Improving Fruit Quality and Storability of Strawberry Fruits by Using Pre and Postharvest Treatments

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

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

Abstract: The objective of the present research was to study the pre and post-harvest changes in quality tributes of strawberry fruit during cold storage. This experiment was carried out on strawberry fruits during the two successive seasons of 2011- 2012 and 2012- 2013 to study the effect of using bio-fertilizers, i.e., effective microorganisms (EM), biofertile at the rate of 20 L / feddan in growing season and some post harvest treatments i.e., chitosan at 1.5%, and modified atmosphere packaging MAP (16%O_2 +20%CO_2) as well as their interaction to improve the keeping quality of strawberry fruits cv. Sweet Charlie during storage at 0°C and 95% relative humidity. The results indicated that the effect of bio- fertilizers applied to strawberry plants with effective microorganisms (EM) and biofertile 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 and anthocyanins content compared to other treatments. Moreover, modified atmosphere packaging (MAP) gave better results (total soluble solid percentage, titratable acidity percentage, ascorbic acid, anthocyanin, color, total sugar content and firmness) than other treatments. On the other hand, using effective microorganisms (EM) on the plants combined with (MAP) caused a significant increase in storability concerning general appearance, total soluble solid percentage, ascorbic acid, firmness, color, titratable acidity, total sugar content and anthocyanins content. Therefore, the effective microorganisms (EM) can be recommended for strawberry to improve productively, fruits quality and storability.

[Hassan, A. H. and Emam, M. S. **Improving Fruit Quality and Storability of Strawberry Fruits by Using Pre and Postharvest Treatments.** *J Am Sci* 2015;11(1s):44-50]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 7

Key Words: Strawberry Fruits**,** Effective Microorganisms (EM)**,** Biofertile**,** Chitosan, Modified Atmosphere Packaging MAP**, Cold** Storage**,** Weight Loss, Decay Percentage, Firmness**,** Color.

1. Introduction

Strawberries have short shelf life due to highly perish ability and are susceptible to mechanical injury, physiological disorders, water loss, and decay (Caner *et al.* 2008). Water loss after harvest results in wilting and shriveling and is one of the major causes of postharvest losses in perishable products. Water loss from the fruits not only leads to loss of saleable weight but also aggravates deterioration as it triggers stress ethylene production and reduces the aesthetic value of the fruits as they shrivel (Siddiqui and Dhua, 2009).

The use of bio- fertilizers may be benefit in reducing high rates of mineral fertilizers, which may help in decreasing environmental pollution and hence increasing vegetable exportation to the European countries.

EM is an abbreviation for effective microorganisms and refers to a cocktail of beneficial microorganisms that is used as a soil amendment (Woodward, 2003). EM contains selected species of microorganisms, including predominant populations of lactic acid bacteria and yeasts and smaller numbers of photosynthetic bacteria, actinomycetes and other types of organisms. Glinicki *et al.* (2011) studied the effect of EM on the vegetative growth of three strawberry cultivars. They found that EM was the most effective treatment in stimulating shoot and root growth in the strawberry cultivar `Honeoye'. They also, revealed that NPK fertilization applied to strawberry plants together with EM-farming can withstand the positive effect on strawberry plant growth, which was gained with single microbial inoculation.

Many workers reported that, inoculation of plants with *Azospirillum*, *Azotobacter*, *Rhizobium* and *Pseudomonas*, singly, in dual or in different combinations with organic and mineral fertilizers increased the growth parameters, yield and its components and chemical constituents in treated plants. The best results were obtained by the various mixture inoculation in which the reduction the amount of mineral fertilizers (Mitkees *et al.* 1996).

Strawberries are highly active metabolically (giving out 50 - 100 ml of CO_2 per kg per hour at 20°C) and may deteriorate in a relatively short time, even without the presence of decay-causing pathogens (De Ell, 2006).

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) respected that respiration rate of fruits and vegetables usually decrease with increasing CO_2 and/or decreasing O_2 concentration. Furthermore, high CO_2 concentration can inhibit the generation of C_2H_4 because it can influence the enzyme's activity, thus the permeability of cells membrane does not increase quickly. MAP is often used to maintain elevated CO2 and reduced O2 concentrations inside consumer-packaged produce containers (Exama *et al.* 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). Modified atmosphere packaging has been reported to delay physical, physiological, and biochemical changes associated with fruit ripening (Sandhya, 2010). The altered atmosphere retards physiological processes such as respiration and ethylene biosynthesis. MAP significantly reduces weight loss because the polymeric films used in MAP hinder water vapor diffusion and as a result, the internal atmosphere package becomes saturated with water vapor pressure. This condition reduces transpiration of the tissues and the resultant weight loss. Several studies show that changes in most of the physicochemical parameters associated with ripening such as total soluble solids, total titratable acidity, peel color, sugars and ascorbic acid are delayed in fruits under MAP conditions (Mathooko, 2003, Baraza, 2013).

Edible films can be used to protect perishable food products from deterioration by retarding dehydration, providing an elective barrier to moisture, oxygen and carbon dioxide, suppressing respiration, improving textural quality, helping retain volatile flavor compounds and reducing microbial growth (Lee *et al.* 2003). Edible coatings based on polysaccharides, for example mixtures of starch, carrageenan and chitosan (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. They added also that 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.

On temperate fruit the use of chitosan to control postharvest decay has been tested since many years. On strawberries the effectiveness in controlling postharvest gray mold and Rhizopus rot of chitosan coating was comparable to the one obtained with synthetic fungicide applications (El Ghaouth *et al.* 1991a; 1991b; Zhang and Quantick, 1998). *Cladosporium sp.* and *Rhizopus sp.* infections decreased in artificially inoculated strawberry fruit that were coated with chitosan and stored up to 20 days at 4-6 °C (Park *et al.* 2005).

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 bio- fertilizers with biofertile 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 effect of bio-fertilizers with effective microorganisms (EM) and biofertile as pre-harvest treatment and potential of modified atmosphere, and chitosan as postharvest treatment on preserving the quality and extends the shelf life of strawberry fruits.

2. Material and methods

Strawberry fruits of Sweet Charlie cultivar, at 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 2011- 2012 and 2012- 2013 to investigate the effect of bio-fertilizers applied with The Effective microorganisms (EM) stock solution that used in the study has been produced and a viable at Ministry of Agriculture, Egypt. EM content different of beneficial microorganisms about 80 species. The main species included in EM are as follows:-

(Lactic acid bacteria, Photosynthetic bacteria, Yeasts, Ray fungi, Fungi).

Biofertile preparation, developed at the Environmental Studies and Research Unit (ESRU), Faculty of Agriculture, Cairo University, are composites of rhizobacterial strains supporting plant nutrition (Table 1) is a mixture of rhizobacterial isolates of diazotrophic nature, i.e. efficient in biological nitrogen fixation and production of auxins, mainly gibrillic acid (Othmann *et al.* 2003, 2004). These strains with their host plants are presented in Table (1).

Bio-fertilizers were added to the absorption zone of plant roots at were added three times at transplanting, beginning of flowering and fruit setting. The two bio- fertilizers, i.e., effective microorganisms (EM) and biofertile at the rate of 20 litre / fed., in addition to the control treatment (without bio-fertilizers).

Table 1. Rhizobacterial isolates in biofertile and their host plants.

Bacterial isolates (diazotrophs)	Host plants and refrence
Azospirillum brasilense	***Ricinus communis* L. (Hamza *et al.* 1994)**
Azotobacter chroocooccum	***Hordeum vulgare* (Ali *et al.* 2005)**
Bacillus polymyxa	***Hamada elegans* (Heagazi and Fayez, 2003)**
Enterobacter agglomerans	***Malva parviflora* (Hegazi and Fayez, 2003)**
Pesudomonas putida	***Sorghum biocolor* (Hamza *et al.* 1994)**

At harvest, strawberry fruits which obtained from the previous experiments were harvested at 3/4 red color stage on the first week of January of the two seasons 2012 and 2013, sorting and grading was carried out. The homogenous samples of uniform, similar size and weight were isolated from the diseased, bruised and irregular shaped fruit and selected for further studies. Then transported in air-conditioned vans to the laboratory of Handling of Vegetable Crops Department, at Giza. 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 conditions (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), modified atmosphere packaging (MAP) infusion was carried out at 20°C in a chamber connected to a modified atmosphere packaging (MAP) pump, then flushed with a gas mixture at 16% O_2 +20%CO_2(MAP).
2- Chitosan solution was prepared by dissolving 30 g Chitosan in 2 L of 0.5% acetic acid solution, by manual stirring for solubilization and fruits were treated with Chitosan at the concentration of 1.5%, then the fruits were allowed to dry for two hours at 20°C, then the fruits were packed in plastic punnets (250g).
3- 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 completely randomized (factorial) design with three replicates. 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.

After the experiment was set up, fruits were stored in a cold room maintained at 0°C, for 15 days. Quality and chemical analysis parameters were evaluated after 0, 3, 6, 9, 12 and 15 days of storage.

The following data were recorded:

A- Fruit physical characteristics.

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

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

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**:

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) (Mc Guire, 1992).

5- **Firmness:**

Firmness recorded by TA-1000 firmness 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.

B-Fruit chemical characteristics.

1. **Total Soluble Solid percentage**: was determined by using digital refract meter (Abbe Leica model).
2. **Ascorbic Acid**: The ascorbic acid content was determined by using 2,6-dichlorophenol indophenols titration method as described by A.O.A.C (1990).

3. **Anthocyanin:** It was determined by using Hcl (1.5N) spectrophotometer as described by A.O.A.C (1990).
4. **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).
5. **Total sugar**: was determined in fresh strawberry fruits by using Lane and Eynon method according to A.O.A.C (2000).

Statistical analysis:

Data were subjected to statistical analysis for calculation of means, variance and stander error according to MSTATC software. Mean separations were estimated by calculating LSD value at 5% level according to Snedecor and Cochran (1991).

3. Results and discussion

A- Fruit physical characteristics:

(1) Weight loss:

Data in Table 2 show that the effect of bio-fertilizers applied to strawberry plants with effective microorganisms (EM) and biofertile significantly decreased the percentage of weight loss in fruits during storage compared with the control treatment during both seasons of study. In this connection, the lowest weight loss was recorded in case of using effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile 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 affects greatly fruit storage ability. In this concern, El-Shafie (2003) and Babalar *et al*. (2007) on strawberry reported that using plant guard, salicylic acid and garlic extract respectively decreased weight loss percentage in stored fruits.

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

Lowest weight loss from 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).

Chitosan 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). Chitosan has been reported to be more 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.

This confirmed the results by Garcia *et al*. (1998), who reported that the chitosan film formed on the surface of the fruit delayed migration of moisture from the fruit into the environment, thus reducing weight loss during storage.

As for storage period, the obtained data showed that weight loss percentage of strawberry fruits was increased with the prolongation of storage at 0°C in both seasons. This may be due to the loss in both the dry matter through respiration and water through respiration and evaporation from the fruit surfaces. Similar results were reported by Hernandez-Munoz *et al*. (2008), Petrisor *et al*. (2010) and Jouki and Khazaei (2012).

The highest weight loss percentage was noticed after 15 days of storage. Similar results were recorded in the two seasons of study. Obtained results may be due to the loss of water, degradation and use of complex molecules in respiration.

The lowest value of weight loss percentage was recorded in case of applying the plants with effective microorganisms (EM) combined with modified atmosphere packaging (MAP).

Applying the plants with effective microorganisms (EM) gave the lowest value of weight loss percentage during all storage period.

The obtained data showed that weight loss percentage of strawberry fruits decreased significantly by using post harvest treatments and the most decrease was observed by modified atmosphere packaging (MAP) after 15 days of storage. These results were true in the two seasons.

As for the interaction between bio- fertilizers applied, some post harvest treatments and storage period, data in Table (10 and 11) indicated that there was a significant effect in fruit weight loss percentage. In this regard, the lowest value of weight loss percentage was recorded in case of applying the plants with the effective microorganisms (EM) combined with MAP packaging during the whole storage period. On the contrary, untreated fruits (control) reflected the highest weight loss percentage for the different periods of storage. These results were true in the two seasons.

(2) Decay:

Data in Table 3 show the effect of bio- fertilizers applied to strawberry plants with effective microorganisms (EM) and biofertile on decay percentage 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 effective microorganisms (EM) followed by biofertile. Such positive effect for using effective microorganisms (EM) and biofertile was true during the two seasons of growth.

Table 2: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on weight loss % of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	0.00	0.15	0.24	0.31	0.35	0.43	0.25	0.00	0.12	0.21	0.28	0.32	0.40	0.26
	Chitosan.	0.00	0.72	1.22	1.85	2.61	2.78	1.53	0.00	0.79	1.09	1.65	2.36	2.64	1.70
	Control	0.00	1.02	1.53	2.15	2.9	3.19	1.80	0.00	0.92	1.23	1.86	2.70	2.98	1.94
	Mean	0.00	0.63	0.99	1.44	1.95	2.13	1.19	0.00	0.61	0.84	1.26	1.79	2.01	1.30
Biofertile	MAP	0.00	0.04	0.11	0.15	0.25	0.32	0.14	0.00	0.04	0.11	0.16	0.23	0.31	0.17
	Chitosan.	0.00	0.48	0.90	1.27	1.68	2.20	1.09	0.00	0.42	0.82	1.25	1.57	2.11	1.03
	Control	0.00	0.71	1.16	1.50	1.98	2.44	1.30	0.00	0.61	0.97	1.42	1.84	2.35	1.44
	Mean	0.00	0.41	0.72	0.97	1.30	1.65	0.84	0.00	0.36	0.63	0.94	1.21	1.59	0.95
EM	MAP	0.00	0.03	0.10	0.14	0.22	0.29	0.13	0.00	0.03	0.09	0.15	0.20	0.28	0.15
	Chitosan.	0.00	0.46	0.74	1.17	1.44	1.99	1.00	0.00	0.36	0.65	1.12	1.35	1.91	1.08
	Control	0.00	0.66	0.88	1.47	1.82	2.18	1.17	0.00	0.59	0.86	1.32	1.61	2.16	1.31
	Mean	0.00	0.38	0.57	0.93	1.16	1.49	0.75	0.00	0.33	0.53	0.86	1.05	1.45	0.70
B X C	MAP	0.00	0.078	0.15	0.20	0.27	0.35	0.17	0.00	0.06	0.14	0.20	0.25	0.33	0.16
	Chitosan.	0.00	0.55	0.95	1.43	1.91	2.32	1.19	0.00	0.52	0.85	1.34	1.76	2.22	1.34
	Control	0.00	0.79	1.19	1.71	2.23	2.60	1.42	0.00	0.71	1.02	1.53	2.05	2.50	1.56
General means of C		0.00	0.47	0.76	1.11	1.47	1.76	0.93	0.00	0.43	0.67	1.02	1.35	1.68	0.86
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.03							0.05						
(B)		0.02							0.02						
(C)		0.03							0.04						
Interactions:															
A X B		0.03							0.02						
AXC		0.03							0.03						
BXC		0.03							0.03						
AXBXC		0.05							0.05						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

Concerning the effect of post harvest treatments on fruit decay percentage, data in same Table 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. In additions chitosan treatment at 1.5% led to significant reduction in decay percentage during storage due to the capacity of chitosan coating to inhibit the growth of several fungi has been shown for a wide variety of harvested commodities. 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.

As for the effect of storage period, the obtained data show that decay percentage of strawberry fruits was increased with the prolongation of storage at 0°C in both seasons. The highest decay percentage was noticed after 15 days of storage. Similar results were recorded in the two seasons of study. These results are in agreement with those obtained by Jouki and Khazaei (2012).

The interaction between bio- fertilizers applied and all used post harvest treatments had a significant effect on fruit decay percentage. In this regard, the lowest value of decay percentage was recorded in case of using effective microorganisms (EM) combined with MAP.

The obtained data showed that decay percentage of strawberry fruits was decreased significantly by using post harvest treatments and noticed that strawberry fruits packed in MAP did not show any sign of fungal decay after 15 days of storage. Also chitosan treatment at 1.5% led to significant reduction in decay percentage after 15 days of storage. These results were true in the two seasons.

As for the interaction between bio- fertilizers applied, post harvest treatments and storage period, data in Table 3 indicate that there was a significant effect on fruit decay percentage. In this regard, applying the plants with effective microorganisms (EM) combined with MAP did not show any sign of fungal decay during all storage periods, the lowest value of decay percentage was recorded in case of applying the plants with effective microorganisms (EM) combined with Chitosan during all storage periods. On the contrary, untreated fruits (control) reflected the highest decay percentage within the different periods of storage. These results were true in the two seasons.

Table 3: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on decay % of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chitosan.	0.00	0.00	0.00	0.00	0.00	4.04	0.67	0.00	0.00	0.00	0.00	0.00	3.60	0.60
	Control	0.00	0.00	6.42	6.98	15.77	23.17	8.72	0.00	0.00	5.79	5.89	14.76	16.99	7.24
	Mean	0.00	0.00	2.14	2.33	5.26	9.07	3.13	0.00	0.00	1.93	1.96	4.92	6.86	2.61
Biofertile	MAP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chitosan.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Control	0.00	0.00	0.00	4.04	7.16	15.14	4.39	0.00	0.00	0.00	3.60	6.42	14.76	4.13
	Mean	0.00	0.00	0.00	1.35	2.39	5.05	1.46	0.00	0.00	0.00	1.20	2.14	4.92	1.38
EM	MAP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chitosan.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Control	0.00	0.00	0.00	3.50	6.56	13.43	3.91	0.00	0.00	0.00	1.85	5.89	12.53	3.38
	Mean	0.00	0.00	0.00	1.17	2.19	4.48	1.30	0.00	0.00	0.00	0.62	1.96	4.18	1.13
B X C	MAP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chitosan.	0.00	0.00	0.00	0.00	0.00	1.34	0.22	0.00	0.00	0.00	0.00	0.00	1.20	0.20
	Control	0.00	0.00	2.14	4.84	9.83	17.25	5.68	0.00	0.00	1.93	3.78	9.02	14.76	4.91
General means of C		0.00	0.00	0.71	1.61	3.28	6.197	1.97	0.00	0.00	0.64	1.26	3.01	5.32	1.70
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.82							0.59						
(B)		0.74							0.88						
(C)		0.56							0.43						
Interactions:															
A X B		1.02							0.88						
AXC		1.17							1.00						
BXC		1.16							1.00						
AXBXC		1.89							1.62						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

(3) General appearance:

Data in Table 4 reveal that the effect of bio-fertilizers applied to strawberry plants including effective microorganisms (EM) and biofertile significantly affected fruit general appearance score.These treatments 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 values of general appearance score were recorded in case of using effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile 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, fruits stored in MAP and treated with exhibited the highest values of chitosan general appearance during storage. These results are in agreement with those obtained by Jouki and Khazaei (2012) who showed that MAP treatment had significant effect on appearance. Strawberries under MAP had better appearance and firmness than strawberries packed under air. The lowest values of general appearance score were recorded with untreated (control). These results were true in the two seasons.

The greater visual acceptance for coated strawberries by consumers correlates with the lower levels of dehydration and darkening experienced by them during storage (Hernandez-Munoz *et al.* 2008).

Concerning storage period, obtained data show that there was a significant reduction in general appearance score by the prolongation of storage period in both seasons. Similar results were reported by Jouki and Khazaei (2012).

The combined effect of bio- fertilizers applied and post harvest treatments caused significant increases in general appearance score of strawberry.The highest general appearance score was obtained by the interaction of applying the plants with effective microorganisms (EM) combined with MAP. On the contrary, the lowest values of general appearance score were recorded with untreated (control) and applying water. These results were similar in the two seasons.

As respect to the interaction among bio-fertilizers applied and storage period, data show that the highest value of general appearance score after 15days were found with applying the strawberry plants with The effective microorganisms (EM) and storing at 0°C.

Concerning the interaction between postharvest treatments and storage period, results show that MAP after 15 days of storage gave the highest value of general appearance score in the two studied seasons.

The interaction between bio- fertilizers applied, post harvest treatments and storage period had a significant effect on general appearance score in the two seasons. Applying the plants with effective microorganisms (EM) combined with fruits packed in MAP have the highest value of general appearance during all storage periods. Obtained results are similar during both seasons of study.

Table 4: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on general appearance (score) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	9.00	9.00	9.00	9.00	7.66	7.00	8.40	9.00	9.00	9.00	9.00	8.33	7.66	8.70
	Chitosan.	9.00	9.00	9.00	9.00	7.00	5.66	8.10	9.00	9.00	9.00	9.00	7.66	6.33	8.30
	Control	9.00	6.33	4.33	3.00	2.33	1.66	4.40	9.00	7.00	5.00	3.66	3.00	2.33	5.00
	Mean	9.00	8.10	7.40	7.00	5.70	4.80	7.00	9.00	8.30	7. 70	7.20	6.33	5.40	7.30
Biofertile	MAP	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
	Chitosan.	9.00	9.00	9.00	9.00	9.00	7.00	8.70	9.00	9.00	9.00	9.00	9.00	7.00	8. 70
	Control	9.00	7.00	6.33	5.66	5.00	3.66	6.10	9.00	7.00	6.33	5.66	5.00	3.66	6.10
	Mean	9.00	8.30	8.10	7.90	7. 70	6.50	7.90	9.00	8.30	8.10	7.90	7. 70	6.50	7.90
EM	MAP	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
	Chitosan.	9.00	9.00	9.00	9.00	8.40	7.80	8.70	9.00	9.00	9.00	9.00	9.00	7.00	8. 70
	Control	9.00	7.54	7.00	5.66	5.00	3.66	6.30	9.00	7.70	7.00	6.33	5.00	4.33	6. 60
	Mean	9.00	8.50	8.30	7.90	7.50	6.80	8.00	9.00	8. 60	8.30	8.10	7. 70	6.80	8.10
B X C	MAP	9.00	9.00	9.00	9.00	8.55	8.33	8.00	9.00	9.00	9.00	9.00	8.77	8.55	8.90
	Chitosan.	9.00	9.00	9.00	9.00	8.33	6.55	8.50	9.00	9.00	9.00	9.00	8.55	6.77	8.50
	Control	9.00	6.77	5.88	4.77	4.11	3.00	5.60	9.00	7.00	6.11	5.22	4.33	3.44	5.80
General means of C		9.00	8.30	8.00	7.60	7.00	5.96	7.60	9.00	8.30	8.04	7.70	7.20	6.20	7.80
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.42							1.62						
(B)		0.98							0.70						
(C)		0.27							0.27						
Interactions:															
A X B		0.41							0.45						
AXC		0.47							0.51						
BXC		0.46							0.51						
AXBXC		0.75							0.83						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

(4) Surface 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 chrome value describes its brightness while the hue angle represents a coordinate in a standardized color space.

Data illustrated in (Tables 5, 6 and 7) show that significant differences were found between bio-fertilizers applied treatments, whereas The effective microorganisms (EM) applied 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 the effective microorganisms (EM) and biofertile 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 color development rate of strawberry increased with increasing maturation. As in the present study, decrease in the L* value of strawberry fruit had previously been reported by Nunes *et al.* (2005) and Almenar *et al.* (2007).

Data presented in (Tables 5, 6 and 7) demonstrate that color of strawberry fruits (L* values) decreased with prolongation of storage period, while C* and H° values increased with prolongation of storage period until 6 days of storage at 0°C and then decreased till the end of storage in both seasons. Similar results were obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012).

Concerning the interaction between all used pre harvest and post harvest treatments such interaction treatments had a significant effect on L*, C* and H° values as a result of the interaction between the different post harvest treatments and bio- fertilizers applied during the growth seasons. In this regard, the highest value of L*, C* and H° values was recorded in case of treatment the plants with effective microorganisms (EM) combined with MAP.

The interaction between bio- fertilizers applied and storage period show that strawberry fruits produced by using effective microorganisms (EM) and biofertile recorded the highest value of L*, C* and H° after 15 days of storage.

The combined between postharvest treatments and storage period showed that chitosan coating caused generally highest value of L*, C* and H° at any storage period. Such effect was significant in the two seasons.

Table 5: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on L. color (L*- value) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	38.86	38.75	38.26	37.68	37.08	36.45	37.85	40.16	39.73	39.31	38.75	38.37	37.85	39.03
	Chitosan.	38.86	38.80	38.31	37.76	37.24	36.61	37.93	40.16	39.81	39.36	38.87	38.46	38.01	39.11
	Control	38.86	38.50	38.02	37.41	36.64	35.92	37.56	40.16	39.49	39.12	38.63	37.89	37.42	38.78
	Mean	38.86	38.68	38.20	37.62	36.99	36.33	37.78	40.16	39.68	39.26	38.75	38.24	37.76	38.97
Biofertile	MAP	41.37	41.11	40.69	40.28	39.91	39.52	40.48	41.87	41.60	41.19	40.87	40.56	40.09	41.03
	Chitosan.	41.37	41.12	40.73	40.32	39.96	39.52	40.50	41.87	41.65	41.20	40.90	40.62	40.17	41.07
	Control	41.37	40.98	40.59	40.11	39.81	39.32	40.36	41.87	41.56	41.15	40.79	40.42	39.86	40.94
	Mean	41.37	41.07	40.67	40.24	39.89	39.45	40.45	41.87	41.60	41.18	40.85	40.53	40.04	41.01
EM	MAP	42.97	42.70	42.36	41.92	41.49	41.12	42.09	43.29	43.02	42.61	42.00	41.61	41.38	42.32
	Chitosan.	42.97	42.72	42.40	41.95	41.56	41.23	42.14	43.29	43.9	42.63	42.05	41.67	41.40	42.49
	Control	42.97	42.64	42.28	41.79	41.37	40.91	41.99	43.29	42.95	42.57	41.91	41.45	41.18	42.22
	Mean	42.97	42.69	42.35	41.89	41.47	41.087	42.07	43.29	43.29	42.60	41.99	41.58	41.32	42.34
B X C	MAP	41.07	40.85	40.43	39.96	39.51	39.03	40.14	41.78	41.45	41.04	40.64	40.18	38.62	40.62
	Chitosan.	41.07	40.89	40.48	40.03	39.58	39.14	40.20	41.78	41.52	41.06	40.62	40.25	39.87	40.85
	Control	41.07	40.71	40.30	39.67	39.27	38.79	39.97	41.78	41.33	40.95	40.44	39.92	39.49	40.65
General means of C		41.07	40.87	40.40	39.89	39.45	38.99	40.10	41.78	41.43	41.02	40.57	40.12	39.33	40.71
LSD at 0.05 probability level:															
Main Factors:															
(A)		1.10							1.28						
(B)		ns							ns						
(C)		0.48							1.28						
Interactions:															
A X B		1.01							1.81						
AXC		1.15							2.05						
BXC		1.15							2.05						
AXBXC		1.87							3.33						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

The effects of the interaction between bio- fertilizers applied, postharvest treatments and storage period were significant in the two seasons. After 15 days of storage at 0°C, strawberry fruits packed in MAP at 16% O_2 +20% CO_2 combined with applying the plants with effective microorganisms (EM) or treated fruits with chitosan combined with applying the plants with effective microorganisms (EM) had the highest values of L*, C* and H° with non-significant differences between them.

(5) Firmness:

Data illustrated in Table 8 show that bio- fertilizers applied to strawberry plants with effective microorganisms (EM) and biofertile significantly affected fruit firmness and resulted in higher firmness value in fruits during the storage compared with the control treatment during both seasons of study. In this connection, the highest firmness was recorded in case of using effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile was true during the two seasons of growth.

Concerning the effect of post harvest treatments (Chitosan and MAP) on firmness. Data in the same Table reveal that there were significant differences between treatments in firmness during storage; however, all treatments retained their 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 firmness during storage at 0°C, followed by Chitosan treatment as compared with control (untreated fruits). 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 (control). These results were true in the two seasons.

Table 6: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on C- color (C*- value) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	43.01	43.41	43.78	42.98	42.36	41.72	42.87	45.19	45.38	45.92	45.48	44.96	44.37	45.22
	Chitosan.	43.01	43.45	43.82	43.06	42.54	42.09	42.99	45.19	45.44	45.96	45.65	45.39	44.78	45.40
	Control	43.01	43.31	43.66	42.23	41.45	40.97	42.44	45.19	45.24	45.76	45.09	44.34	43.51	44.855
	Mean	43.01	43.39	43.75	42.76	42.12	41.59	42.77	45.19	45.35	45.88	45.41	44.90	44.22	45.16
Biofertile	MAP	43.91	44.29	44.46	44.21	43.81	43.47	44.02	45.52	45.88	46.09	45.76	45.50	45.23	45.66
	Chitosan.	43.91	44.32	44.54	44.26	43.98	43.71	44.12	45.52	45.93	46.26	45.89	45.66	45.41	45.78
	Control	43.91	44.18	44.31	43.65	43.22	42.61	43.65	45.52	45.77	45.92	45.32	44.92	44.28	45.29
	Mean	43.91	44.26	44.45	44.04	43.67	43.26	43.93	45.52	45.86	46.09	45.66	45.36	44.97	45.58
EM	MAP	44.15	44.37	44.65	44.49	44.19	43.82	44.28	46.05	46.25	46.60	46.49	46.17	45.82	46.23
	Chitosan.	44.15	44.41	44.70	44.53	44.32	44.10	44.37	46.05	46.28	46.63	46.51	46.24	45.88	46.265
	Control	44.15	44.27	44.53	44.03	43.63	43.02	43.94	46.05	46.16	46.47	46.08	45.73	45.20	45.95
	Mean	44.15	44.35	44.63	44.35	44.05	43.65	44.19	46.05	46.23	46.57	46.36	46.05	45.63	46.15
B X C	MAP	43.69	44.02	44.30	43.90	43.45	43.00	43.73	45.59	45.84	46.20	45.91	45.55	45.14	45.70
	Chitosan.	43.69	44.06	44.35	43.95	43.61	43.30	43.83	45.59	45.89	46.28	46.02	45.76	45.36	45.82
	Control	43.69	43.92	44.17	43.30	42.77	42.20	43.34	45.59	45.73	46.05	45.50	45.00	44.33	45.37
General means of C		43.69	44	44.27	43.72	43.28	42.83	43.63	45.59	45.82	46.18	45.81	45.44	44.94	45.63
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.73							0.54						
(B)		0.41							0.38						
(C)		0.94							0.58						
Interactions:															
A X B		1.06							0.90						
AXC		1.20							1.02						
BXC		1.20							1.02						
AXBXC		1.95							1.66						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

Table 7: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on H- color (hue angle) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	45.06	45.38	45.65	45.42	44.91	44.64	45.18	47.31	47.57	47.78	47.37	46.98	46.65	47.28
	Chitosan.	45.06	45.41	45.67	45.46	45.02	44.78	45.23	47.31	47.62	47.81	47.45	47.45	46.78	47.40
	Control	45.06	45.30	45.51	45.08	44.42	44.05	44.90	47.31	47.45	47.61	47.14	46.53	46.16	47.03
	Mean	45.06	45.36	45.61	45.32	44.78	44.49	45.10	47.31	47.55	47.73	47.32	46.99	46.53	47.24
Biofertile	MAP	45.95	46.23	46.45	46.30	46.02	45.69	46.11	48.01	48.23	48.42	48.33	48.04	47.78	48.13
	Chitosan.	45.95	46.26	46.49	46.38	46.07	45.78	46.15	48.01	48.27	48.49	48.38	48.11	47.89	48.19
	Control	45.95	46.11	46.27	46.09	45.73	45.30	45.91	48.01	48.13	48.31	48.19	47.81	47.48	47.99
	Mean	45.95	46.20	46.40	46.26	45.94	45.59	46.06	48.01	48.21	48.41	48.3	47.99	47.72	48.10
EM	MAP	46.22	46.43	46.69	46.59	46.38	46.12	46.405	48.27	48.46	48.69	48.57	48.39	48.07	48.41
	Chitosan.	46.22	46.45	46.73	46.66	46.42	46.17	46.44	48.27	48.51	48.73	48.65	48.47	48.19	48.47
	Control	46.22	46.34	46.59	46.43	46.09	45.81	46.25	48.27	48.36	48.59	48.42	48.17	47.85	48.28
	Mean	46.22	46.41	46.67	46.56	46.30	46.03	46.36	48.27	48.44	48.67	48.55	48.34	48.04	48.385
B X C	MAP	45.74	46.01	46.26	46.10	45.77	45.48	45.89	47.86	48.09	48.30	48.09	47.80	47.50	47.94
	Chitosan.	45.74	46.04	46.29	46.15	45.82	45.52	45.93	47.86	48.13	48.34	48.16	47.89	47.62	48.00
	Control	45.74	45.92	46.12	45.86	45.41	45.06	45.68	47.86	47.98	48.17	47.92	47.50	47.16	47.76
General means of C		45.74	45.99	46.22	46.04	45.67	45.35	45.83	47.86	48.07	48.27	48.06	47.73	47.43	47.90
LSD at 0.05 probability level:															
Main Factors:															
(A)		1.03								0.98					
(B)		ns								ns					
(C)		0.65								0.63					
Interactions:															
A X B		1.01								0.91					
AXC		1.15								1.03					
BXC		1.14								1.03					
AXBXC		1.85								1.68					

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

Table 8: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on firmness g/cm^2 of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	10.97	10.60	10.43	9.90	9.36	9.00	10.04	11.30	11.07	10.90	10.43	10.20	9.66	10.59
		10.97	10.43	10.27	9.60	9.16	8.82	9.87	11.30	10.76	10.57	10.27	9.63	9.34	10.31
	Control	10.97	10.20	10.00	9.36	8.86	8.30	9.61	11.30	10.23	9.73	9.20	8.86	8.58	9.65
	Mean	10.97	10.41	10.23	9.62	9.13	8.71	9.84	11.3	10.69	10.4	9.97	9.56	9.19	10.18
Biofertile	MAP	12.00	11.90	11.84	11.67	11.35	11.00	11.63	13.00	12.74	12.33	12.18	12.00	11.67	12.32
	Chitosan.	12.00	11.77	11.65	11.50	11.15	10.62	11.45	13.00	12.65	12.15	11.98	11.65	11.33	12.13
	Control	12.00	11.33	11.17	11.00	10.50	10.00	11.00	13.00	12.00	11.67	11.46	10.85	10.42	11.57
	Mean	12.00	11.67	11.55	11.39	11.00	10.54	11.36	13	12.46	12.05	11.87	11.50	11.14	12.00
EM	MAP	12.23	12.17	12.00	11.83	11.50	11.33	11.77	14.67	14.43	14.17	14.00	13.82	13.46	14.09
	Chitosan.	12.23	12.10	11.93	11.67	11.33	11.00	11.71	14.67	14.32	14.00	13.83	13.50	13.31	13.94
	Control	12.23	11.67	11.50	11.17	10.83	10.33	11.29	14.67	13.50	13.12	12.65	12.42	12.00	13.06
	Mean	12.23	11.98	11.81	11.56	11.22	10.89	11.62	14.67	14.08	13.76	13.49	13.25	12.92	13.70
B X C	MAP	11.73	11.56	11.42	11.13	10.73	10.45	11.17	12.99	12.75	12.43	12.16	11.94	11.58	12.31
	Chitosan.	11.73	11.43	11.29	10.93	10.54	10.16	11.01	12.99	12.58	12.24	12.03	11.60	11.38	12.14
	Control	11.73	11.07	10.89	10.51	10.06	9.52	10.63	12.99	11.91	11.52	11.12	10.74	10.32	11.43
General means of C		11.73	11.35	11.20	10.86	10.44	10.04	10.94	12.99	12.41	12.06	11.77	11.43	11.09	11.96
LSD at 0.05 probability level:															
Main Factors:															
(A)		1.45							1.74						
(B)		1.10							1.32						
(C)		0.68							1.12						
Interactions:															
A X B		1.02							1.85						
AXC		1.17							2.11						
BXC		1.16							2.11						
AXBXC		1.89							3.42						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

The results obtained in this study are in agreement with other studies, which have generally reported that fruits stored in MAP are firmer than those stored in air (Ozkaya *et al.* 2009 and Nunes *et al*. 2005). Gains in firmness were greater for strawberries packed under MAP owing to the increasing CO_2concentration in the package headspace (Jouki and Khazaei, 2012).

Concerning storage period, obtained data showed that there was a significant reduction in fruit firmness by the prolongation of storage period in both seasons. Similar results were reported by Petrisor *et al.* (2010), Jouki and Khazaei (2012).This decrease may be due to the active role of protopectinase, pectin methyl estrase (pectin estrase or pectase) and polygalacturonase which convert the unsoluble protopectins to soluble pectins.

The combined effect of bio- fertilizers applied and post harvest treatments caused significant increases in fruit firmness of strawberry.The highest fruit firmness was obtained by the interaction of applying the plants with effective microorganisms (EM) combined with MAP at 16% O_2 +20% CO_2.On the contrary, the lowest values of firmness were recorded with untreated (control) and applying water. These results were similar in the two seasons.

The interaction among bio- fertilizers applied and storage period show that the highest value of firmness after 15days were found with using applying the strawberry plants with the effective microorganisms (EM) and storing at 0°C.

Concerning the interaction, the combination between postharvest treatments and storage period showed that MAP after 15 days of storage gave the highest value of firmness in the two studied seasons.

As respect to the interaction between bio-fertilizers applied, post harvest treatments and storage period such interactions had a significant effect on fruit firmness in the two seasons. Applying the plants with effective microorganisms (EM) combined with fruits packed in MAP have the highest value of fruit firmness for all storage periods. Obtained results are similar during both seasons of study.

B-Fruit chemical characteristics:

(1) Total soluble solids:

Data in the Table 9 show the effect bio-fertilizers applied of strawberry plants with effective microorganisms (EM) and biofertile significantly affected their TSS percentage and resulted in higher TSS percentage value in fruits during storage compared with the control treatment during both seasons of study. In this connection, the highest TSS percentage was recorded in case of using effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile was true during the two seasons of growth.

Table 9: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on TSS % of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	9.43	9.63	9.76	9.86	9.63	9.26	9.59	10.13	10.27	10.33	10.47	10.17	9.83	10.20
	Chitosan.	9.43	9.60	9.73	9.83	9.50	9.16	9.54	10.13	10.23	10.30	10.43	10.07	9.70	10.14
	Control	9.43	9.50	9.63	9.70	9.26	8.70	9.37	10.13	10.17	10.20	10.27	9.86	9.36	10.00
	Mean	9.43	9.50	9.63	9.70	9.26	8.70	9.50	10.13	10.17	10.20	10.27	9.86	9.36	10.11
Biofertile	MAP	10.67	10.83	10.97	11.07	10.80	10.43	10.79	10.77	10.97	11.07	11.13	10.83	10.50	10.87
	Chitosan.	10.67	10.80	10.93	11.03	10.73	10.30	10.74	10.77	10.93	11.03	11.10	10.80	10.40	10.84
	Control	10.67	10.70	10.53	10.90	10.33	9.77	10.48	10.77	10.83	10.90	11.00	10.53	10.03	10.68
	Mean	10.67	10.78	10.81	11.00	10.62	10.17	10.67	10.77	10.91	11.00	11.08	10.72	10.31	10.80
EM	MAP	11.00	11.13	11.27	11.40	11.23	10.90	11.15	11.17	11.30	11.37	11.47	11.30	10.97	11.26
	Chitosan.	11.00	11.10	11.23	11.37	11.20	10.83	11.12	11.17	11.23	11.27	11.40	11.25	10.93	11.21
	Control	11.00	11.03	11.13	11.23	10.77	10.33	10.91	11.17	11.20	11.23	11.27	10.84	10.53	11.04
	Mean	11.00	11.09	11.21	11.33	11.07	10.69	10.96	11.17	11.24	11.29	11.38	11.13	10.81	11.17
B X C	MAP	10.37	10.53	10.67	10.78	10.56	10.20	10.52	10.69	10.84	10.92	11.02	10.75	10.43	10.77
	Chitosan.	10.37	10.50	10.63	10.74	10.48	10.10	10.47	10.69	10.80	10.87	10.98	10.71	10.34	10.73
	Control	10.37	10.41	10.53	10.61	10.12	9.60	10.27	10.69	10.73	10.82	10.86	10.41	9.94	10.575
General means of C		10.37	10.48	10.61	10.71	10.39	10.00	10.42	10.69	10.79	10.87	10.95	10.62	10.24	10.69
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.50							0.59						
(B)		ns							ns						
(C)		0.34							0.42						
Interactions:															
A X B		0.55							0.53						
AXC		0.63							0.61						
BXC		0.63							0.61						
AXBXC		1.02							0.99						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

Data illustrated in the same Table show that the effect of post harvests treatments (Chitosan and MAP) on total soluble solids. Data reveal that there were no significant differences between treatments in TSS percentage during storage. Moreover, MAP was the most effective treatment in reducing the loss of TSS percentage during storage at 0°C, followed by Chitosan treatment. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012). The lowest value of TSS percentage was recorded with untreated (control). These results were true in the two seasons.

Data presented in the same Table **d**emonstrate that total soluble solids percentage of strawberry fruits increased with prolongation of storage period until 9 days of storage at 0°C and then decreased till the end of storage in both seasons.Similar results were obtained by Petrisor *et al.* (2010).

On discussing the previous results, it may be noted that the changes in TSS percentage at any storage period is the resultant of three aspects. The first aspect is the loss of dry matter by means of respiration and metabolic activity. Secondly, the inversion of insoluble compounds to simple soluble substances. The third aspect is the loss of moisture from the fruits by evaporation or respiration. Thus, the tendency to fluctuations in TSS percentage during storage may be attributed to the equal rate of dry matter 1osses on one side and the rate of moisture loss as well as the inversion to simpler forms on the other side.

Concerning the interaction between bio-fertilizers applied and all used post harvest treatments such interactions had a significant effect on TSS percentage during the storage. In this regard, the highest value of TSS percentage was recorded in case of applying the plants with effective microorganisms (EM) combined with MAP.

As for the interaction between bio- fertilizers applied and storage period data showed that strawberry fruits of plants applied with effective microorganisms (EM) and biofertile recorded the highest value of TSS percentage after 15 days of storage.

The combined between postharvest treatments and storage period showed that MAP caused generally the highest value of TSS percentage at any storage period. Such effect was significant in the two seasons.

The interaction between bio- fertilizers applied, postharvest treatments and storage period was significant in the two seasons. After 15 days of storage at 0°C, applying the plants with effective microorganisms (EM) combined with strawberry fruits packed in MAP or applying the plants with effective microorganisms (EM) combined with fruits treated with chitosan had the highest values of TSS % with non-significant differences between them.

(2) Ascorbic acid content:

Data in Table 10 reveal that there were no significant differences due to bio- fertilizers applied treatments in ascorbic acid content during storage in both seasons. Moreover in the second season strawberry plants treated with effective microorganisms (EM) resulted in maintaining higher ascorbic acid content compared with the other treatment (Biofertile). These results are in agreement with those obtained by Lee and Kader (2000) and Manleitner *et al.* (2002).

Data presented in the same Table demonstrate that there were no significant differences due to post harvest treatments in ascorbic acid content during storage in both seasons. However, 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).

Concerning storage period, obtained data show that there was a significant reduction in ascorbic acid content by the prolongation of storage period in both seasons. Similar results were reported by Lee and Kader (2000) and Manleitner *et al.* (2002).

In explaining the previous trend of decrease, it could be mentioned that ascorbic acid acts as a catalyst in respiration, and has an important role in the biological and biochemical oxidation - reduction reactions during the various vital processes occurring in stored fruits.

Furthermore ascorbic acid is known to be in equilibrium with its oxidized form. Thus, the previous decrease may be attributed to its distraction and exhaustion during respiration as well as to the transference of ascorbic acid to its oxidized form.

The combined effect of bio- fertilizers applied and post harvest treatments caused statistical increases in ascorbic acid content of strawberry.The highest ascorbic acid content of fruit was obtained by the interaction of applying the plants with effective microorganisms (EM) combined with MAP. On the contrary, the lowest values of ascorbic acid content were recorded with untreated control treatment. These results were similar in the two seasons.

The interaction among bio- fertilizers applied and storage period showed that the highest value of ascorbic acid content after 15days were found with using effective microorganisms (EM), stored at 0°C.

Concerning the interaction between postharvest treatments and storage period data show that MAP after 15 days of storage gave the highest value of ascorbic acid content in the two studied seasons.

As respect to the interaction between bio-fertilizers applied, post harvest treatments and storage period had significant effect on ascorbic acid content of fruit in the two seasons. In this respect treatment plants with effective microorganisms (EM) combined with fruits packed in MAP at have the highest value of ascorbic acid content during all storage period. Obtained results are similar during both seasons of study.

Table 10: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on vitamin C (mg/100g F.W.) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	46.42	45.94	45.46	44.81	44.12	43.07	44.97	46.61	46.21	45.72	45.17	44.48	43.35	45.26
	Chitosan.	46.42	45.87	45.36	44.72	43.90	42.59	44.81	46.61	46.13	45.63	45.06	44.38	43.32	45.19
	Control	46.42	45.46	45.13	45.59	43.57	42.34	44.75	46.61	45.79	45.39	44.67	44.10	43.01	44.93
	Mean	46.42	45.76	45.32	45.04	43.86	42.67	44.84	46.61	46.04	45.58	44.97	44.32	43.23	45.12
Biofertile	MAP	47.07	46.67	46.20	45.77	44.97	43.89	45.76	47.20	46.97	46.63	46.20	45.50	44.57	46.18
	Chitosan.	47.07	46.60	46.18	45.74	44.87	43.69	45.69	47.20	46.91	46.55	46.15	45.32	44.39	46.09
	Control	47.07	46.51	46.02	45.59	44.76	43.45	45.57	47.20	46.81	46.41	45.94	45.15	44.12	45.94
	Mean	47.07	46.59	46.13	45.7	44.87	43.68	45.67	47.2	46.89	46.53	46.10	45.32	44.36	46.07
EM	MAP	47.30	46.87	46.53	46.17	45.57	44.41	46.14	47.40	47.27	47.03	46.67	46.17	45.30	46.64
	Chitosan.	47.30	46.85	46.49	46.09	45.54	44.36	46.10	47.40	47.05	46.91	46.52	45.89	45.10	46.48
	Control	47.30	46.61	46.37	45.93	45.32	44.02	45.92	47.40	46.88	46.63	46.21	45.72	44.57	46.23
	Mean	47.3	46.77	46.46	46.06	45.48	44.26	46.06	47.4	47.07	46.86	46.47	45.93	44.99	46.45
B X C	MAP	46.93	46.48	46.01	45.58	44.87	43.80	45.61	47.07	46.81	46.46	46.01	45.38	44.40	46.02
	Chitosan.	46.93	46.44	46.02	45.53	44.77	43.54	45.54	47.07	46.70	46.36	45.92	45.22	44.27	45.92
	Control	46.93	46.19	45.84	45.35	44.58	43.27	45.36	47.07	46.49	46.49	45.61	44.99	43.90	45.76
General means of C		46.93	46.37	45.96	45.49	44.74	43.54	45.50	47.07	46.67	46.44	45.85	45.20	44.19	45.90
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.82							1.27						
(B)		ns							ns						
(C)		0.58							0.13						
Interactions:															
A X B		1.07							0.79						
AXC		1.21							0.90						
BXC		1.22							0.90						
AXBXC		1.97							1.46						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

Table 11: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on anthocyanin content (mg/100g F.W.) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	84.2	84.9	86.3	88.7	90.6	91.0	87.6	82.9	83.1	85.6	86.4	86.6	88.4	85.5
	Chitosan.	84.2	85.0	86.7	88.8	90.7	91.1	87.7	82.9	83.3	85.9	86.8	86.9	88.7	85.75
	Control	84.2	85.5	87.6	89.8	91.6	91.9	88.4	82.9	83.2	86.4	87.0	87.9	89.1	86.1
	Mean	84.2	85.1	86.9	89.1	91.0	91.3	87.9	82.9	83.2	86.0	86.7	87.1	88.7	85. 8
Biofertile	MAP	81.0	81.8	84.8	85.9	88.5	89.1	85.2	76.3	77.0	79.2	81.1	82.2	84.6	80.1
	Chitosan.	81.0	81.9	84.9	86.2	88.9	89.4	85.4	76.3	77.1	79.3	81.3	82.3	76.3	78.8
	Control	81.0	82.9	85.4	86.8	89.3	89.9	85.9	76.3	77.9	80.2	82.3	83.2	85.3	80.9
	Mean	81.0	82.2	85.0	86.3	88.9	89.5	85.5	76.3	77.3	79.6	81.6	82.6	82.1	79.9
EM	MAP	79.2	79.4	81.6	82.9	83.8	84.6	81.9	73.7	74.7	75.8	77.4	79.4	80.0	76.8
	Chitosan.	79.2	79.6	81.7	83.2	84.1	84.8	82.1	73.7	74.8	75.9	77.6	79.7	80.1	77.0
	Control	79.2	80.0	82.3	84.6	85.1	85.8	82.8	73.7	75.1	76.1	77.9	80.2	80.9	77.3
	Mean	79.2	79. 7	81.9	83.6	84.3	85.1	82. 3	73.7	74.9	75.9	77.6	79.8	80.3	77.0
B X C	MAP	81.5	82.0	84.2	85.8	87.7	88.2	84.9	77.6	78.3	80.3	81.7	82.8	84.4	80.8
	Chitosan.	81.5	82.1	84.4	86.0	87.8	88.3	85.0	77.6	78.3	80.4	81.8	83.0	84.5	80.9
	Control	81.5	82.8	85.1	87.1	88.7	88.3	85.6	77.6	78.7	80.9	82.4	83.8	85.1	81.4
General means of C		81.5	82.3	84.6	86.3	88.1	88.3	85.2	77.6	78.4	80.5	82.0	83.2	84. 7	81.0
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.46							0.41						
(B)		0.59							0.33						
(C)		0.69							0.59						
Interactions:															
A X B		0.83							0.75						
AXC		0.95							0.83						
BXC		0.94							0.82						
AXBXC		1.53							1.23						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

(3) Anthocyanins content:

As shown in Table 11 data indicate that applying strawberry plants with effective microorganisms (EM) and biofertile 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 effective microorganisms (EM) followed by biofertile. Such positive effect for using effective microorganisms (EM) and biofertile 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). In additions, 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.

Data in the same Table demonstrate that anthocyanin content of strawberry fruits increased with prolongation of storage period till the end of storage in both seasons. These results are in agreement with those obtained by Abu-Zahra *et al*. (2005), Nunes *et al*. (2005), Petrisor *et al*. (2010) and Almenar *et al.* (2007) who found an increase in anthocyanin concentration during strawberry storage, due to continuous synthesis of this pigment especially in fruits wrapped with PVC film.

The combined effect of bio- fertilizers applied and post harvest treatments caused statistical decreases in anthocyanins content of strawberry.The lowest anthocyanins content of fruit was obtained by the interaction of applying the plants with effective microorganisms (EM) combined with MAP. On the contrary, the highest values of anthocyanins content were recorded with untreated (control) and applying water. These results were similar in the two seasons.

The interaction among bio- fertilizers applied and storage period showed that the lowest value of anthocyanins content after 15days were found with using effective microorganisms (EM) and storing at 0°C.

Concerning the interaction, the combination between postharvest treatments and storage period showed that MAP after 15 days of storage gave the lowest value of anthocyanins content in the two studied seasons.

As respect to the interaction between bio-fertilizers applied, postharvest treatments and storage period these interactions had significant effect on the anthocyanins content of fruit in the two seasons. Applying the plants with effective microorganisms (EM) combined with fruits packed in MAP has the lowest value of anthocyanins content during all storage period. Obtained results are similar during both seasons of study.

Table 12: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on titratable acidity % of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	0.800	0.793	0.760	0.726	0.676	0.663	0.736	0.876	0.870	0.853	0.816	0.800	0.750	0.827
	Chitosan.	0.800	0.783	0.743	0.693	0.643	0.593	0.709	0.876	0.853	0.810	0.776	0.750	0.696	0.793
	Control	0.800	0.696	0.663	0.573	0.530	0.483	0.624	0.876	0.820	0.760	0.706	0.683	0.616	0.743
	Mean	0.800	0.757	0.722	0.664	0.616	0.580	0.690	0.876	0.848	0.808	0.766	0.744	0.687	0.788
Biofertile	MAP	0.836	0.820	0.800	0.776	0.750	0.706	0.781	0.956	0.946	0.916	0.880	0.863	0.820	0.897
	Chitosan.	0.836	0.806	0.790	0.743	0.696	0.646	0.753	0.956	0.936	0.896	0.863	0.830	0.786	0.878
	Control	0.836	0.763	0.710	0.640	0.600	0.553	0.684	0.956	0.916	0.863	0.810	0.773	0.723	0.840
	Mean	0.836	0.796	0.770	0.720	0.682	0.635	0.739	0.956	0.933	0.892	0.851	0.822	0.776	0.871
EM	MAP	0.870	0.860	0.836	0.806	0.790	0.763	0.821	0.990	0.980	0.956	0.926	0.896	0.870	0.936
	Chitosan.	0.870	0.846	0.820	0.780	0.746	0.706	0.795	0.990	0.966	0.946	0.906	0.870	0.830	0.918
	Control	0.870	0.783	0.746	0.713	0.653	0.620	0.731	0.990	0.936	0.906	0.863	0.810	0.770	0.879
	Mean	0.870	0.830	0.801	0.766	0.730	0.696	0.782	0.99	0.961	0.936	0.898	0.859	0.823	0.911
B X C	MAP	0.835	0.824	0.798	0.770	0.738	0.711	0.779	0.941	0.932	0.908	0.874	0.853	0.813	0.887
	Chitosan.	0.835	0.812	0.784	0.738	0.695	0.648	0.752	0.941	0.918	0.884	0.848	0.816	0.771	0.863
	Control	0.835	0.747	0.706	0.642	0.594	0.552	0.679	0.941	0.891	0.843	0.793	0.755	0.703	0.821
General means of C		0.835	0.794	0.763	0.717	0.676	0.637	0.737	0.941	0.914	0.878	0.838	0.808	0.762	0.857
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.026							0.082						
(B)		0.019							0.062						
(C)		0.022							0.069						
Interactions:															
A X B		0.461							0.092						
AXC		0.033							0.105						
BXC		0.033							0.105						
AXBXC		0.053							0.170						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

(4) Titratable acidity:

As shown in Table 12 data indicate that the effect of bio- fertilizers applied of strawberry plants with effective microorganisms (EM) and biofertile 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 effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile 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. Chitosan had slight effects on titratable acidity preservation during storage as compared with the other treatments. The lowest values of titratable acidity were recorded with untreated (control). These results were true in the two seasons. These results are in agreement with those obtained by Petrisor *et al.* (2010) and Jouki and Khazaei (2012).

Concerning storage period, obtained data show that there was a significant reduction in titratable acidity content by the prolongation of storage period in both seasons. Similar results were reported by Petrisor *et al.* (2010).

In addition, the previous results, researchers mentioned that the acidity in strawberry fruits is a result of two processes.The first process is the transformation and accumulation of organic acids during fruits vital reactions which increase the titratable acidity. The second process is the oxidation of acids to carbon dioxide and water during respirations which decrease the acid contents. Thus, the increase or the decrease in acid contents may be assigned to the fact that the first or the second process was faster than the other.

The combined effect of bio- fertilizers applied and post harvest treatments caused statistical increases in titratable acidity content of strawberry.The highest titratable acidity content of fruit was obtained by the interaction of applying the plants with effective microorganisms (EM) combined with MAP. On the contrary, the lowest values of titratable acidity content were recorded with untreated (control) and applying water. These results were similar in the two seasons.

The interaction among bio- fertilizers applied and storage period showed that the highest value of titratable acidity content after 15days were found with using effective microorganisms (EM) and storing at 0°C.

Concerning the interaction between postharvest treatments and storage period showed that MAP after 15 days of storage gave the highest value of titratable acidity content in the two studied seasons.

As respect to the interaction between bio-fertilizers applied, post harvest treatments and storage period had significant effect on titratable acidity content of fruit in the two seasons. Applying the plants with effective microorganisms (EM) combined with fruits packed in MAP had the highest value of titratable acidity during all storage period. Obtained results are similar during both seasons of study.

(5) Total sugar content:

Data in Table 13 show the effect of bio- fertilizers applied to strawberry plants i.e., effective microorganisms (EM) and biofertile on total sugars content of fruits during storage. 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 effective microorganisms (EM) followed by biofertile. Such a positive effect for using effective microorganisms (EM) and biofertile 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. In additions chitosan treatment had slight effects on total sugar content preservation during storage as compared with the other treatments. The lowest values of total sugar content were recorded with untreated (control). These results were true in the two seasons. These results are in agreement with those obtained by Jouki and Khazaei (2012).

As shown in the same Table data indicate that total sugar content of strawberry fruits increased with prolongation of storage period until 9 days of storage at 0°C and then decreased till the end of storage in both seasons. Similar results were obtained by Lee and Kader (2000) and Manleitner *et al.* (2002).

The interaction between bio- fertilizers applied and all used post harvest treatments had a significant effect in total sugar content as a result of the interaction between the bio- fertilizers applied and different post harvest treatments during the storage. In this regard, the highest value of total sugar content was recorded in case of applying the plants with effective microorganisms (EM) combined with MAP.

Concerning the interaction among bio- fertilizers applied and storage period showed that strawberry fruits applying with effective microorganisms (EM) and biofertile recorded the highest value of total sugar content after 15 days of storage compared with the control treatment in both seasons of study.

As respect to the interaction between postharvest treatments and storage period showed that MAP caused generally the highest value of total sugar content at any storage period. Such effect was significant in the two seasons.

The combined between bio- fertilizers applied, postharvest treatments and storage period were significant in the two seasons. After 15 days of storage at 0°C, applying the plants with effective microorganisms (EM) combined with strawberry fruits packed in MAP or applying the plants with effective microorganisms (EM) combined with fruits treated with chitosan had the highest values of total sugar content with significant differences between them.

Table 13: Effect of some bio-fertilizer, packaging treatments, storage period and their interaction on total sugar content (mg/ g F.W.) of strawberry fruits during the storage in two seasons.

Bio-fertilizers (A)	Packaging (B)	First season (2011- 2012)							Second season (2013- 2013)						
		Storage period / days (C)							Storage period / days (C)						
		Start	3d	6d	9d	12d	15d	Mean	Start	3d	6d	9d	12d	15d	Mean
Without	MAP	7.15	7.35	7.55	7.70	7.39	7.02	7.36	7.28	7.50	7.69	7.81	7.53	7.14	7.49
	Chitosan.	7.15	7.33	7.53	7.67	7.35	6.68	7.285	7.28	7.48	7.67	7.79	7.49	7.08	7.46
	Control	7.15	7.26	7.50	7.61	7.24	6.55	7.22	7.28	7.43	7.59	7.73	7.32	6.87	7.37
	Mean	7.15	7.31	7.53	7.66	7.33	6.75	7.29	7.28	7.47	7.65	7.78	7.45	7.03	7.44
Biofertile	MAP	7.49	7.62	7.74	7.84	7.56	7.23	7.58	7.60	7.70	7.85	7.92	7.63	7.33	7.67
	Chitosan.	7.49	7.60	7.73	7.83	7.51	7.17	7.55	7.60	7.68	7.84	7.91	7.61	7.28	7.65
	Control	7.49	7.54	7.69	7.76	7.43	7.05	7.49	7.60	7.65	7.80	7.85	7.49	7.12	7.58
	Mean	7.49	7.59	7.72	7.81	7.5	7.15	7.54	22.8	7.68	7.83	7.89	7.58	7.24	7.64
EM	MAP	7.57	7.70	7.85	7.94	7.63	7.39	7.68	7.68	7.76	7.90	7.96	7.69	7.47	7.74
	Chitosan.	7.57	7.69	7.83	7.91	7.61	7.33	7.66	7.68	7.75	7.88	7.94	7.66	7.43	7.72
	Control	7.57	7.62	7.80	7.85	7.50	7.22	7.59	7.68	7.71	7.83	7.90	7.57	7.29	7.66
	Mean	7.57	7.67	7.83	7.9	7.58	7.31	7.64	7.68	7.74	7.87	7.93	7.64	7.40	7.71
B X C	MAP	7.40	7.55	7.71	7.82	7.52	7.21	7.53	7.52	7.65	7.81	7.89	7.62	7.31	7.63
	Chitosan.	7.40	7.54	7.70	7.80	7.49	7.06	7.50	7.52	7.63	7.79	7.88	7.59	7.26	7.61
	Control	7.40	7.47	7.66	7.74	7.39	6.94	7.43	7.52	7.59	7.74	7.82	7.46	7.09	7.54
General means of C		7.4	7.52	7.69	7.79	7.47	7.07	7.49	7.52	7.62	7.78	7.86	22.67	7.22	10.11
LSD at 0.05 probability level:															
Main Factors:															
(A)		0.04							0.06						
(B)		0.08							0.04						
(C)		0.09							0.05						
Interactions:															
A X B		0.11							0.09						
AXC		0.12							0.09						
BXC		0.12							0.10						
AXBXC		0.20							0.16						

ns =not significant; MAP (Modified Atmosphere Packaging); EM (Effective Microorganisms)

References

1. A.O.A.C. (2000). Association of Official Analytical Chemists. Washington DC. International 17th Edition, Revision I.
2. A.O.A.C.(1990).Official Methods of Analysis, 14th ed. Association of Official Analytical Chemists, Washington.
3. Abu-Zahra, T.R., Shatat, F. F. and Al-Ismail, K. (2005). Production, Storage and Quality of Strawberry *(Fragaria* X *Ananassa* Duch) Grown Under Organic and Conventional Systems in A Plastic house in the Jordan Valley. Ph.D. Theses, University of Jordan, Amman, Jordan.
4. 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.
5. Ali, M.S., Hamza, M.A., Amin, G., Fayez, M., EL-Tahan, M. and Monib M. (2005). Production of Biofertilizers using baker’s yeast effluent and their application to wheat and barley grown in north Sinai deserts. Arch Agron and Soil Sci. 51:589–604.
6. Amarante, C.; Banks, N.H. (2001). Postharvest physiology and quality of coated fruits and vegetables. Hortic. Rev. 26, 161–238.
7. Babalar, M.; Asghari, M.; Talaei, A. and Khosroshahi, A. (2007). Effect of pre and postharvest salicylic acid treatment on ethylene production, fungal,decay and overall quality of Selva strawberry fruit. Food chemistry J., 105:449-453.
8. Baraza, A., Ambuko, J., Kubo, Y. W. and Owino, O. (2013). Effect of Agro- Ecological Zone and Maturity on the Efficacy of 1- Methylcyclopropene 1-MCP) in Extending Postharvest Life of Purple Passion *(Passiflora edulis* Sims) Fruits in Kenya. Acta Horticulturae, 1007:73-79.
9. Caner, C., Aday, M.S., Demir, M. (2008). Extending the quality of fresh strawberries by equilibrium.
10. Caner, C. and Aday, M. S. (2009). Maintaining quality of fresh strawberries through various modified atmosphere packaging. Packaging Technology and Science, 22:115-122.
11. Cheour, F. J., Willemot, J., Arul, J., Desjardins, J., Mathlouf, P. M., Charest, F.M. and Gosselin, A. (1990). Bio- fertilizers application of calcium chloride delays postharvest ripening of strawberry. J. Amer. Soc. Hort. Sci.,115(5):785-792.
12. Church, N. (1994). Developments in modified atmosphere packaging and related technologies. Trends Food Sci Technol 5: 345-352.
13. Day, B. (1990). Modified atmosphere packaging of selected prepared fruit and vegetables. In: Processing and Quality of Foods 3: 230-233.
14. DeEll, J. (2006). Postharvest Handling and Storage of Strawberries. Fresh Market Quality Program Lead/OMFRA. Ministry of Agriculture Food and Rural Affairs, Ontario.
15. EI- Shafie, L.M.W. (2003). Effect of some pre- and post harvest treatments on quality and storage ability of strawberry Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., (Benha Branch), Egypt.
16. 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.
17. 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.
18. 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.
19. Garcia, M.A., Martino, M.N. and Zaritzky, N.E. (1998). Plasticized starch-based coatings to improve strawberry (FragariaxAnanassa) quality and stability. J. Agric. Food Chem., 46 (9): 3758-3767.
20. Glinicki, R., Paszt, L. S. and Tobjasz, E.J. (2011). The effect of microbial inoculation with EM-farming inoculum on the vegetative growth of three strawberry cultivars. Horticulture and Landscape Architecture, 32: 3–14.
21. Hamza, M.A., Youssef, H., Helmy,A., Amin, G.A., Fayez M. and Higazy, A. (1994).Mixed cultivation and inoculation of various genera of associative diazotrophs. In: Hegazi N.A., Fayez M., Monib M., editors. Nitrogen fixation with non-legumes. The American University in Cairo Press; Cairo, Egypt: pp. 319–326.
22. 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.
23. Hegazi, N. A. and Fayez, M. (2003). Biodiversity and endophytic nature of diazotrophs other than rhizobia associated to non-leguminous plants of semi-arid environments. Arch Agron Soil Sci. 49:213–235.
24. 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.
25. 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.
26. 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.
27. 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.
28. 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.
29. Lee, J.Y., Park, H.J., Lee, C.Y. and Choi, W.Y. (2003). Extending shelf life of minimally processed

apples with edible coatings and antibrowning agents. Lebensm. -Wiss. U. -Technol. 36, 323–329.
30. 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.
31. Manleitner, S., Lippertand, F. and Noga, G. (2002). Influence of packaging material on quality and shelf life of strawberries Acta Horticulturae. 567:771- 773.
32. Mathooko, F.M. (2003). A comparison of Modified atmosphere packaging under ambient conditions and low temperature storage on quality of tomato fruit. African Journal of Food Agriculture Nutrition and Development, 3: 2-9.
33. Mc Guire, R.G. (1992). Reporting of objective color measurements. HortScience, 27: 1254- 1255.
34. Mitkees, R.A., Saad, H.E., Iman, M.M., Amer, H.A. and Mahamoud, S.K.h. (1996). Importance of N2 fixing Biofertileileileilizer for decreasing the use of mineral nitrogen fertilizer for wheat plant Egypt J. Appl. Sci., 11(1): 34- 41.
35. 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.
36. Othman, A.A., Amer, W.M., Fayez, M., Monib, M. and Hegazi, N.A. (2003). Biodiversity of diazotrophs associated to the plant cover of north Sinai deserts. Arch Agron Soil Sci. 49:683–705.
37. Othman, A.A., Amer, W.M., Fayez, M. and Hegazi, N.A. (2004). Rhizosheath of Sinai desert plants is a potential repository for associative diazotrophs. Microbiol Res. 2004;159:285–293.
38. Ozkaya, O., Dundar, O., Scovazzo, G.C. and Volpe, G. (2009). Evaluation of quality parameters of strawberry fruits in modified atmosphere packaging during storage. African Journal of Biotechnology 8: 789-793.
39. 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.
40. Park, S., Stan, S.D., Daeschel, M.A. and Zhao, Y. (2005). Antifungal coatings on fresh strawberry (*Fragaria* x *ananassa*) to control mold growth during cold storage. Journal Food Science, 70:202-207.
41. 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, Vol. XXVI.
42. 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.
43. Sandhya, L.W.T. (2010). Modified atmosphere packaging of fresh produce: Current status and future needs. Food Science and Technology, 43: 381–392.
44. 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.
45. 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.
46. Siddiqui, M. W., Dhua, R. S. (2009). Standardization of ethrel treatment for inducing ripening of mango var. Himsagar. Proceedings of International Conference on Horticulture (ICH- 2009), Bangalore, 9–12 November 2009, pp. 1641–1648.
47. Snedecor, G.W. and Cochran, W.G.(1991). Statistical Methods. 8th Ed., Iowa State Univ. Press, Iowa, USA.
48. Thompson, A.K.1996. Post-harvest Technology of Fruits and Vegetables, Blackwell, Oxford.
49. Wang, C. Y. and Qi, L.(1997). Modified atmosphere package alleviates chilling injury in cucumbers. Post harvest Biology and Technology, 10:195-200.
50. Woodward, D., 2003. Soil and sustainability. Effective micro-organisms as regenerative systems in earth healing. http://www.livingsoil.co.uk/learning/soilsustain.htm (Accessed 23/9/2008).
51. Zhang, D.L. and Quantick, P.C. (1998). Antiftmgal effects of chitosan coating on fresh strawberries and raspberries during storage. J. Hortic. Sci. Biotechnol., 73 (6): 763-767.

5/9/2015