Effect of Gelatin and Ascorbic Acid Edible Coatings on the Quality of Sweet Pepper Fruits.

Mohamed A. A. Abdullah and Saleh M. Abou-Elwafa
Postharvest and Handling of Vegetable Crops Dept., Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.

ABSTRACT

Sweet peppers (*Capsicum annuum* L) have a short storage period and marketing of less than two weeks, due to their susceptibility to fungal diseases, decay, shriveling, flaccidity and wilting. Therefore, the present study was to determine the effect of composite gelatin and ascorbic acid Edible Coatings on the physical and chemical properties of sweet pepper fruits stored at 10˚C and 90-95% relative humidity. The obtained results revealed that the treatments of Sweet peppers with composite 5% ascorbic acid with 1.5% gelatin edible coating reduced the weight loss % and decay, Also maintained general appearance, fruit firmness, total soluble solids (TSS), ascorbic acid content, total carotenoids content and total chlorophyll content to 35 days of cold storage followed by 5% ascorbic acid with 5% gelatin treatment compared with other treatments and untreated as a control. The development in this study of edible film and a coating prepared from ascorbic acid and gelatin can be a new approach to preventing postharvest loss and increasing the shelf life of sweet pepper.

Keywords: Gelatin, Edible Coatings, Sweet Pepper, Vitamin C, Quality attributes.

INTRODUCTION

Sweet Pepper (*Capsicum annuum* L) is a very important vegetable crop for excellent nutrition value. During extended storage at 7°C of sweet pepper fruits, deterioration changes occur such as quality degradation, poor quality, decay and, shriveling (Shehata et al., 2013).

The usage of edible coating could be of great value in keeping quality attributes of sweet pepper fruits in cold storage and extend their shelf life. It is defined as a thin layer of edible material that coats the fruits and limits the migration of oxygen, CO_2 and water vapor, among others (Teacă et al., 2019). The use of biopolymers edible coatings for fruits storage has been largely employed in the last decade to improve their shelf life and maintain their freshness (Da Silva Pereira et al., 2021).

The polymers that are usually used for edible coating could be polymers of protein, carbohydrates, and lipid derivatives (Jancikova et al., 2021 and Hassan et al., 2018).

Also, the edible coatings could contain several polymers from non-volatile or volatile parts (Teacă et al., 2019). The physical and chemical characteristics of the biopolymer used determine their efficacy in prolonging the fruit shelf life. Also, these coatings can become bioactive by the incorporation of biomolecules with antimicrobial and antioxidant properties (Shehata et al., 2013).

The edible coating can extend the storage period of minimally treated fruit and maintain quality. The used edible coatings are confined to those that do not affect the taste and smell of the fruit used and are easy to digest, easy to obtain and non-toxic (Yang et al., 2017 and Da Silva Pereira et al., 2021).

Gelatin is one of the ingredients that is often used as a component of edible coatings. One type of fish that is effective in producing gelatin is tuna. Gelatin from tuna fish skin as a food by-product has a good gel strength and viscosity (Jancikova et al., 2021and Hassan et al., 2018). Several studies have succeeded in combining gelatin with chitosan as a composite edible coating. Chitosan is one of the polysaccharides that are widely used as a constituent of edible coatings because it has antimicrobial properties. The combination of gelatin and chitosan can increase the antimicrobial properties of chitosan (Ehsani et al., 2020 and Benítez et al., 2015).

Ascorbic acid is a water-soluble vitamin and plays a key physiological role in scavenging reactive oxygen species (Fang et al., 2017). The application of exogenous ascorbic acid has received much attention for use as a biologically safe molecule for postharvest quality maintenance of fruits. It has been reported that ascorbic acid treatment delayed ripening either alone or in combination with edible coatings film (Barzegar et al., 2018). Sogvar et al. (2016) also suggested that ascorbic acid in combination with Aloe vera had benefits in delaying changes in the ripening and reducing microbial populations of strawberry fruit.

The aims of the current study is to extend the storage period with best quality maintenance of sweet pepper fruits by using exogenous postharvest Treatments of composite gelatin concentration with ascorbic acid as edible coatings during storage at 10˚C and 90-95% relative humidity.

MATERIALS AND METHODS

Sweet pepper fruits (*Capsicum annuum L. cv*. 7158 F1 hybrid imported from G.S.I Company for seeds) were obtained, from the farm at El Monufia Governorate. Fruits were harvested at the ripening stage of 75% coloration, uniform size (about 190±10g each fruit) and color with a short calyx (1 cm long) on January 10th and 17th in 2022 and 2023 respectively and then transported immediately to the Vegetable Handling Department. Five coating treatments addition to control were carried out as follows: Fruits divided to six treatments and dipped the following solutions

(T1) Ascorbic acid 5 % for 5 min.
(T2) Gelatin 1.5 % for 5 min.
(T3) Gelatin 5 % for 5 min.
(T4) Ascorbic acid 5%+ Gelatin 1.5% for 5 min.
(T5) Ascorbic acid 5% + Gelatin 5 % for 5 min.
(T6) Tap water (control) for 5 min.

Gelatin Coating Preparation:

The concentrate required of gelatin powder (1.5 and 2 grams) was dissolved in 100 mL of sterile distilled water for each concentrate and stirred at 45°C for 10 min to get to concentrate. Sorbitol (w/w of gelatin) was added to increase mixture stability and homogenization, Fakhouri et al. (2015).

Pepper fruits were placed in boxes for each treatment arranged in a complete randomized design and stored at 10˚C and 90-95% relative humidity for 35 days. Samples were collected immediately after treatments and evaluated every seven days interval for the following parameters.

Weight loss percentage:

It was estimated according to the following equation: Weight loss% = [(Initial weight - weight at time of sampling)/ the initial weight of fruits] * 100.

Decay: it was determined by a scoring system (Watada and Morris, 1996; Jimenez et al., 1998).

General appearance: was determined by a scoring system (Watada and Morris, 1996; Jimenez et al., 1998).

Fruit firmness: was determined as kg/cm^2 by digital force Gauge model FGV 50 A, Shimpo Instrument Co, Japan, with a total capacity of 20kg/cm^2 and resolution of 0.01kg/cm^2 using cone pointed head.

Total soluble solids percentage (T.S.S.) was determined by digital refractometer of model Abbe Leica (A.O.A.C., 2000).

Ascorbic acid content was determined using the dye 2, 6-dichloro-phenol indophenols method (A.O.A.C., 2000).

Total carotenoid content (mg/100g fresh weight) was determined according to A.O.A.C. (2000).

Total chlorophyll (chlorophyll a & b) was measured by extracting the chlorophyll from a 2-gram sample of fruits with acetone (85%) as described by Singh (1982).

Statistical analysis:

The experiment was factorial with 2 factors in a complete randomized design (CRD) with 3 replicates. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance (1955). The statistical analysis was performed according to Sendecor and Cochran (1982).

RESULTS AND DISCUSSION

Weight loss (%):

Data in Fig. (a1, 2, 3, 4) and Table (1) show that in general, weight loss percentage increased with a prolonged storage period. Presented data clarify that all applied treatments decreased weight loss significantly than control with significant differences among treatments. After 35 days of storage, the highest percentage was found in the control while the solution of ascorbic acid 5% with gelatin 1.5% recorded lowest percentage of weight loss followed by the solution of ascorbic acid 5% with gelatin 5% in both seasons, respectively. The reduction in weight loss may be attributed to reducing the respiration rates during storage, the obtained results are in agreement with Ngcobo et al. (2012) and Wang *et al*. (2015 Edible coatings show good characteristics against oxygen transfer at low and intermediate relative humidity. However, they had poor properties against water vapor transfer due to their hydrophilic nature Elabd and Gomma (2018) and (Andrade et al., 2014). Therefore, to have a good result from the poor water vapor properties of gelatin film, a mixed coating of gelatin with other treatments may be used. However, weight loss depends on moisture evaporation through the surface of fruits (Olivas et al., 2007). In this concern, Salsabiela et al. (2022) showed that edible coating Gelatin reduces the weight loss of fresh-cut watermelon and inhibits the processes of respiration, transpiration, and syneresis during storage time.

Decay (score):

The Data presented in Fig.1 (b1, 2, 3, 4) and Table (1) show that the period of storage markedly affected the decay during cold storage. In this regard, it was noticed that the score of decay increased with the progress of storage period. The increase in decay at the end of storage might be due to the low biological activity of fruits and this in turn facilitates the infection of fruits by micro-organisms (Wills et al., 1981). As for the effect of postharvest treatments, all treatments had a positive effect in reducing the decay score compared with the control which gave the highest score during the storage period. All treatments showed significant differences among them

The highest decay score was found in the control while solution of ascorbic acid 5% with gelatin 1.5% recorded lowest score. Gelatin and ascorbic acid have important effects in delaying, slowing maturation and ripening fruit also maintaining postharvest quality when used during the storage period. These results are in agreement with (Zhang et al., 2021).

General appearance (score):

Data in Fig. 2 (a1, 2, 3, 4) and Table (1) show that the general appearance (score) of sweet pepper fruits decreased significantly with prolonging storage period in the two successive seasons.

Concerning the effect of postharvest treatments, data show that all treatments were better than the control during the storage period. Fruits dipped in a solution of ascorbic acid 5% with gelatin 1.5% the best general appearance during the two successive seasons of storage. In other words, these treatments gave the highest score of appearance, while untreated fruits obtained the lowest one in this concern. These results are in agreement with Salsabiela et al. (2022). Improvement of fruits' general appearance by using gelatin as an edible coating may be attributed to the effect of gelatin on the reduction of weight loss and rot rate of fruits Salsabiela et al. (2022).

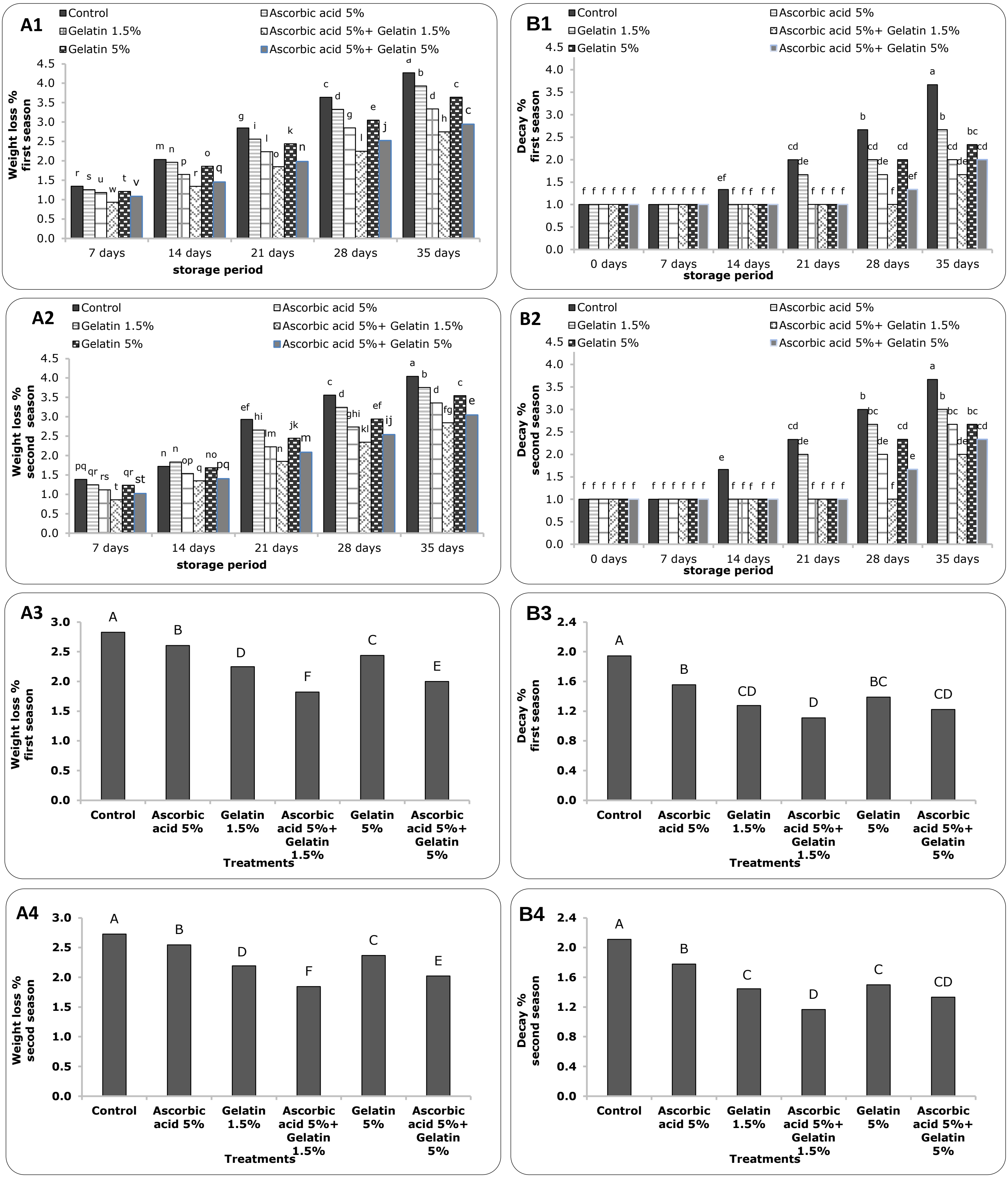

Figure (1): Effect of ascorbic acid and gelatin treatments on weight loss% (a1, 2, 3, 4) and decay% (b1, 2, 3, 4) of sweet pepper during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

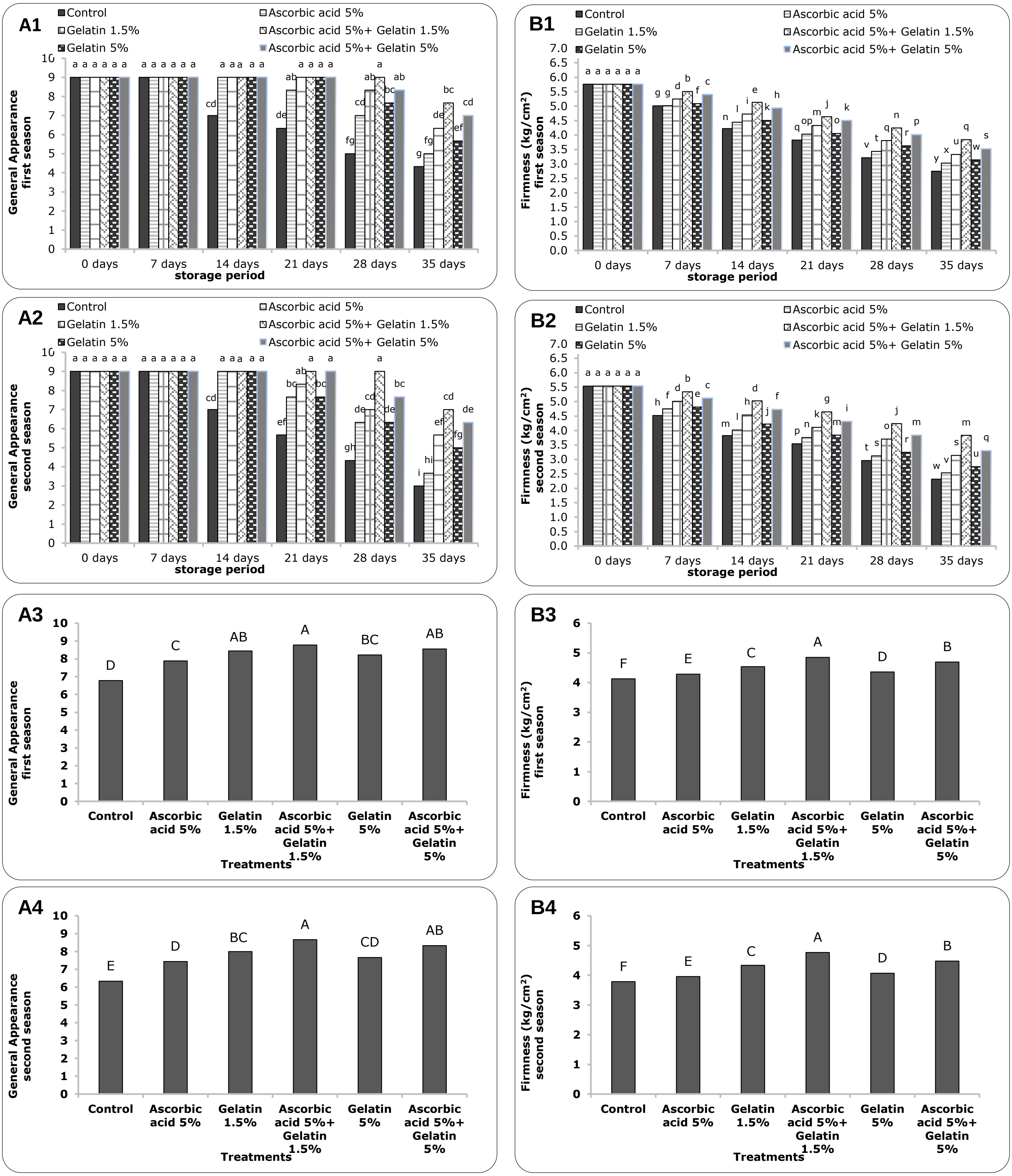

Figure (2): Effect of ascorbic acid and gelatin treatments on general appearance (a1, 2, 3, 4) and Firmness (kg/cm^2) (b1, 2, 3, 4) of sweet pepper during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

Table (1): Effect of ascorbic acid and gelatin treatments on weight loss %, decay and general appearance of sweet pepper during cold storage.

Treatments	First season			Second season		
	Weight loss %	Decay	General Appearance	Weight loss %	Decay	General appearance
Control	2.827A	1.944A	6.778D	2.729A	2.111A	6.333E
Ascorbic acid 5%	2.606B	1.556B	7.889C	2.545B	1.778B	7.444D
Gelatin 1.5%	2.250D	1.278CD	8.444AB	2.192D	1.444C	8.000BC
Ascorbic acid 5%+ Gelatin 1.5%	1.823F	1.111D	8.778A	1.846F	1.167D	8.667A
Gelatin 5%	2.438C	1.389BC	8.222BC	2.369C	1.500C	7.667CD
Ascorbic acid 5%+ Gelatin 5%	1.999E	1.222CD	8.556AB	2.021E	1.333CD	8.333AB

Values followed by the same letter (s) are not significantly different at 5 %.

Fruit firmness (kg/cm^2):

As shown in Fig. 2 (b1, 2, 3, 4) and Table (2) prolonging the storage period led to a reduction in firmness values. The storage period had an effect in this respect, as there was a gradual reduction in firmness till the end of storage. The trend was similar in both seasons.

Sweet pepper fruits treated with a solution of ascorbic acid 5% with gelatin 1.5% were significantly firmer than all treated after 35 days of storage. However, control fruits had the lowest value in both seasons, respectively. These results are in agreement with Benitez et al. (2013) and Radi et al. (2017). Softening in general occurs during the process of deterioration of the cell structure, primarily by the hydrolysis of peptic polymers in the cell wall and middle lamella of the fruit. Ripening involves the depolymerization or shortening of the chain length of pectin substances along with an increase in pectinesterase and polygalacturonase activities (Yaman and Bayoindirli, 2002).

Total soluble solids (Brix %)

Regarding the total soluble solids content, data in Fig.3 (a1, 2, 3, 4) and Table (2) indicate that it decreased significantly and consistently with prolonging the cold storage period, in both seasons. The decrease in T.S.S. during storage might be due to the relatively higher rates of sugar loss through respiration than water loss through evaporation (Giacomin et al., 2021).

The total soluble solids of the control and coated treatments significantly increased with the storage period. In this regard, there was a significant difference between all treatments, with coated samples experiencing a slight increase in TSS when compared to the control. Total soluble solids of fruits dipped in the solution of ascorbic acid 5% with gelatin 1.5% contained more T.S.S. as compared with other treatments. After 35 days of cold storage the control showed the highest decrease in TSS. This finding was similar to the results of Ahmed et al. (2009), Marpudi et al. (2011) and Radi et al. (2017).

Ascorbic acid content:

Data in Fig. 3 (b1, 2, 3, 4) and Table (2) indicate that fruits after the harvest had a higher content of ascorbic acid as compared with the end of cold storage period. Significant losses in ascorbic acid were exhibited when the sweet pepper fruits were subjected to cold storage. It was evident that there was a persistent decrease in ascorbic acid during the storage period.

These results are those obtained by (E. Poverenov et al., 2014) on bell pepper fruits. Furthermore, Paradis et al. (1995) and Trail et al. (1992) indicated that the decrease in ascorbic acid content in pepper fruits may be due to its susceptibility to oxidation, either directly or through the action of an enzyme ascorbic acid oxidase.

Regarding the effect of treatments on ascorbic acid, data show that the treatments significantly affected the ascorbic acid content in the pepper fruits. Fruits treated with a solution of ascorbic acid 5% with gelatin 1.5% contained attained significantly higher values of ascorbic acid compared with other treatments, in both seasons. In general, untreated pepper fruits (control) contained the lowest value in ascorbic acid contents. These results agreed with Abd El-Rahman (1990) and Poverenov et al., (2014) on bell pepper fruits.

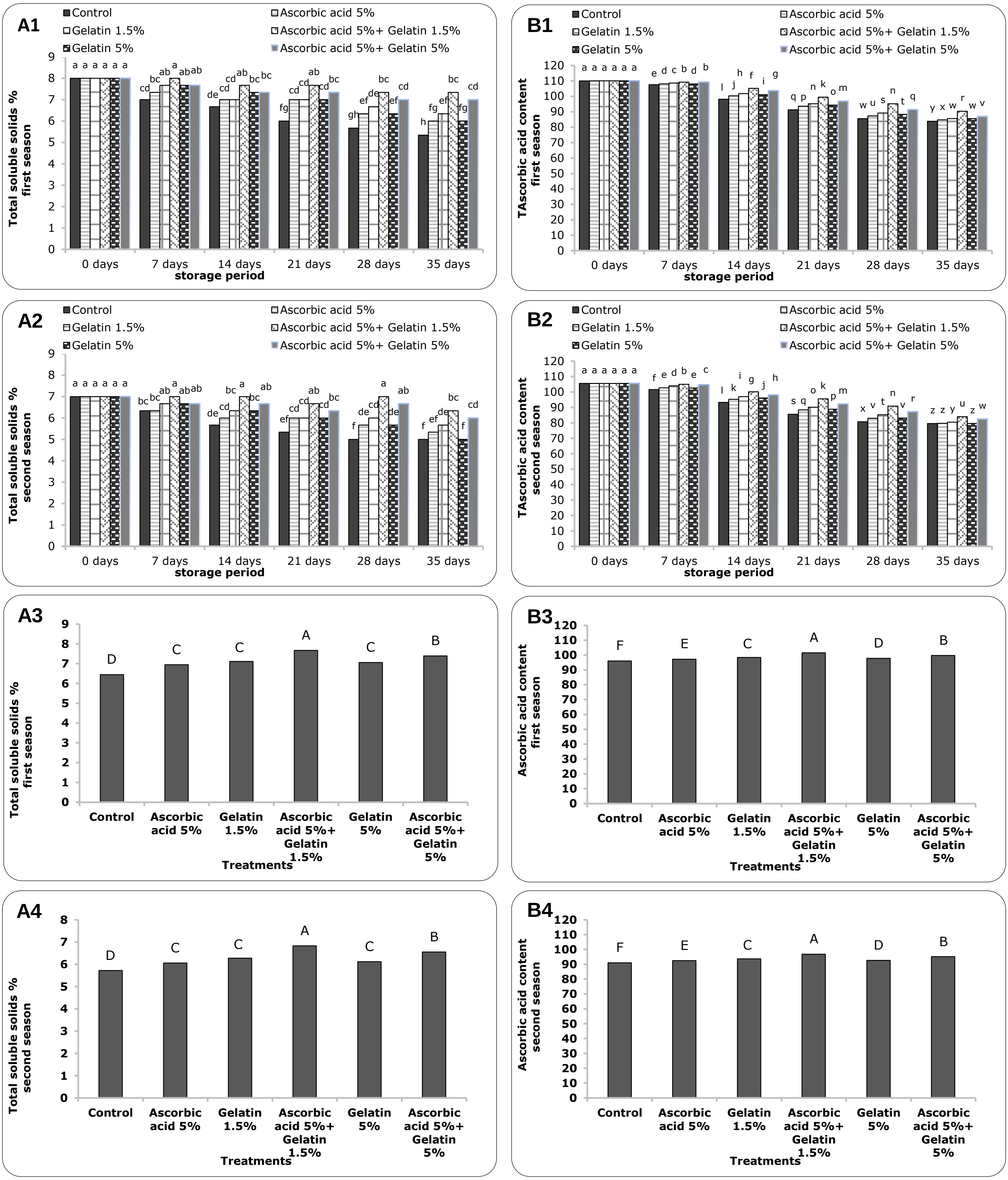

Figure (3): Effect of ascorbic acid and gelatin treatments on total soluble solids % (a1, 2, 3, 4) and ascorbic acid content (b1, 2, 3, 4) of sweet pepper during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

Table (2): Effect of ascorbic acid and gelatin treatments on Firmness (kg/cm2), total soluble solids % and ascorbic acid content of sweet pepper during cold storage.

Treatments	First season			Second season		
	Firmness (kg/cm2)	Total soluble solids %	Ascorbic acid content	Firmness (kg/cm2)	Total soluble solids %	Ascorbic acid content
Control	4.129F	6.444D	96.080F	3.784F	5.722D	91.056F
Ascorbic acid 5%	4.288E	6.944C	97.300E	3.954E	6.056C	92.473E
Gelatin 1.5%	4.535C	7.111C	98.360C	4.340C	6.278C	93.734C
Ascorbic acid 5%+ Gelatin 1.5%	4.853A	7.667A	101.530A	4.770A	6.833A	96.856A
Gelatin 5%	4.363D	7.056C	97.860D	4.067D	6.111C	92.649D
Ascorbic acid 5%+ Gelatin 5%	4.692B	7.389B	99.690B	4.476B	6.556B	95.082B

Values followed by the same letter (s) are not significantly different at 5 %.

Total carotenoids content:

Data in Fig. 4 (a1, 2, 3, 4) and Table (3) show that carotenoid contents in sweet pepper fruits increased gradually with prolonging the cold storage period in both seasons. This increment could be attributed to the gradual transforming from chlorophyll pigment to carotenoid pigment during the turning to ripening stage. These results are in agreement with (Kays, 1991) and (Nyanjage et al., 2005)

Regarding the effect of treatments on Total carotenoid content, data reveal that there was a significant difference among treatments after 35 days of storage. Sweet pepper fruits treated with a solution of ascorbic acid 5% with gelatin 1.5% contained significantly lower contents of total carotenoid compared with other treatments, in both seasons. In general untreated sweet pepper fruits (control) contained the highest value of total carotenoid content till the end of storage.

Total chlorophyll content (mg /100g FW):-

Data in Fig. 4 (b1, 2, 3, 4) and Table (3) show that the chlorophyll contents (mg /100g FW) of fruits decreased with prolonging cold storage period. The decrease could be attributed to the gradual destruction by chlorophyllase activity and the transformation of chloroplasts to chromoplasts**.** These results agree with Shehata et al. (2018).

It is clear from the presented data that there were significant differences between all treatments compared with the untreated control during storage. However, Sweet Pepper fruits dipped in solution of ascorbic acid 5% with gelatin 1.5%, exhibited the highest chlorophyll content. Ascorbic acid 5% with gelatin 1.5% was the most effective treatment in reducing chlorophyll loss similar results were agreed with (Poverenov et al., 2014) on bell Pepper fruits.

Table (3): Effect of ascorbic acid and gelatin treatments on total carotenoids content and total chlorophyll content (mg /100g FW) of sweet pepper during cold storage.

Treatments	First season		Second season	
	Total carotenoids content	Total chlorophyll content (mg /100g FW)	Total carotenoids content	Total chlorophyll content (mg /100g FW)
Control	4.986A	9.566F	4.923A	8.854F
Ascorbic acid 5%	4.651B	9.823E	4.617B	9.151E
Gelatin 1.5%	4.267D	10.180C	4.136D	9.525C
Ascorbic acid 5%+ Gelatin 1.5%	3.949F	10.548A	3.828F	10.016A
Gelatin 5%	4.473C	10.032D	4.368C	9.351D
Ascorbic acid 5%+ Gelatin 5%	4.084E	10.364B	3.984E	9.744B

Values followed by the same letter (s) are not significantly different at 5 %

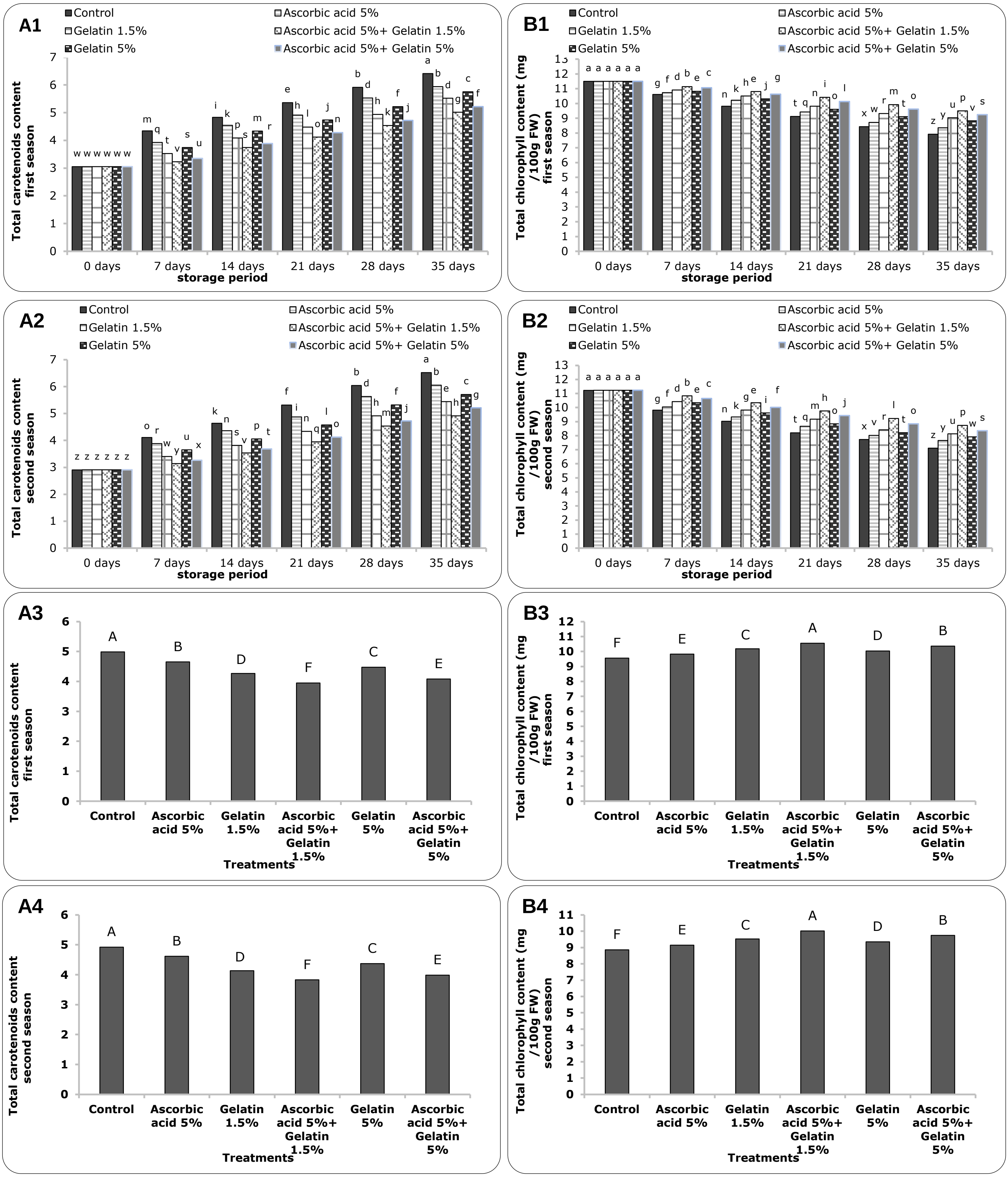

Figure (4): Effect of ascorbic acid and gelatin treatments on total carotenoids content (a1, 2, 3, 4) and Total chlorophyll content (mg /100g FW) (b1, 2, 3, 4) of sweet pepper during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

Conclusion

Our results have demonstrated that the best treatment which maintains fruits of sweet pepper under cold storage conditions is the dipping in the solution of ascorbic acid 5% with gelatin 1.5% which preserve the physical and chemical properties of fruits.

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تأثير الأغشيه الصالحة للأكل الجيلاتين وحمض الأسكوربيك على جودة ثمار الفلفل الحلو.

محمد أحمد أحمد عبدالله و صالح محمد ابو الوفا

قسم بحوث تداول الخضر- معهد بحوث البساتين- مركز البحوث الزراعيه

أجريت هذه التجربة خلال موسمى ٢٠٢٢ و ٢٠٢٣ لدراسة تأثير بعض معاملات ما بعد الحصاد على القدرة التخزينية وجودة ثمار الفلفل الحلو أثناء التخزين عن طريق معاملة الثمار بتركيزات مختلفة من الأغشيه الصالحة للأكل الجيلاتين وحمض الأسكوربيك . تم حصاد الثمار في مرحلة التلوين ٧٥% تلوين وتم نقلها إلى ثلاجات قسم بحوث تداول الخضر – معهد بحوث البساتين – مركز البحوث الزراعية لاجراء معاملات على الثمار حيث تم غمس الثمار في محاليل من الجيلاتين بتركيز ١.٥و ٥ % لمدة دقيقة ،حمض الاسكوربيك ٥% ، المعاملة بالجيلاتين ١.٥ مع حمض الاسكوربيك ٥% كذلك المعاملة بالجيلاتين ٥ % مع حمض الاسكوربيك ٥% بالإضافة إلي معاملة الكنترول (ماء الصنبور لمدة ٥ دقائق) ثم التخزين عند ١٠ درجه مئوية ٩٠-٩٥٪ رطوبة نسبية وتسجيل القراءات لتقدير التغيرات في صفات جوده ثمار الفلفل أثناء التخزين كل ٧ أيام لمدة ٣٥ يومًا.

اوضحت النتائج أن دلالات جودة الثمار التي تشمل المظهر العام، الصلابة، المواد الصلبة الذائبة الكلية ،محتوى حامض الاسكوربيك، محتوى الكاروتين و المحتوى الكلى من الكلورفيل قد انخفضت أثناء التخزين بالاضافة الي زيادة الفقد في الوزن و التالف فى الثمار مع إطالة فترة التخزين.

وأدت معاملة الغمس في محلول المعاملة بالجيلاتين ١.٥ مع حمض الاسكوربيك ٥% إلى الحفاظ على الجودة المظهرية وتقليل التالف فى ثمار الفلفل حتى ٣٥ يوماً من التخزين عند درجة حرارة ١٠ مئوية ٩٠-٩٥% رطوبة نسبية مقارنةً بالمعاملات الأخرى.

كما أدت ايضا معاملة الغمس في محلول المعاملة بالجيلاتين ١.٥ مع حمض الاسكوربيك ٥% إلى الحفاظ على خصائص الجودة (الصلابة، المواد الصلبة الذائبة الكلية،محتوى حامض الاسكوربيك محتوى الكاروتين و المحتوى الكلى من الكلورفيل) حتى ٣٥ يوماً من التخزين عند درجة حرارة ١٠ مئوية ٩٠-٩٥% رطوبة نسبية مقارنةً بالمعاملات الأخرى.