Effect of Some Pre and Postharvest Treatments on Quality and Storability of Strawberry Fruits

Khreba, A.H[1].; Hassan, A.H.[2]; Emam, M.S. and [2]Atala, S.A.

[1]Vegetable Dept. Fac. of Agric., Cairo. University., Egypt
[2] Postharvest and Handling of Vegetable Crops Res. Dept., Hort.Res.Inst. Agric, Res. Center, Giza, Egypt
drhassannali5@yahoo.com, Hassanali5@agr.cu.edu.eg

Abstract: This study was conducted at Qalubia Governorate, Egypt during the two successive seasons 2011- 2012 and 2012- 2013 to elucidate the effect of pre-harvest foliar spray with humic acid at 2 L / feddan and amica at 2 cm ^{3}/ L apply every 15 days with a total of 5 application times as well as modified atmosphere of (16% O_2 plus 20% CO_2) or vacuum packaging or chitosan at 1.5% and vapor gard at 0.1% as post-harvest treatment on the storability of strawberry fruits cv. Sweet Charlie during storage at 0°C and 95% relative humidity. A complete randomized (factorial design) with three replicates. The results indicated that sparing plants with amica in growing season reflected higher values in general appearance, total soluble solid percentage, ascorbic acid, firmness, color, texture, titratable acidity, total sugars content and lower values in weight loss, decay percentage, pH and anthocyanins content compared to other treatments. Therefore, these amica can be recommended for strawberry to improve fruits quality and storability. Concerning the modified atmosphere packaging MAP (16%O_2 +20%CO_2) gave better results (total soluble solid percentage, titratable acidity, ascorbic acid, anthocyanin, color, total sugars content, firmness and pH) than other treatments. On the other hand, using spraying the plants with amica combined with MAP caused a significant increase in storability concerning weight loss, decay percentage, general appearance, total soluble solid percentage, ascorbic acid, firmness, color, texture, titratable acidity, total sugar content, pH and anthocyanins content.

[Khreba, A.H.; Hassan, A.H.; Emam, M.S. and Atala, S.A. **Effect of Some Pre and Postharvest Treatments on Quality and Storability of Strawberry Fruits Cirrhosis.** *J Am Sci* 2014;10(11):239-248]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 33

Keywords: Strawberry, preharvest, amica, humic acid, postharvest, modified atmosphere, chitosan, vacuum, vapor gard.

1. Introduction

Strawberry is a non-climacteric fruit with a very short post harvest shelf-life. Loss of quality in this fruit is mostly due to its relatively high metabolic activity and sensitivity to fungal decay, mainly grey mold (*Botrytis cinerea*). Strawberries are also susceptible to water loss, bruising and mechanical injury due to soft texture and lack of a protective rind. To reduce spoilage, metabolism, and deterioration and to extend the shelf life, strawberry fruit should be kept at 0°C after harvest (Hernandez-Munoz *et al.,* 2006). The shelf-life of fresh strawberries at low temperatures (0–4°C) is usually around 5 days. In order to extend fruit shelf-life, cold storage combined with controlled and modified atmospheres has been studied (Holcroft and Kader, 1999; Sanz *et al.,* 1999; P´erez and Sanz, 2001). Low storage temperatures and modified atmospheres with elevated CO_2 levels are common tools for avoiding, mold growth and senescence, and extending fruit shelf-life (Manning, 1996). The shelf-life of fresh produce is limited to 1~2 days at room temperature (Ghuoath *et al.,* 1991 and Harker *et al.,* 2000). The shelf life of fresh strawberry is inversely proportional to respiration rate (Day, 1990). Consequently, the most commonly used method for shelf-life extension is low temperature. But storage quality can be further improved by altering the gas atmosphere surrounding the fresh strawberry (Church, 1994; Holcroft and Kader, 1999). MAP is often used to maintain elevated CO_2 and reduced O_2 concentrations inside consumer-packaged produce containers (Exama, 1993). Modified atmosphere packaging (MAP) of low oxygen and high carbon dioxide is known to suppress physiological changes and microbial deterioration of strawberry fruit, thus extending its shelf life (Caner and Aday, 2009). Several studies reported different strategies to reduce postharvest losses, combination of low temperature, high – humidity storage and the use the carbon dioxide (Ke *et al.,* 1991; Nunes *et al.,* 1995; Krivorot and Dris, 2002). Abu-Zinada (1988) stated that snap beans dipped in solutions of vapor gard reduced weight loss during storage and lessened the percentage of decay. Awad (1989) found that strawberry treated with vapor gard lessened the decay percentage and an unmarketable fruit during storage but this treatment was not affected ascorbic acid content of the fruit. Also, El-Seifi and Attia (1990) showed that treated squash fruits in vapor gard decreased the decay percentage during storage. Le Lagadec and Moruda (2002) found that vapor gard is an anti-transpirant which forms a coating on the fruit and prevents evaporative water loss thus retaining fruit turgidity and retaining fruit firmness. Chitosan (poly b-(1,4)N-acetyl-D-glucosamine) and its derivatives have been shown to inhibit the growth of a wide range of fungi and trigger defensive mechanisms in plants and fruits against infections caused by several pathogens. Chitosan possesses excellent film-forming properties and can be applied as an edible surface coating to fruits and vegetables. Chitosan coatings have been reported to limit fungal decay and delay the ripening of several commodities, including strawberry (El Ghaouth *et al.,* 1991a; Han *et al.,*2004 and Ribeiro *et al.,* 2007). Recent studies on the sensory evaluation of chitosan-coated strawberries have reported that chitosan solution prepared at a low acid concentration did not change astringency of the fruit. Chitosan coatings did not change consumer acceptance of strawberries stored for one week at 2 °C (Han *et al.,* 2005). Edible coatings have been reported to be more effective at delaying the ripening of fruit and vegetables at room temperature than under cold storage (Amarante and Banks, 2001). Hernandez-Munoz *et al.* (2006). Reported that no sign of fungal decay was observed in fruit coated with 1.5% chitosan which also reduced fruit weight loss. Chitosan coatings markedly slowed the ripening of strawberries as shown by their retention of firmness and delayed changes in their external color. To a lesser extent titratable acidity and pH were also affected by coatings. Shehata *et al.* (2011) found that foliar fertilizers with humic acid at a rate of 1g/ l exhibited higher plant length, fruit weight and higher level of total soluble solid and anthocyanin content of strawberry as compared to mineral fertilizer.

The aim of the present work was to evaluate the potential of pre-harvest foliar spray with humic acid and amica as well as modified atmosphere or vacuum packaging or chitosan and vapor gard as post-harvest treatment in preserving the quality and storability of strawberry fruits.

2. Materials and methods

Effect of pre-harvest foliar spray with humic acid or amica and postharvest treatment with modified atmosphere or vacuum packaging or chitosan or vapor gard on the storability of cv. Sweet Charlie fruits were studied.

At harvested fruits the three quarter red stage of maturity, were harvested from private farm at Qalubia governorate, Egypt in the first week of January of the two seasons 2012 and 2013 to investigate the effect of foliar spray with humic acid (HA) [Hammar, Arabian Group of Agricultural Service (AGAS),Egypt, potassium humate 86% and potassium oxide 6%] and amica, (N>5%, CaO>14%, amino acid>10%) foliar spray with humic acid at 2 L / feddan and amica at 2 cm ^{3}/ L apply every 15 days with a total of 5 application times. In addition to the control (sprayed with distilled water). At harvest fruits from each experimental plot were transported to the Postharvest and Handling Research department at Giza governorate. Sound and healthy fruits were packed in plastic punnets (250g) and put in the strawberry carton boxes (2kg eight punnets per carton) and stored under cold room condition (0°C and 95 % RH) for 15 days for the following treatment.

1- The fruits were packed in plastic punnets (250g) then the punnets were inserted into the polypropylene bags (30 μ thickness,20 × 20 cm size), then flushed with a gas mixture at 16% O_2 +20% CO_2(MAP).
2- The fruits were packed in plastic punnets (250g) then the punnets were inserted into the polypropylene bags (30 μ thicknesses, 20 × 20 cm size), Vacuum infusion was carried out at 20°C in a chamber connected to a vacuum pump.
3-Chitosan solution was prepared by dissolving 1.5% chitosan in 0.5% acetic acid solution and fruits were sprayed with chitosan at the concentration1.5%then the fruits were allowed to dry for tow hour at 20°C then the fruits were packed in plastic punnets (250g).
4-Vapor gard: fruits were sprayed with vapor gard at the concentration 0.1%then the fruits were allowed to dry for two hour at 20°C then the fruits were packed in plastic punnets (250g).
5- Samples that were not placed in a packaging were also prepared, then were kept in punnet and served as control.

The treatments were arranged in a complete randomized (factorial design) with three replicates was adopted. Each replicate consisted of 3 strawberry carton boxes (2kg eight punnets per carton) three punnets were taken for chemical analysis and measuring weight loss and decay percentage during the storage periods.

Storage fruits were inspected at 3 days interval for determining weight loss, decay and chemical analysis and the following data were recorded.

1-Weight loss percentage: It was estimated according to the equation:

$$\text{Weight loss percentage} = \frac{\text{Initial weight} - \text{weight at each specific interval} \times 100}{\text{Initial weight}}$$

2- Decay percentage: Decayed fruits were counted and recorded by visual examination (decayed fruits included all the shrieked, injured or spoiled, resulting from microorganisms infections) percentage of decay was calculated in relation to total initial weight of stored fruits (Cheour *et al.,* 1990).
3- General appearance based on fresh appearance, fresh calyx and dryness or watery condition, and change of color and decay was determined according to the following score system: 9=excellent, 7=good, 5=fair, 3=poor,1=unsalable.
4 – Surface color was measured on two sides of each fruit by using Tistimulus Hunter colorimeter Minolta, Ramsey, N.J. (Model Dp 9000 which measured L* C* value and hue angle) (McGuire, 1992).
5 – Pulp texture recorded by TA-1000 texture analyzer instrument using a penetrating cylinder of 1mm of diameter, to a constant distance (3 and 5 mm)inside the pulp of fruits, and by a constant speed 2mm per sec., and the peak of resistance was recorded per g/cm^2.
6- Total Soluble Solid percentage was determined by using digital refract meter (Abbe Leica model).
7- Titratable acidity percentage was measured by titration the juice of fruits against 0.1 N NaoH to pH 8.1 and expressed as percent of citric A.O.A.C. (1990).
8- Ascorbic Acid: The ascorbic acid content was determined by using 2,6-dichlorophenol indophenols titration method as described by A.O.A.C (1990).
9-Anthocyanin: It was determined by using Hcl (1.5N) spectrophotometer as described by A.O.A.C (1990).
10-Total sugar was determined in fresh strawberry fruits by using Lane and Eynon method according to A.O.A.C (2000).

All data were subjected to the statistical analysis according to the method described by Snedecor and Cochran (1991).

3. Results and Discussion

1- Weight loss

Data in Table 1 show the effect of foliar spray of strawberry plants with amica and humic acid significantly decreased the percentage of weight loss in fruits during storage compared with the control treatment during the both seasons of study. In this connection, the lowest weight loss was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

Obtained results may be attributed to the role of such natural anti diseases substances in decreasing the susceptibility for diseases infection, decreasing the respiration rate and production of ethylene which affect greatly on fruit storage ability.

Concerning the effect of post harvest treatments (vacuum, chitosan, vapor gard and MAP) on weight loss percentage, data reveal that there were significant differences between treatments in weight loss percentage during storage; however, all treatments retained their weight during storage as compared with the control (untreated fruits). Moreover, strawberry fruits packed in vacuum or MAP resulted in prominent reduction in weight loss percentage during storage. These results are in agreement with those obtained by Petrisor *et al.* (2010).On the other hand the highest values of weight loss percent was recorded with untreated (control). These results were true in the two seasons.

Lowest weight loss from vacuum or MAP is due to the confinement of moisture around the produce by polypropylene bags. This increases the relative humidity and reduces vapor pressure deficit and transpiration. In addition, packaging creates a modified atmosphere with higher concentration of carbon dioxide and reduced oxygen around the produce which slows down the metabolic processes and transpiration (Thompson, 1996), which diminished the weight loss during storage (Wang and Qi, 1997). Also, MAP reduced the water loss by minimizing the contact of fruits with the surrounding air or by inhibiting the diffusion of water vapor with permeability of vapors of the films (Akbudak, 2008).

The highest weight loss observed in untreated fruits throughout the storage period can be attributed to air movement, which tends to sweep away the unstirred layer of air (at equilibrium vapor pressure with the tissues) adjacent to the surface of the produce, thus increasing the vapor pressure deficit (Wills *et al.,*1998).

Chitosan and vapor gard treatments significantly reduced fresh weight loss of strawberry fruits as compared with untreated fruits (control) during storage. These results agree with the results obtained by Hernandez-Munoz *et al.* (2008) for chitosan and Shabana *et al.* (1985) for vapor gard. Apart from strawberry fruit, chitosan coatings have been effective at controlling waterloss from other commodities, including cucumber and pepper (El Ghaouth *et al.,* 1991b) and longan fruit (Jiang and Li, 2001). Chitosan has been reported to bemore effective at delaying weight loss in banana and mango (Kittur *et al.,*2001) and strawberries (Ribeiro *et al.,* 2007) than are starch and cellulose derivatives.

The interaction between foliar spray and all used postharvest treatments had a significant effect on fruit weight loss percentage during the storage. In this regard, the lowest value of weight loss percentage was recorded incase of using spraying the plants with amica combined with vacuum.

2- Firmness

Data in Table 1 show the effect of foliar spray with amica and humic acid significantly affected their firmness and resulted in higher values of fruit firmness compared with the control treatment during the both seasons of study. In this connection, the highest firmness was recorded in case of using amica followed by humic acid. Such positive effect by using amica and humic acid was true during the two seasons of study.

Concerning the effect of post harvest treatments (vacuum, chitosan, vapor gard and MAP) on fruit firmness, data in the same table reveal that there were significant differences between treatments in firmness during storage; however, all treatments retained their fruit firmness during storage as compared with the control (untreated fruits). Moreover, strawberry fruits packed in MAP were the most effective treatment in reducing the loss of fruit firmness during storage at 0°C, followed by chitosan treatment. Vapor gard treatment was less effective in reducing firmness as compared with the other treatments. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012). The lowest values of firmness were recorded with untreated treatment (control). These results were true in the two seasons.

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

The interaction between foliar spray and post harvest treatments had a significant effect on fruit firmness during the storage. In this regard, the highest value of fruit firmness was recorded in case of using spraying the plants with amica combined with MAP.

Table 1: Effect of some pre and postharvest treatments and their interaction on Weight loss, Firmness and TSS % of st rawberry fruits at end of the storage in 2012 and 2013 seasons

Treatment		First season (2012)			Second season (2013)		
Foliar	packaging	Weight loss	Firmness	TSS %	Weight loss	Firmness	TSS %
Humic acid		1.05 B	10.06 A	10.07 B	0.96 B	10.47 A	10.27 B
Amica		0.94 C	10.55 A	10.41 A	0.90 C	10.83 A	10.69 A
Spraying water		1.14 A	9.33 B	9.52 C	1.04 A	9.77 A	9.73 C
	Modified atmosphere	0.25 D	10.44 A	10.05 A	0.21 C	10.86 A	10.28 A
	Vacuum	0.12 E	10.08 AB	10.01 A	0.11 D	10.54 A	10.24 A
	Vapor gard	1.63 B	9.77 AB	9.98 A	1.53 A	10.04 AB	10.21 A
	Chitosan	1.50 C	10.22 AB	10.03 A	1.43 B	10.68 A	10.26 A
	Without	1.72 A	9.38 B	9.95 A	1.56 A	9.68 B	10.17 A
	Modified atmosphere	0.26 GH	10.50 AB	10.12 ABC	0.21 G	10.94 AB	10.32 ABC
	Vacuum	0.11 J	10.22 ABCD	10.07 BC	0.10 I	10.70 ABC	10.27 ABC
	Vapor gard	1.63 C	9.84 BCDEF	10.04 C	1.52 B	10.17 ABCD	10.24 BCD
	Chitosan	1.52 DE	10.33 ABCD	10.09 ABC	1.41 D	10.81 AB	10.30 ABC
Humic acid	**Without**	1.71 B	9.42 EFG	10.03 C	1.56 B	9.75 BCD	10.22 CDE
	Modified atmosphere	0.20 HI	10.88 A	10.46 A	0.17 H	11.17 A	10.74 A
	Vacuum	0.10 J	10.58 AB	10.42 ABC	0.09 I	10.92 AB	10.69 AB
	Vapor gard	1.48 E	10.39 AB	10.38 ABC	1.43 CD	10.64 ABC	10.67 ABC
	Chitosan	1.32 F	10.75 A	10.44 ABC	1.32 E	11.06 AB	10.71 AB
Amica	**Without**	1.58 CD	10.11 ABCDE	10.37 ABC	1.46 C	10.38 ABC	10.63 ABC
	Modified atmosphere	0.29 G	9.92 BCDE	9.57 D	0.25 F	10.47 ABC	9.79 DEF
	Vacuum	0.15 IJ	9.44 DEF	9.52 D	0.12 I	10.00 ABCD	9.74 F
	Vapor gard	1.77 B	9.09 FG	9.50 D	1.64 A	9.31 CD	9.70 F
Spraying	**Chitosan**	1.65 C	9.58 CDEF	9.55 D	1.55 B	10.17 ABCD	9.77 EF
water	**Without**	1.85 A	8.63 G	9.47 D	1.67 A	8.89 D	9.67 F

Values followed by the same letter (s) within column are not significantly different (P<0.05)

3- Total soluble solids

Data in Table1 reveal that the effect of foliar spray with amica and humic acid significantly has higher (TSS) percentage value in fruits during storage compared with the control treatment during storage. These were true the both seasons of study.

Concerning the effect of post harvest treatments, there were no significant differences between treatments in (TSS) percentage during storage. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012). These results were true in the two seasons.

The interaction between foliar spray and post harvest treatments had a significant effect in (TSS) percentage during the storage. In this regard, the highest value of (TSS) percentage was recorded in case of using spraying the plants with amica combined with MAP.

(4) Color

Color of strawberry is one of the most important quality factors of fresh strawberry for consumer preference. Color of strawberry was measured by Colorimeter and Color Difference on color coordinates L*, C* and H* values, where L-value is lightness, the chroma value describes its brightness while the hue angle represents a coordinate in a standardized color space.

Data in Table 2 reveal that significant differences were found between foliar spray treatments, where as amica spary had higher L*, C* and H* values as compared with the other treatment and the control which showed the lowest value.Such positive effect for using amica and humic acid was true in the two seasons.

There were no significant differences between postharvest treatments in L*, C* and H* values during storage. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012)who demonstrated that MAP was able to retard discoloration and the samples under MAP showed lower decrease in L*, C* and H* values. These results were true in the two seasons.

The interaction between foliar spray and postharvest treatments in L*, C* and H* values were significant. Amica combined with MAP packing and amica treatment combined with chitosan had the higher values in the first season, but no significant differnces were found as a result of the interaction in the second season.

Table 2: Effect of some pre and postharvest treatments and their interaction on L.color, H.color and C.color of strawberry fruits at end of the storage in 2012 and 2013 seasons.

Treatment		**First season (2012)**						**Second season (2013)**					
Foliar	packaging	L.color		H.color		C.color		L.color		H.color		C.color	
Humic acid		38.67	AB	44.31	AB	42.21	AB	39.55	AB	46.97	A	44.64	AB
Amica		39.45	A	44.80	A	42.80	A	40.00	A	47.57	A	44.97	A
Spraying water		37.98	B	43.93	B	41.55	B	39.32	B	46.22	B	44.24	B
	Modified atmosphere	38.76	A	44.42	A	42.34	A	39.69	A	46.99	A	44.71	A
	Vacuum	38.72	A	44.38	A	42.25	A	39.62	A	46.95	A	44.65	A
	Vapor gard	38.65	A	44.27	A	42.01	A	39.57	A	46.86	A	44.47	A
	Chitosan	38.82	A	44.48	A	42.44	A	39.74	A	47.00	A	44.91	A
	Without	38.54	A	44.19	A	41.87	A	39.51	A	46.80	A	44.35	A
	Modified atmosphere	38.75	ABC	44.40	ABCD	42.38	ABCD	39.61	A	47.02	ABC	44.72	ABC
	Vacuum	38.69	ABCD	44.35	ABCD	42.27	ABCD	39.55	A	46.99	ABC	44.67	ABC
	Vapor gard	38.61	ABCD	44.22	ABCD	42.02	BCDE	39.51	A	46.92	ABCD	44.49	ABC
	Chitosan	38.80	ABC	44.43	ABCD	42.46	ABCD	39.66	A	47.05	AB	44.93	ABC
Humic acid	**Without**	38.51	BCD	44.15	ABCD	41.90	CDE	39.43	A	46.86	ABCD	44.36	ABC
	Modified atmosphere	39.51	A	44.86	AB	42.96	A	40.05	A	47.63	A	45.05	A
	Vacuum	39.47	A	44.83	AB	42.87	AB	40.00	A	47.59	A	44.99	AB
	Vapor gard	39.39	AB	44.73	ABC	42.65	ABC	39.95	A	47.51	A	44.86	ABC
	Chitosan	39.55	A	44.91	A	43.04	A	40.10	A	47.64	A	45.22	A
Amica	**Without**	39.32	AB	44.67	ABC	42.50	ABCD	39.90	A	47.46	A	44.72	ABC
	Modified atmosphere	38.01	CD	44.00	A	41.68	A	39.41	A	46.30	BCD	44.34	ABC
	Vacuum	38.00	CD	43.97	BCD	41.62	DE	39.32	A	46.26	BCD	44.28	ABC
	Vapor gard	37.94	CD	43.87	CD	41.36	E	39.24	A	46.15	CD	44.06	BC
Spraying	**Chitosan**	38.11	CD	44.09	ABCD	41.83	CDE	39.45	A	46.31	BCD	44.56	ABC
water	**Without**	37.80	D	43.74	D	41.23	E	39.19	A	46.08	D	43.95	C

Values followed by the same letter (s) within column are not significantly different (P<0.05)

(5) Ascorbic acid content

Data in Table 3 reveal that there were no significant differences due to foliar spray and post harvest treatments in ascorbic acid content during storage in both seasons. Moreover in the second season strawberry plants treated with amica resulted in maintaining higher ascorbic acid content compared with the other treatment (humic acid). These results are in agreement with those obtained by Lee and Kader (2000) and Manleitner *et al.,* (2002).

Modified atmosphere packages prevent ascorbic acid degradation caused by low O_2 concentrations.

Moreover, high CO_2 treatment retarded the change in ascorbic acid content of pepper fruits during storage (Akbudak, 2008).

The interaction between foliar spray and post harvest treatments had significant effect on ascorbic acid content as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the highest value of ascorbic acid content was recorded incase of using spraying the plants with amica combined with MAP.

(6) Anthocyanins content

Data in Table 3 reveal that spraying strawberry plants with amica and humic acid significantly decreased the content of anthocyanins in fruits compared with the control treatment during both seasons of study. In this connection, the lowest anthocyanins content was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of study.

There were no significant differences between postharvest treatments in anthocyanins content.These results are in agreement with those obtained by P´erez and Sanz (2001) and Petrisor *et al.* (2010). These results were true in the two seasons. Sanz *et al.* (1999) pointed out that CO_2 and/or O_2 content seemed to affect anthocyanin synthesis and/or degradation rates. In the same way, P´erez and Sanz (2001) detected a lower anthocyanin concentration in strawberries cv. Camarosa stored in controlled atmospheres

The interaction between foliar spray and postharvest treatments had a significant effect on fruit anthocyanins content. In this regard, the lowest value of anthocyanins content was recorded incase of using spraying the plants with amica combined with MAP.

(7) Texture

Data in Table 3 show the effect of foliar spray of strawberry plants with amica and humic acid significantly affected fruit texture and resulted in higher texture value in fruits during storage compared with the control treatment in the both seasons of study. In this connection, the highest texture was recorded incase of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

Concerning the effect of post harvest treatments on fruit texture, data reveal that there were no significant differences between treatments in texture during storage; Moreover, strawberry fruits packed in MAP resulted in higher texture in fruit during storage. These results are in agreement with those obtained by Shehata *et al.,* (2010). The lowest values of texture were recorded with untreated (control). These results were true in the two seasons.

The interaction between foliar spray and all used post harvest treatments was significant effect on fruit texture as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the highest value of texture was recorded incase of using spraying the plants with amica combined with MAP.

(8) Decay

Data in Table 4 show the effect of foliar spray of strawberry plants with amica and humic acid significantly decreased the percentage of decay in fruits during storage compared with the control treatment in both seasons of study. In this connection, the lowest decay was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

Concerning the effect of post harvest treatments on fruit decay percentage, data reveal that there were significant differences between treatments in decay percentage during storage; moreover, at the end of storage noticed that strawberry fruits packed in MAP did not show any sign of fungal decay. Chitosan treatment at1.5%led to significant reduction in decay percentage during storage. These results are in agreement with those obtained by Jouki and Khazaei (2012). The highest values of decay percent were recorded with untreated (control). These results were true in the two seasons.

Jobling (2001) and Lee *et al.* (2006a&b) stated that elevated CO_2, levels can reduce the products sensitivity to C_2H_4; it can also slow the growth of many of the post harvest fungi that cause rots.

The interaction between foliar spray and all used post harvest treatments had a significant effect on fruit decay percentage as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the lowest value of decay percentage was recorded incase of using spraying the plants with amica combined with MAP.

(9) General appearance

Data in Table 4 reveal that the effect of foliar spray of strawberry plants with amica and humic acid significantly affected their general appearance score and resulted in higher general appearance score in fruits during storage compared with the control treatment in both seasons of study. In this connection, the highest general appearance score was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

There were significant differences between postharvest treatments in general appearance score during storage; moreover, all treatments were better than the control. However, strawberry stored in MAP, vacuum and chitosan was the most effective treatments for maintained general appearance during storage.Vapor gard treatment had slight effects on general appearance preservation during storage as compared with the other treatments. These results are in agreement with those obtained by Jouki and Khazaei (2012). The lowest values of general appearance score was recorded with untreated (control). These results were true in the two seasons.

The interaction between foliar spray and postharvest treatments had significant effect on general appearance score as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the highest score of general appearance was recorded in case of using spraying the plants with amica combined with MAP.

Table 3: Effect of some pre and postharvest treatments and their interaction on Vitamin C, Anthocyanins and Texture of strawberry fruits at end of the storage in 2012 and 2013 seasons

Treatment		First season (2012)						Second season (2013)					
Foliar	packaging	Vitamin C		Anthocyanins		Texture		Vitamin C		Anthocyanins		Texture	
Humic acid		44.50	A	82.62	B	13.02	AB	44.83	B	77.78	AB	13.49	AB
Amica		45.00	A	81.79	C	13.30	A	45.46	A	76.78	B	13.84	A
Spraying water		44.30	A	84.69	A	12.67	B	44.66	B	78.38	A	13.15	B
	Modified atmosphere	44.75	A	82.76	A	13.17	A	45.12	A	77.41	A	13.65	A
	Vacuum	44.61	A	82.95	A	13.01	A	44.99	A	77.61	A	13.52	A
	Vapor gard	44.52	A	83.09	A	12.92	A	44.90	A	77.77	A	13.42	A
	Chitosan	44.66	A	82.87	A	13.08	A	45.06	A	77.53	A	13.57	A
	Without	44.46	A	83.50	A	12.81	A	44.83	A	77.90	A	13.31	A
Humic acid	**Modified atmosphere**	44.64	ABC	82.28	CDE	13.19	ABCD	44.98	ABCDEF	77.57	ABCDEF	13.65	ABCD
	Vacuum	44.51	ABC	82.49	CD	13.03	ABCD	44.84	BCDEF	77.76	ABCDEF	13.52	ABCD
	Vapor gard	44.42	ABC	82.66	BC	12.95	ABCD	44.75	CDEF	77.89	ABCDEF	13.42	ABCD
	Chitosan	44.55	ABC	82.38	CDE	13.10	ABCD	44.90	ABCDEF	77.67	ABCDEF	13.56	ABCD
	Without	44.38	ABC	83.26	B	12.83	ABCD	44.66	EF	78.01	ABCDEF	13.30	ABCD
Amica	**Modified atmosphere**	45.14	A	81.50	F	13.47	A	45.58	A	76.53	F	13.97	A
	Vacuum	45.00	ABC	81.73	DEF	13.30	ABC	45.44	ABC	76.77	DEF	13.87	ABC
	Vapor gard	44.92	ABC	81.86	DEF	13.23	ABC	45.39	ABCD	76.92	CDEF	13.79	ABC
	Chitosan	45.07	AB	81.65	EF	13.39	AB	45.53	AB	76.67	EF	13.92	AB
	Without	44.86	ABC	82.22	CDEF	13.13	ABCD	45.35	ABCDE	77.02	BCDEF	13.66	ABCD
Spraying water	**Modified atmosphere**	44.47	ABC	84.49	A	12.85	ABCD	44.81	CDEF	78.14	ABC	13.32	ABCD
	Vacuum	44.31	ABC	84.63	A	12.69	BCD	44.70	DEF	78.32	A	13.17	CD
	Vapor gard	44.20	BC	84.73	A	12.59	CD	44.57	F	78.49	A	13.07	D
	Chitosan	44.37	ABC	84.57	A	12.75	ABCD	44.74	CDEF	78.25	AB	13.23	BCD
	Without	44.13	C	85.03	A	12.46	D	44.48	F	78.67	A	12.97	D

Values followed by the same letter (s) within column are not significantly different ($P<0.05$)

(10) Titratable acidity

Data in Table 4 reveal that the effect of foliar spray of strawberry plants with amica and humic acid significantly affected the titratable acidity and resulted in higher titratable acidity content in fruits during storage compared with the control treatment in both seasons of study. In this connection, the highest titratable acidity was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

There were significant differences between postharvest treatments in titratable acidity during storage; Moreover, strawberry fruits packed in MAP resulted in maintaining titratable acidity content. Vapor gard treatment had slight effects on titratable acidity preservation during storage as compared with the other treatments. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012). The lowest values of titratable acidity were recorded with untreated (control). These results were true in the two seasons.

The interaction between foliar spray and postharvest treatments had significant effect on titratable acidity during the storage. In this regard, the highest value of titratable acidity was recorded in case of using spraying the plants with amica combined with MAP.

Table 4: Effect of some pre and postharvest treatments and their interaction on decay(%), general appearance and titratable acidity of strawberry fruits at end of the storage in 2012 and 2013 seasons

Treatment		First season (2012)						Second season (2013)					
Foliar	packaging	decay(%)		general appearance		titratable acidity		decay(%)		general appearance		titratable acidity	
Humic acid		2.30	AB	7.34	AB	0.68	B	2.05	AB	7.49	AB	0.76	B
Amica		1.96	B	7.58	A	0.70	A	1.83	B	7.67	A	0.79	A
Spraying water		2.68	A	7.05	B	0.65	C	2.52	A	7.27	B	0.74	C
	Modified atmosphere	0.00	D	8.78	A	0.71	A	0.00	D	8.89	A	0.81	A
	Vacuum	0.83	C	8.22	A	0.68	B	0.72	C	8.15	B	0.76	C
	Vapor gard	2.22	B	6.22	B	0.67	C	2.15	B	6.67	C	0.74	CD
	Chitosan	0.64	C	8.45	A	0.69	B	0.60	C	8.45	B	0.78	B
	Without	7.87	A	4.93	C	0.64	C	7.20	A	5.22	D	0.73	D
	Modified atmosphere	0.00	F	8.78	AB	0.71	ABC	0.00	E	8.89	A	0.81	AB
	Vacuum	0.89	E	8.22	BCD	0.67	DEF	0.60	DE	8.22	CD	0.76	DEF
	Vapor gard	2.06	D	6.22	G	0.66	FG	2.03	C	6.67	EF	0.75	EFG
	Chitosan	0.67	EF	8.45	DE	0.69	CDE	0.59	DE	8.45	BC	0.78	CD
Humic acid	**Without**	7.88	B	5.00	I	0.64	GHI	7.03	B	5.22	GH	0.73	GH
	Modified atmosphere	0.00	F	8.89	A	0.73	A	0.00	E	9.00	A	0.83	A
	Vacuum	0.62	EF	8.45	ABCD	0.70	BCD	0.59	DE	8.22	CD	0.79	BC
	Vapor gard	2.01	D	6.67	F	0.68	DEF	1.91	C	7.00	E	0.77	CDE
	Chitosan	0.31	EF	8.56	BCD	0.71	AB	0.29	DE	8.67	AB	0.80	B
Amica	**Without**	6.83	C	5.33	I	0.66	FG	6.34	B	5.45	G	0.76	DEF
	Modified atmosphere	0.00	F	8.67	ABC	0.69	BCDE	0.00	E	8.78	AB	0.79	BC
	Vacuum	0.98	E	8.00	CDE	0.65	FGH	0.96	D	8.00	D	0.74	FGH
	Vapor gard	2.59	D	5.78	H	0.63	HI	2.50	C	6.33	F	0.72	HI
	Chitosan	0.93	E	8.33	EF	0.67	EF	0.91	D	8.22	CD	0.76	DEF
Spraying water	**Without**	8.90	A	4.44	J	0.62	I	8.23	A	5.00	H	0.70	I

Values followed by the same letter (s) within column are not significantly different ($P<0.05$)

(11) Total sugar content

Data in Table 5 show the effect of foliar spray of strawberry plants with amica and humic acid such treatments significantly affected on total sugar content and resulted in higher total sugar content in fruits during storage compared with the control treatment in both seasons of study. In this connection, the highest total sugar content was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

Concerning the effect of postharvest treatments on total sugar content, data reveals that there were significant differences between treatments in total sugar content during storage; Moreover, strawberry fruits packed in MAP resulted in maintaining total sugar content. Vapor gard treatment had slight effects on total sugar content preservation during storage as compared with the other treatments. These results are in agreement with those obtained by Jouki and Khazaei (2012). The lowest values of total sugar content were recorded with untreated (control). These results were true in the two seasons.

The interaction between foliar spray and all used post harvest treatments had significant effect on total sugar content as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the highest value of total sugar content was recorded in case of using spraying the plants with amica combined with MAP.

(12) pH

Data in Table 5 show that the effect of spray of strawberry plants with amica and humic acid both decreased the content of pH in fruits during storage compared with the control treatment in both seasons of study. In this connection, the lowest pH content was recorded in case of using amica followed by humic acid. Such positive effect for using amica and humic acid was true during the two seasons of growth.

Concerning the effect of postharvest treatments reveals that there were no significant differences between treatments in pH content during storage; Moreover, strawberry fruits packed in MAP resulted in lower pH concentration in fruit during storage. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012). The highest values of pH content were recorded with untreated (control). These results were true in the two seasons.

The interaction between foliar spray and all used postharvest treatments had no significant effect in fruit pH content as a result of the interaction between foliar spray and the different post harvest treatments during the storage. In this regard, the lowest value of pH content was recorded in case of using spraying the plants with amica combined with MAP.

Table 5: Effect of some pre and postharvest treatments and their interaction on total sugar content and pH of strawberry fruits at end of the storage in 2012 and 2013 seasons

Treatment		**First season (2012)**				**Second season (2013)**			
Foliar	packaging	total sugar content		pH		total sugar content		pH	
Humic acid		7.46	B	3.91	A	7.62	B	3.67	A
Amica		7.64	A	3.88	A	7.81	A	3.65	A
Spraying water		7.29	C	3.94	A	7.40	C	3.70	A
	Modified atmosphere	7.54	A	3.89	A	7.73	A	3.64	A
	Vacuum	7.47	B	3.92	A	7.62	C	3.68	A
	Vapor gard	7.41	C	3.93	A	7.54	D	3.69	A
	Chitosan	7.52	A	3.90	A	7.69	B	3.67	A
	Without	7.37	D	3.94	A	7.48	E	3.70	A
	Modified atmosphere	7.55	DE	3.89	A	7.74	C	3.64	A
	Vacuum	7.47	F	3.92	A	7.61	E	3.67	A
	Vapor gard	7.39	G	3.93	A	7.53	F	3.68	A
	Chitosan	7.53	E	3.90	A	7.70	D	3.66	A
Humic acid	**Without**	7.37	G	3.94	A	7.49	G	3.69	A
	Modified atmosphere	7.69	A	3.86	A	7.91	A	3.62	A
	Vacuum	7.64	B	3.88	A	7.82	B	3.66	A
	Vapor gard	7.60	C	3.90	A	7.75	C	3.67	A
	Chitosan	7.66	AB	3.87	A	7.88	A	3.65	A
Amica	**Without**	7.58	CD	3.91	A	7.71	D	3.68	A
	Modified atmosphere	7.39	G	3.91	A	7.53	F	3.66	A
	Vacuum	7.31	H	3.95	A	7.42	H	3.70	A
	Vapor gard	7.24	I	3.95	A	7.35	I	3.71	A
	Chitosan	7.37	G	3.92	A	7.47	G	3.69	A
Spraying water	**Without**	7.14	J	3.96	A	7.24	J	3.72	A

Values followed by the same letter (s) within column are not significantly different (P<0.05)

References

Abu-Zinada, I.A. (1988). Physiological studies on the keeping quality of snap beans. M.Sc. Thesis, Fac. Agric., Al-Azhar Univ.

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.

Amarante, C.; Banks, N.H.(2001). Postharvest physiology and quality of coated fruits and vegetables. Hortic. Rev. 26, 161–238.

A.O.A.C.(1990). Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington.

A.O.A.C. (2000). Association of Official Analytical Chemists. Washington DC. International 17th Edition, Revision I.

Awad, A.M.A. (1989). Physiological studies on the keeping quality of strawberry. M. Sc. Thesis. Fac. Agric., Al-Azhar Univ.

Caner, C. and Aday, M. S. (2009). Maintaining quality of fresh strawberries through various modified atmosphere packaging. Packaging Technology and Science, 22:115-122.

Cheour,F.J.C.;Willemot,J.; Arul,J.; Desjardins,J.; Mathlouf, P.M.; Charest, F.M. and Gosselin, A. (1990). Foliar application of calcium chloride delays postharvest ripening of strawberry. J. Amer. Soc. Hort. Sci., 115(5):785-792.

Church, N. (1994) Developments in modified atmosphere packaging and related technologies. Trends Food Sci Technol 5: 345-352.

Day, B. (1990) Modified atmosphere packaging of selected prepared fruit and vegetables. In: Processing and Quality of Foods 3: 230-233.

El Ghaouth, A.; Arul, J.; Ponnampalam, R.and Boulet, M. (1991a). Chitosan coating effect on storability and quality of strawberries. Journal of Food Science, 56, 1618–1620.

El Ghaouth, A.; Arul, J.; Ponnampalam, R. and Boulet. M. (1991b). Use of chitosan coating to reduce water-loss and maintain quality of cucumber and bell pepper fruits. Journal of Food Processing and Preservation, 15: 359–368.

El-Seifi, S.K. and Attia, H.A. (1990). Effect of calcium chlorid and Vapor gard on keeping quality of squash fruits during storage. Zagazig J. Agric. Res., 17:877-882.

Exama, A.; Aru, J.l.; Lencki, R.; Lee, L.Z. and Toupin, C. (1993). Suitability of plastic films for modified atmosphere packaging of fruits and vegetables. J. Food Sci., 58: 1365-1370.

Ghuoath, A.E.L.; Arul, J.and Ponnampalam, R. (1991). Chitosan coating effect on storability and quality of fresh strawberry. J.Food Sci.56: 1618.

Han, C.; Lederer, C.; McDaniel, M.and Zhao, Y.(2005). Sensory evaluation of fresh strawberries (*Fragaria*× *ananassa*) coated with chitosan-basededible coatings. J. Food Sci. 70, 172–180.

Han, C.; Zhao, Y.; Leonard, S.W. and Traber, M.G. (2004). Edible coatings to improve storability and enhance nutritional value of fresh and frozen strawberries (*Fragaria* × *ananassa*) and raspberries (*Rubus ideaus*). Post harvest Biology and Technology, 33: 67–78.

Harker, F.R.; Elgar, H.J.; Watkins, C.B.; Jackson, P. J. and Hallett, I.C. (2000). Physical and mechanical changes in strawberry fruit after high carbon dioxide treatments. Postharvest Biol. Technol. 19, 139–146.

Hernandez-Munoz,H.; Almenar, E.; Ocio, M.J. and Gavara, R. (2006). Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria* x *ananassa*). Postharvest Biology and Technology, 39: 247–253.

Hernandez-Munoz,H.; Almenar, E.; Valle, V. D.; Velez, D. and Gavara, R. (2008). Effect of chitosan coating combined with post harvest calcium treatment on strawberry (*Fragaria×ananassa*) quality during refrigerated storage. Food Chemistry, 110: 428–435.

Holcroft,D.M.and Kader,A.A. (1999). Controlled-atmosphere-induced changes in pH and organic acid metabolism may affect colour of stored strawberry fruit. Postharvest Biol. Technol. 17, 19–32.

Jiang, Y. M. and Li, Y. B. (2001). Effects of chitosan coating on postharvest life and quality of longan fruit. Food Chemistry, 73: 139–143.

Jobling, J. (2001). Modified atmosphere packaging: Not as simple as it seems. Good Fruit and Vegetables Magazine 11:1-3.

Jouki, M. and Khazaei, N. (2012). The effect of modified atmosphere packaging and calcium chloride dripping on the quality and shelf life of kurdistan strawberries. J. Food Process Technol, 3:2-7.

Ke D.; Goldstein L.; Mahony, K. and Kader, A.A. (1991). Effects of short-term exposure to low $O_2$and high CO_2 atmospheres on quality of strawberries. J Food Sci 56:50-54

Kittur, F. S.; Saroja, N. and Habibunnisa, R. N. (2001). Polysaccharide-based composite coating formulations for shelf-life extension of fresh banana and mango. European Food Research and Technology, 213:306–311.

Krivorot, A.M. and Dris, R.(2002). Shelf life and quality changes of strawberry cultivars. Acta Hortic., 567: 755-758.

Lazan, H.; Ali, Z.M. and Sani, H.A. (1990). Effect of vapor gard on polygalacturonase, malic enzyme and ripening of harumanis mango. Acta. Hort., 269: 359-366.

Le Lagadec,M.D.and Morudu, M. (2002). Colouring up green skin mango cultivars. Merensky Technological Services, Mariepskop Estate, Private Bag X3009, Hoedspruit 1380,daniellel@hansmeren-sky.co.za.

Lee, K.S.; Woo, K.L. and Lee, D.S. (2006a). Modified atmosphere packaging for green chili peppers. Packaging Technol. Sci., 7:51-58.

Lee, L.; Arul, J.; Lencki, R. and Castaigne, F. (2006b). A review on modified atmosphere packaging and preservation of fresh fruits and vegetables: physiological basis and practical aspects-part I. Packaging Technol. Sci., 8:315-331.

Lee, K.S. and Kader, A.A. (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops.Postharvest Biology and Technology 20: 207-220.

Manleitner, S.; Lippertand, F. and Noga, G. (2002). Influence of packaging material on quality and shelf life of strawberries Acta Horticulturae. 567:771- 773.

Manning, K. (1996). Soft fruits. In G. B. Seymour, J. E. Taylor, & G. A.Tucker (Eds.), Biochemistry of fruit ripening (pp. 347–377). London:Chapman & Hall.

McGuire, R.G.(1992). Reporting of objective color measurements. HortScience, 27: 1254- 1255.

Nunes M.C.; Morais A. M. B.; Brecht, J.K. and Sargent, S.A.(1995). Quality of strawberries after storage in controlled atmospheres at above optimum storage temperatures, Proc. Fla. State Hort. Soc.108:273-278.

P´erez, A.G. and Sanz, C.(2001). Effect of high oxygen and high carbondioxide atmospheres on strawberry flavor and other quality traits. J.Agric. Food Chem. 49, 2370–2375.

Petrisor, C.; lie, A. I.; Barbulescu, A.; Petcu, A. and Dumitru, M. (2010). Effects of refrigeration and modified atmosphere packaging on quality of strawberries. Scientific Papers of the R.I.F.G. Pitesti.

Ribeiro, C.; Vicente, A. A.; Teixeira, J. A. and Miranda, C. (2007). Optimization of edible coating composition to retard strawberry fruit senescence.Postharvest Biology & Technology, 44:63–70.

Sanz, C.; Pérez, A.G.; Olías, R. and Olías, J.M. (1999). Quality of strawberries packed with perforated polypropylene. Journal of Food Science, 64(4):748-752.

Shabana, H.R.; Al-Khalid, M.S. and Benjamin, N.D. (1985). Effect of vapor gard and some preservatives on the quality of date fruits (Zahdi cv.) at rutab stage during cold storage. J. Agri. &Water Resources. Research Center Sc., Baghdad, Iraq.,4(3):207-220.

Shehata,S.A.; Emam, M.S. and Abou EL- Wafa, S.M. (2010). Effect of active and passive modified atmosphere packaging on the quality attributes of strawberries. Annals of Agric. Sci., Moshtohor, 48(2): 119-130.

Shehata, S. A.; Gharib, A.A.; El-Mogy, M.M.; Abdel Gawad, K.F. and Shalaby, E.A. (2011). Influence of compost, amino and humic acids on the growth, yield and chemical parameters of strawberries. Journal of Medicinal Plants Research, 5(11): 2304-2308.

Snedecor, G.W. and Cochran, W.G.(1991). Statistical Methods. 8th Ed., Iowa State Univ. Press, Iowa, USA.

Thompson, A.K. (1996). Post-harvest Technology of Fruits and Vegetables, Blackwell, Oxford.

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

Wills, R.; Mcglasson, B.; Graham, D. and Joyce, D. (1998). Post harvest: An Introduction to the Physiology and Handling of fruit, Vegetables and Ornamentals. Ed.: CAB International, Wallingford, UK. Zagazig Jour. Agric. Res., 17:877-882.

11/2/2014