.00 B	19.77 A	**14.05 A**
	Mean	**5.01 H**	**6.53 F**	**8.88 C**	**11.27 B**	**14.08 A**	**9.15 A**
	A	0.03 T	1.30 S	2.43 R	3.93 P	4.50 0	**2.44 F**
Polypropylene	B	5.00 N	5.70 M	6.67 L	7.30 K	8.53 J	**6.64 D**
	C	10.00 I	10.40 H	10.90 G	11.37 F	11.93 E	**10.92 B**
	Mean	**5.01 H**	**5.80 G**	**6.67 F**	**7.53 E**	**8.32 D**	**6.67 B**
	A	0.03 L	1.75 K	3.00 J	4.83 I	5.85 H	**3.09 C**
Mean	B	5.00 I	5.85 H	8.34 G	9.69 F	11.90 C	**8.15 B**
of (MAP)	C	10.00 E	10.90 D	11.99 C	13.69 B	15.85 A	**12.48 A**
	Mean	**5.01 E**	**6.17 D**	**7.77 C**	**9.40 B**	**11.20 A**	
		2010 season					
	A	0.03 N	2.30 LM	4.07 K	5.80 I	7.30 H	**3.90 E**
Polyethylene	B	5.00 I-K	7.07 H	10.07 FG	13.17 D	15.47 C	**10.16 C**
	C	10.00 FG	11.50 E	14.17 D	17.17 B	19.07 A	**14.38 A**
	Mean	**5.01 H**	**6.96 EF**	**9.44 C**	**12.05 B**	**13.95 A**	**9.48 A**
	A	0.03 N	1.30 M	2.73 L	3.97 K	4.63 JK	**2.53 F**
Polypropylene	B	5.00 I-K	5.43 IJ	5.90 I	7.40 H	9.83 G	**6.71 D**
	C	10.00 FG	10.53 E-G	10.70 E-G	11.13 EF	11.57 E	**10.79 B**
	Mean	**5.01 H**	**5.75 G**	**6.44 F**	**7.50 E**	**8.68 D**	**6.68 B**
	A	0.03 K	1.80 J	3.40 I	4.89 H	5.97 G	**3.22 C**
Mean	B	5.00 H	6.25 G	7.99 F	10.29 DE	12.65 C	**8.432 B**
of (MAP)	C	10.00 E	11.02 D	12.44 C	14.15 B	15.32 A	**12.58 A**
	Mean	**5.01 E**	**6.36 D**	**7.94C**	**9.77 B**	**11.31 A**	

Means in the same column having the same letter are not significantly different at 0.05 level by Duncan's multiple rang test.
A=Passive MAP
B=Active MAP(5%02+5%Co2)
C=Active MAP(5%02+10%Co2)

The O_2 levels in active MAP were lower than that of passive MAP as shown in Table (7). While the values of Co_2 were higher (Table 8). The O_2 level decreased and Co_2 increased continuously until reached 6.09 % O_2 and 11.26% Co_2 after 16 days of storage at 0°C (average of the two seasons)**.**

After 16 days at 0°C, the gas concentrations were 2.88 % O_2 & 12.28% Co_2 and 2.89% O_2 & 15.59% Co_2 (average of the two seasons) in active MAP at 5% O_2 + 5% Co_2 and 5% O_2 + 10% $C0_2$ respectively. The gas composition inside the passive package reached 12.5% O_2 & 5.91% Co_2 in the same period.

CONCLUSION

Broccoli florets packed in polypropylene film and exposed to active MAP (5% O_2 + 10% Co_2) were the most effective treatment for reducing weight loss and color change and maintaining high content of chlorophyll and gave florets with a good appearance for 16 days at 0°C and 95% RH.

REFERENCES

A.O.A.C. 1990. *Official Methods of Analysis* Association of Official Analytical Chemists 13 the ed. Washington, S.C., U.S.A.

Ballantyne, A., R. Stark and J. D. Selman .1988. Modified atmosphere packaging of broccoli florets. *International Journal of Food Science and Technology.* 23:353-360

Barth, M. M., F. L. Kerbel, A. K. Perry and S. J. Schmidt .1993. Modified atmosphere packaging effect ascorbic acid, enzyme activity and market quality of broccoli. *Journal of Food Science*. 58(1): 140-143.

Brennan, P. S. and R. L. Shewfelt .1989. Effect of cooling delay at harvest on broccoli quality during postharvest storage.J.*Food Qual*. 12:13-22.

Charles, F., C. F. Forney and R. E. Rij .1991. Temperature of broccoli florets at time of packaging influences package. *HortScience.*26:1301-1303.

Dong, H., Y. Jiang, Y. Wang, R. Liu and H. Guan.2004. Effects of Hot Water Immersion on Storage Quality of Fresh Broccoli Heads. *Food T echnol. Biotechnol*. 42(2):135-139.

Elkashif, M. E., D. J. Huber and M. Sherman .1993. Delaying deterioration of broccoli and cucumber using polymeric films.Proc. *Fla. Syate Hort. Soc*. 96:332-335.

Forney, C.F. and R. E. Rij.1991. Temperature of broccoli florets at time of packaging influences package. *HortScience*.26:1301-1303.

Hansen, M., R. G. Buttery, D. J. Stern, M. I. Cantwell, and L.C. Ling .1992. Broccoli storage under low-oxygen atmosphere identification of higher boiling volatiles. *Journal of Agricultural Food Chemistry*. 40(5):850-852.

Hansen, M., C. E. Olsen, L. Poll, and, M. I. Cantwell .1993. Volatile constituents and sensory quality of cooked broccoli florets after aerobic and anaerobic storage. *Postharvest*. 92:105-111.

Hu, W.Z., A. L. Jiang, K. Pang and H. P. Qi .2007. Atmosphere composition, respiration rate and quality of fresh-cut cabbages in active modified atmosphere packaging. Proc. IC on Qual. Manag. Fresh Cut Produce. *Acta Hort.* 746:69-72

Jacobsson, A. and T. Nielsen .2003. Influence of packaging material and storage temperature on the texture, colour, and weight of broccoli. Proc.8th Int. CA Conference. *Acta Hort*. 600:323-325.

Jacobsson, A., T. Nielsen and Karin Wendin .2003. Influence of packaging material and storage temperature on the texture, colour, and weight of broccoli. *Acta Hort*. 599:91-93.

Jacobsson, A., T. Nielsen, I. Sjöholm and K. Wendin .2004. Influence of packaging material and storage condition on the sensory quality of broccoli. *Food Quality and Preference*. 15:301-310.

Joseph, H. H. and j. B. Mishael .1992. Influence of new packaging technologies on the growth of microorganisms in produce.*Journal of Food protectin*.55 (10):815-820

Makhlouf, J., J. A. Castaigne, C. Willemot and A. Gosselin .1989. Long-term storage of broccoli under controlled atmosphere. *HortScience*. 24(4):637-639.

Ryall, A. L. and W. J. Lipton .1979. Handling, transportation and storage of fruit and vegetables. 2nd ed.AVI, Westport, Conn.

Snedecor, G. W. and W. G. Cochran .1980. Statistical methods.Iowa.State Univ. Press. USA.

Wang, C.Y. and H. W. Hruschka .1977. Quality maintenance in polyethelne-packaged broccoli.U.S. Dept. Agr. Mhtg. Res. Rpt.1085.

تأثير التعبئة فى جو هوائى معدل على صفات الجودة لرؤوس البروكولى المفصصة.

محسن السيد محمد[١]، محمد امام رجب[٢]، صلاح الدين محمود المنياوى[٢]و راوية البسيونى ابراهيم البسيونى[١]

١- قسم بحوث تداول الخضر- معهد بحوث البساتين- مركز البحوث الزراعية- الدقى- الجيزة- مصر.

٢- قسم البساتين- كلية الزراعة- جامعة عين شمس- شبرا الخيمة- القاهرة- مصر.

أجريت هذه التجربة خلال موسمى ٢٠٠٩ ، ٢٠١٠ على هجين البروكولى (*ساكورا*) لدراسة تأثير نوعين من المغلفات والجو الهوائى المعدل(بالحقن الغازى داخل العبوة أو الذى تحدثه الثمار نفسها) على صفات الجودة لرؤوس البروكولى المفصصة خلال التخزين المبرد على درجة صفردرجة مئوى ورطوبة نسبية ٩٥ % لمدة ١٦ يوم.

أدى تعبئة رؤوس البروكولى المفصصة فى البولى بروبالين الى احتفاظها بالطزاجة والاخضرار والاندماج وأقل رائحة غير مرغوبة خلال التخزين مقارنة بالتى تم تعبئتها فى البولى ايثيلين. حيث لوحظ عن وجود فرق معنوى فى فقد الوزن أثناء التخزين للبروكولى المخزن فى الانواع المختلفة من المغلفات.

أدى حقن الاكياس بالغازات الى تقليل فقد الوزن للبروكولى المفصص مقارنة بالتى لم يتم حقنها بالغازات خلال التخزين.

كما اوضحت النتائج أن أنسب نسب غازات مختبرة هى ٥ % أكسجين ، ١٠ % ثانى أكسيد الكربون حيث ادت الى احتفاظ رؤوس البروكولى المفصصة بجودتها خلال التخزين. لم يلاحظ أية رائحة غير مرغوبة فى البروكولى المفصص والمعبأ فى البولى بروبالين ثم حقنه بالغازات بنسب ٥ % أكسجين ، ٥ % ثانى أكسيد الكربون بينما التى حقنت بـ ٥ % أكسجين ، ١٠ % ثانى أكسيد الكربون أو التى لم يتم حقنها بالغازات أعطت رائحة بسيطة.

وعليه يمكن التوصية بتعبئة البروكولى المفصص فى عبوات من البولى بروبالين وحقنه بالغازات بنسبة ٥% أكسجين و١٠% ثانى أكسيد الكربون حيث يمكن ان يظل على درجة الصفر المئوى ورطوبة نسبية ٩٥% لمدة ١٦ يوم محتفظ بمظهر خارجى جيد.

قام بتحكيم البحث

أ.د / هاله عبد الغفار السيد — كلية الزراعة – جامعة المنصورة

أ.د / سعيد زكريا عبد الرحمن — مركز البحوث الزراعية