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RESEARCH ARTICLE

The Effects of Salicylic, Folic and Ascorbic Acid Treatment on Shelf Life Quality of Broccoli Florets

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ABSTRACT

This study aims to investigate the effect of Salicylic acid (2 mM), Folic acid (5 mg L^{-1}) and Ascorbic acid (2 mM) treatments on the shelf life and quality of 'Belstar F1' broccoli variety. Treated broccoli heads were stored at 21±2°C for 4 days in plastic containers with lids. It is determined that at the end of the storage period, the lowest weight loss (2.74%), total soluble solids (8.07%), pH value (7.14) and the highest amount of titratable acidity (0.12%) were found in the group treated with ascorbic acid and the least change in color parameters (L*; 29.41, a*; -4.59, b*; 10.78) and the highest total chlorophyll content (0.32 mg/g) in the group treated with folic acid. It is thought that the effects of ascorbic acid, salicylic acid and folic acid treatment at postharvest storage period should be investigated in detail in molecular and biochemical studies for more concrete data.

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Introduction

Broccoli is a nutritionally important vegetable due to its high fiber content, ascorbic acid and antioxidants with low calorie (Büchert et al., 2011). Harvesting of broccoli is done before blooming and the sudden increase in energy during the harvest, the stress caused by nutrient and hormone deterioration activate the aging process in broccoli. This process manifests itself as chlorophyll breakdown (yellowing) and a decrease in nutritional value. As a result, these changes reduce the economic value of broccoli heads (Hasperué et al., 2013).

The loss of biochemical content in the post-harvest period in broccoli, which is considered to be the vegetable with the highest nutritional value per unit weight consumed, is of great importance. (Hasperué et al., 2016). Storage of broccoli flowers were studied with the increase in demand for minimally processed vegetables (Yuan et al., 2010). As with many other species of vegetables, broccoli also have a high respiratory rate and metabolic activity at post-harvest period. Due to rapid post-harvest spoilage and short post-harvest life, the use of chemicals is limited to maintain product quality during storage and transportation, and alternative treatments must be tested for the use in post-harvest technology.

Storage temperature significantly affects the storage life of broccoli. There are many studies which investigated the effect of different temperatures postharvest quality of broccoli. While broccoli can be stored for 21-28 days at 0°C, it can be stored for about 5 days at 10°C (Cantwell & Suslow, 1997). Wang and Hruschka (1977) reported that when broccoli was stored at 0 °C and 95% relative humidity, its green colour was maintained for much longer than when it was not unrefrigerated. Broccoli is a highly perishable fruit, especially in shelf life conditions. Takeda et al. (1993) reported that chlorophyll levels in broccoli decreased during storage at 20 or 23 °C, while chlorophyll levels remained nearly constant at 2 °C. Shi et al. (2016) reported that broccoli showed rapid molecular and biochemical changes for 4 day- storage at 20°C. Deschene et al. (1991) reported that broccoli florets rapidly senesced when stored in air at 23 or 10 °C and chlorophyll

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levels declined by 80–90% within 4 days at 23 °C and within 10 days at 10 °C.

Many treatments have been investigated to preserve the postharvest quality of broccoli. The treatments of some chemicals (Xu et al., 2016; Cai et al., 2019; Al Ubeed et al., 2017) such as preservation in modified atmosphere (Wang et al., 2019; Xu et al., 2006; Fernández-León et al., 2013), the use of LED rays (Hasperué et al., 2016; Jiang et al., 2019), UV-B (Topcu et al., 2015), UV-C (Dogan et al., 2018) radiation treatments, hormone treatments (Zheng et al., 2019), ethylene (Gong & Mattheis, 2003), 1-MCP (Gong & Mattheis, 2003; Cefola et al., 2010; Yuan et al., 2010), folic acid (Xu et al., 2021) were tested in broccoli preservation, and it was reported that the treatments preserve the visual quality of broccoli, prevent chlorophyll breakdown and delay senesences.

It is of great importance that the products applied externally are safe for consumption as well as extending the storage period for products with high postharvest losses and short-term storage period. In this study, the effects of salicylic, folic and ascorbic acid treatments, which are organic compounds, on storage of broccoli were investigated.

Ascorbic acid (AA) is a water-soluble vitamin that plays an important physiological role in suppressing reactive oxygen species (ROS) that occur in plants under stress conditions. In recent years, it has been noted that exogenous ascorbic acid treatments in the preservation of horticultural crops are a biologically safe molecule that can be used to maintain post-harvest quality (Alaey et al., 2011). Broccoli heads contain high levels of ascorbic acid, but it has been observed that this compound decreases rapidly in the postharvest period, especially during the shelf life (Nishikawa et al., 2003). During the aging process in broccoli, it has been observed that the accumulation of active oxygen species increases and therefore the content of antioxidants, especially ascorbic acid, decreases (Casajús et al., 2019).

Besides being a phenolic compound, salicylic acid is also defined as a plant growth regulator (Popova et al., 1997). It was observed that salicylic acid regulates different physiological and biochemical processes in plants. Some of those are plant growth (Tufail et al., 2013), stomatal conductivity (Hayat et al., 2010), photosynthesis (Khodary, 2004), seed germination (Babalar et al., 2007), disease resistance (Delaney et al., 1994; Dempsey et al., 1999), heavy metal, low temperature, high temperature and resistance to salinity stress (Hayat et al., 2008). It was also stated that salicylic acid, a natural compound, has a high potential in suppressing ethylene production and fungal rot in harvested fruits, prevents chlorophyll degradation and contributes to the preservation of color values (Leslie & Romani, 1988; Romani et al., 1989; Zhang et al., 2003; Babalar et al., 2007; Sayyari et al., 2009; Wei et al., 2011).

Folic acid (FA) is a water-soluble vitamin, also known as vitamin B9, which refers to tetrahydrofolate and its derivatives. Although the effect of folic acid on human health is known, its functions on plants have recently been discovered and little is known about the effect of exogenous folic treatment on post-harvest physiology (Xu et al., 2021). It has been reported that folic acid regulates gene expression through the riboswitch mechanism and also plays a role in chlorophyll biosynthesis and oxidative stress tolerance (Al-Said & Kamal, 2008; Raeisi et al., 2017; Xu et al., 2021).

Xu et al. (2021) stated that different doses of folic acid treatments after harvest reduced the yellowing rate in broccoli, prevented weight loss and decreased respiratory rate and ethylene formation. In this study, the effective dose was determined as 5 mg L^{-1} in broccoli. There is no literature investigating the effects of salicylic acid and ascorbic acid on broccoli storage.

In this study, the effects of folic, ascorbic and salicylic acid applications on the shelf life of broccoli flowers were investigated.

Materials and Methods

The variety "Belstar F_1" grown in Sarıcakaya region of Eskişehir province (40°2' N, 30°39' E; altitude: 520m) was used in the study. Broccoli was harvested during the commercial maturity stage (Average weight; 450-500 g, total soluble solids content; 7.7%, total titratable acidity; 0.14%). Homogeneously selected heads were treated salicylic acid (2 mM), ascorbic acid (2 mM) and folic acid (5 mg L^{-1}). 0.01% Tween 80 were added in prepared solution for better adhesive. The heads were dipped in prepared solutions for 10 minutes after dipping fruits waited one hour to dry. Control heads were treated with pure water. After all treatments, florets were kept in non-colour plastic containers (11x19x7cm) at 21±2°C for 4 days.

Investigated Features

Broccoli florets were weighed at harvest and re-weighed in each storage periods and weight losses were calculated as percent loss of initial weight with following formula:

$$Weight\ loss\ (\%) = \left(\frac{initial\ weight - final\ weight}{initial\ weight}\right) x\ 100$$

Color of broccoli florets was measured from three points of each floret using a digital chromameter (Konica Minolta, Japan).

Broccoli juice was obtained for total soluble solic (TSS), titretable acidity (TA) and pH analysis. TSS were measured with a refractometer (ATAGO Co. Ltd. Tokyo, Japan) and results were were given as %. pH level was measured with pH meter (HI9321, Hanna, USA).

2 ml juice was used with 38 ml of distilled water for determined TA. The mixture was titrated with 0.1 N NaOH solution until the pH reaches 8.1. The amount of TA was calculated as % citric acid equivalents.

Total chlorophyll content of broccoli sample on a fresh weight (FW) basis was determined by using the colourimetric method of Yuan et al. (2010) using pure material obtained from ground broccoli florets and kept frozen at -18°C. Frozen powdered samples of broccoli florets (2gr) were ground and extracted in 20 ml of 80% acetone, centrifuged at 5000 rpm for 5 min. The optical densities at 645 and 663 nm were recorded for each sample and the total chlorophyll was estimated by the following formula.

$$Total\ Chlorophyll(mg/g) = \frac{(20.2 \times OD_{645\ nm} + 8.02 \times OD_{663\ nm} \times V)}{100 \times W}$$

where, OD is optical density, V is volume of the extract (ml) and W is weight of the sample (g).

Statistical Method

The research was carried out in 3 replications by designing random plots according to a 4x5 factorial trial pattern. In the study, the treatment method (Control, Folic Acid, Salicylic Acid and Ascorbic Acid) and shelf life (0 day, 1st day, 2nd day, 3rd day and 4th day) were taken in the statistical model, and it was investigated whether there was a statistically significant difference between the treatment and shelf life averages and the existence of interaction. In the statistical analysis of the study, two-way analysis of variance (Two-way ANOVA) was applied. In order to determine the effect of the treatment subjects on the properties examined in the experiment, the 'R studio program' was used in statistical analysis in terms of the property (R Core Team, 2020). In the research, Tukey HSD multiple comparison test at the 5% significance level revealed which treatment and shelf-life averages are statistically significant in terms of the existence of differences and interactions.

Results and Discussion

Weight Loss

Weight loss is a very important feature which is caused by the loss of water in stored products. Weight loss in stored products gives an idea about the storage life of the product. The averages of the weight loss of florets were examined and it was observed that there was a continuous increase in the weight loss (Table 1). When the treatment averages were examined, the average weight loss in the control group was 4.35%, the averages of ascorbic, folic and salicylic acid treatments were determined as 2.49%, 2.74% and 3.40%, respectively. When Table 1 is examined, it is seen that the difference between the treatment averages is statistically significant, and all the treatments compared to the control group have an effect on preventing weight loss. In addition, the existence of DayxTreatment interaction was determined ($p<0.01$).

Similar to these findings, it was reported that folic acid treatment in broccoli florets (Xu et al., 2021); salicylic acid treatments in banana (Srivastava & Dwivedi, 2000), green onion (Freddo et al., 2013), strawberry (Shafiee et al., 2010) and peach (Khademi & Ershadi, 2013; Han et al., 2002) tomato (Kant et al., 2013); ascorbic acid treatment in lychee (Terdbaramee et al., 2006) and strawberry (Sogvar et al., 2016) have a preventive effect on weight loss compared to the control group.

It has been determined that folic acid treatment has a preventive effect on weight loss in broccoli. Although the findings are in agreement, Xu et al. (2021) stated that the weight loss of broccoli treated with folic acid was less than 1% in 4 day storage at 20˚C and there was no significant increase. In addition, at the 4th day, it was reported that 26 times more weight loss occurred in the control group compared to the group treated with folic acid. In the study, while the weight loss was 2.66% on the 1st day of storage period in broccoli treated with folic acid, this value increased to 5.16% on the 4th day. The difference between the findings is thought to be due to the use of broccoli florets as a material in this study, while Xu et al. (2021) used broccoli heads.

There was no statistically significant difference between the averages of the treatments (AA, SA and FA), the weight loss occurred in the florets treated with ascorbic acid at the lowest rate on the 1st, 2nd and 3rd days of the storage. On the 4th day of the storage period, it is seen that salicylic acid and ascorbic acid have similar values respectively %4.03 and %4.13. It was determined that the weight loss in the control group was 2 times more than ascorbic acid, which had the lowest average in terms of the properties examined. In this case, it can be said that ascorbic acid treatment is the most effective treatment in terms of preventing weight loss.

*Color Parameters (L *, a *, b *)*

Changes in color values are one of the important factors affecting visual quality at the posharvest period. The L * value indicates brightness, a * value indicates green-red color tone, b * value indicates blue-yellow tone.

Cantwell and Suslow (1997) have researched the color changes that occur in broccoli flowers during the storage period, they reported that as the storage period is extended, the yellowing was increased and the L (brightness) value was increased. Table 1 shows that the difference between all treatments (AA, FA and SA) compared with the control group is statistically significant ($p<0.01$). Although there is no significant level between salicylic acid, ascorbic acid and folic acid treatment averages, the highest L* value was determined in the folic acid treatment.

When the findings of a* and b* values of broccoli florets are examined, the difference between the treatment averages is statistically significant, and the existence of DayxTreatment interaction was detected (Table 1) ($p<0.05$). A highest a* value was determined in all treatments compared to the control group at the 4th day of storage period, control group a* value average was -1.89, ascorbic, salicylic and folic acid average was -2.18, -2.47 and -2.76 respectively. The 1st, 2nd, 3rd and 4th day of the storage period has lowest a* value averages at folic acid-treated florets.

Compared with the control group, all treatments (AA, SA and FA) prevent the increase in b* value. In terms of the investigated feature, the presence of variety of treatment interaction was determined (Table 1) ($p<0.01$). At the 4th day of storage period, control group b* value average was 16.61, ascorbic, salicylic and folic acid average was 13.60, 13.18 and 12.65 respectively. At 1st 2nd 3rd and 4th day of the storage period, it was determined that the change in the b * value occurred at the lowest level in the folic acid group. Considering these findings, it can be said that folic acid treatment is the most effective treatment in order to prevent the change in a * and b* value during the 4-day storage period.

Similar to these findings, Xu et al. (2021), reported that folic acid treatment prevented the increase in L*, a* and b* values during the storage period. In addition, there are also studies reported to prevent the change in color values in different species; salicylic acid (Shafiee et al., 2010; Wei et al., 2011; Kant et al., 2013; Chavan & Sakhal, 2020) and ascorbic acid treatments (Gil et al., 1998; Terdbaramee et al., 2006; Lin et al., 2007; Liu et al., 2014; Sikora & Świeca, 2018).

Table 1. Weight loss, Color parameters (*L*, a* b* h°* and *C**) of 'Belstar F1' broccolis during shelf life at 20 °C

Investigated Features	Treatments	Storage Period (Day)					Mean[2]
		0	1	2	3	4	
Weight Loss (%)	Control	-	3.63±0.04Ca	4.76±0.05Ba	6.55±0.22Aa	6.80±0.05Aa	4.35±0.66
	FA	-	2.66±0.13Db	4.37±0.06Ca	4.82±0.04Bb	5.16±0.27Ab	3.40±0.51
	SA	-	2.22±0.07Cc	3.73±0.07Bb	3.74±0.13Bc	4.03±0.02Ac	2.74±0.40
	AA	-	1.87±0.12Cd	3.18±0.03Bc	3.26±0.12Bd	4.13±0.01Ac	2.49±0.39
	Mean[1]	-	2.59±0.20	4.01±0.18	4.59±0.38	5.03±0.34	
*L**	Control	25.77±0.42	29.57±0.39	32.55±1.27	35.92±1.48	37.40±0.36	32.24±1.18W
	FA	26.61±1.09	29.24±1.97	29.63±1.28	30.49±2.00	31.10±0.16	29.41±0.69X
	SA	25.57±0.12	30.18±0.42	30.74±0.39	30.60±0.14	32.84±0.50	29.99± 0.65X
	AA	25.85±0.79	29.12±0.57	29.12±0.90	32.28±0.17	34.38±2.47	30.15±0.92X
	Mean[1]	25.95±0.32z	29.53±0.47y	30.51±0.59xy	32.32±0.85wx	33.93±0.88w	
*a**	Control	-6.55±0.09Aa	-3.86±0.01Bb	-3.24±0.01Cc	-2.51±0.01Dc	-1.89±0.12Eb	-3.61±0.43
	FA	-6.42±0.09Aa	-4.99±0.51Ba	-5.32±0.01Ba	-3.45±0.02Ca	-2.76±0.05Da	-4.59±0.36
	SA	-6.53±0.04Aa	-4.84±0.36Ba	-3.67±0.09Cb	-2.93±0.09Db	-2.47±0.01Ea	-4.09±0.40
	AA	-6.28±0.23Aa	-4.86±0.02Ba	-3.32±0.00Cc	-2.61±0.01Db	-2.18±0.03Eb	-3.85±0.41
	Mean[1]	-6.44±0.06	-4.64±0.19	-3.89±0.25	-2.87±0.11	-2.32±0.10	
*b**	Control	6.95±0.03Bb	12.70±0.24Aa	16.41±0.84Aa	16.39±0.28Aa	16.61±0.29Aa	13.81±1.01
	FA	7.45±0.45Cb	9.65±1.08Bb	11.97±0.73Ab	12.18±0.36Ab	12.65±0.08Ab	10.78±0.58
	SA	8.56±0.44Ba	12.42±0.30Aa	12.95±0.43Ab	13.13±0.75Ab	13.18±0.66Ab	12.05±0.51
	AA	8.63±0.01Ca	11.80±0.45Bab	12.95±0.03ABb	12.88±0.89Bb	13.60±1.25Ab	11.97±0.54
	Mean[1]	7.90±0.26	11.64±0.45	13.57±0.57	13.64±0.56	14.01±0.56	

[1]Storage time, [2]Treatment, Different capital letters show significant differences foreach treatment during the storage and the lowercase letters show significant differences among treatments for each sampling date. Means of treatments and storage time also show capital letter. Data are the mean ± SE of three replicates.

Total Soluble Solids (TSS) and pH Level

Sugar constitutes the majority of the TSS in the products. Sugar plays an important role in controlling the aging process as they are used as a carbon source to maintain increased respiratory activity in tissues during the post-harvest period. Some studies reported decrease in sugar levels and TSS amount in the post-harvest period in broccoli (Büchert et al., 2011; Topcu et al., 2015). In addition, there are studies reporting increase and decrease in fluctuations in TSS ratio (Düzen, 2019).

Kader (1992) stated that the increase in the amount of soluble solids in the stored products is due to water loss, the products that lose water become more concentrated and the TSS ratios increase. In the study, an increase was observed in the amount of TSS in broccoli florets during the storage period similar to Fernández-León et al. (2013) (Table 2). The differences between the treatments ($p<0.05$) and the days of storage ($p<0.01$) were statistically significant, and it was determined that the most effective treatment in terms of preventing the change in the amount of TSS were ascorbic acid similar to the weight loss feature (8.07%) (Table 2). The 4th day of storage period, the mean amount of TSS in the control group increased up to 9.8%. In flowers treated with ascorbic, folic and salicylic acid, these values were determined as 8.50%, 8.67% and 8.67%, respectively. These findings show that all of the treatments (AA, SA, FA) prevented the change in the amount of TSS.

Similar to these findings, many researchers reported that salicylic acid treatment prevented the increase in the amount TSS compared to the control group; peach (Khademi & Ershadi, 2013), apple (Mo et al., 2008), apricot (Hajilou & Fakhimrezaei, 2013), tomato (Chavan & Sakhal, 2020), kiwifruit (Fatemi. et al., 2013) and ascorbic acid treatment; pear (Lin et al., 2007), guava (Gill et al., 2014; Azam et al., 2020), strawberry (Sogvar et al., 2016) and lychee (Terdbaramee et al., 2006).

PH value increased during storage period similar to Lebermann (1965) and Özer (1999). In addition, the existence of DayxTreatment interaction was determined in terms of the property examined ($p<0.01$). It is seen that there is no significant difference between the averages of treatment (AA, FA, and SA) on the 1st day of storage, however, ascorbic acid treatment has the lowest pH values on the 2nd, 3rd and 4th days of storage. At the 4th day of storage period, pH value averages control, AA, SA and FA treatment is respectively 7.7, 7.5, 7.3 and 7.2. These findings show that all treatments (AA, FA and SA) prevented changes in pH value compared to the control group. Similar to these findings, it has been reported that salicylic acid treatment has an inhibitory effect on the change in pH level in kiwifruit (Fatemi et al., 2013), and ascorbic acid treatment in guava (Gill et al., 2014; Azam et al., 2020).

Titratable Acidity (TA)

A decrease in the amount of TA is observed with the use of organic acids as primary respiratory substrate. It was observed that, similar to the findings of Lebermann (1965), Topcu et al. (2015), there was decrease in TA values in broccoli during the storage period (Table 2). The existence of DayxTreatment interaction was determined in terms of this feature ($p<0.01$). During the entire storage period, the lowest values in terms of TA content were observed in the control group, and all the treatments performed prevented the losses in TA content (Table 2). At the 4th day, the titratable acidity amount was 0.05% in the Control group; It is 0.09% (approximately 2 times more) in florets treated with ascorbic acid and salicylic acid, and 0.08% in florets treated with folic acid.

The florets treated with ascorbic acid during the entire storage period have the highest TA values. According to these findings, treatment of ascorbic acid is recommended to prevent postharvest TA loss in florets. Similar to these findings, Azam et al. (2020) reported that the treatment of ascorbic acid in guava preserved the amount of TA. When Table 2 was examined, higher TA averages were found in the florets treated with salicylic acid compared to the control group. Similar to these findings; Hajilou and Fakhimrezaei (2013) reported that ascorbic acid treatment preserved the amount of TA in apricot, Chavan and Sakhal (2020) reported that it preserved the amount of TA in tomato, Fatemi et al. (2013) reported it preserved TA in kiwi and Sogvar et al. (2016) stated that it preserved in strawberry.

Table 2. TSS, pH, TA and total chlorophyll content of 'Belstar F1' broccolis during shelf life at 20°C

Investigated Features	Treatments	Storage Period (Day)					Mean[2]
		0	1	2	3	4	
TSS (%)	Control	7.67±0.33	7.83±0.17	8.50±0.29	9.17±0.17	9.83±0.44	8.60±0.24W
	FA	7.67±0.33	7.33±0.33	8.67±0.17	8.33±0.33	8.67±0.33	8.13±0.19WX
	SA	8.0±0.0	7.83±0.17	8.00±0.29	8.17±0.17	8.67±0.17	8.13±0.10WX
	AA	7.67±0.33	7.50±0.29	8.00±0.29	8.67±0.33	8.50±0.29	8.07±0.17X
	Mean[1]	7.75 ±0.13y	7.62±0.12y	8.29±0.14xy	8.58±0.16wx	8.92±0.21w	
pH	Control	6.81±0.07Da	7.32±0.03Ca	7.55±0.05BCa	7.66±0.05Ba	7.79±0.02Aa	7.43±0.09
	FA	6.75±0.01Da	7.19±0.05Cb	7.39±0.02Bb	7.41±0.03ABb	7.50±0.01Ab	7.25±0.07
	SA	6.81±0.06Ca	7.16±0.02Bb	7.24±0.01Bc	7.28±0.02ABc	7.33±0.01Ac	7.16±0.05
	AA	6.83±0.03Ba	7.20±0.03Ab	7.19±0.05Ac	7.21±0.03Ac	7.25±0.02Ac	7.14±0.04
	Mean[1]	6.80±0.02	7.22±0.02	7.34±0.04	7.39±0.05	7.469±0.063	
TA (%)	Control	0.14±0.00Aa	0.11±0.00Bc	0.09±0.00Cb	0.06±0.00Dc	0.05±0.00Ec	0.09±0.01
	FA	0.15±0.00Aa	0.13±0.00Bb	0.10±0.00Cb	0.08±0.00Db	0.08±0.00Db	0.11±0.01
	SA	0.14±0.01Aa	0.13±0.00Aa	0.11±0.00Bb	0.11±0.01Ba	0.09±0.00Ca	0.11±0.00
	AA	0.15±0.01Aa	0.14±0.00Aa	0.12±0.00Ba	0.12±0.00Ba	0.09±0.01Ca	0.12±0.01
	Mean[1]	0.14±0.00	0.13±0.00	0.10±0.00	0.09±0.01	0.08±0.00	
Total Chlorophyll Content (mg/g)	Control	0.41±0.01Aa	0.37±0.00Bb	0.22±0.01Cd	0.17±0.00Dd	0.08±0.00Ed	0.25±0.03
	FA	0.41±0.01Ba	0.44±0.01Aa	0.28±0.00Ca	0.26±0.00Da	0.20±0.00Ea	0.32±0.02
	SA	0.41±0.01Ba	0.44±0.01Aa	0.23±0.00Cc	0.21±0.01Dc	0.15±0.00Ec	0.29±0.03
	AA	0.40±0.00Bb	0.44±0.01Aa	0.25±0.01Cb	0.24±0.00Db	0.17±0.01Eb	0.30±0.03
	Mean[1]	0.41±0.00	0.42±0.01	0.24±0.01	0.22±0.01	0.15±0.01	

[1]Storage time, [2]Treatment, Different capital letters show significant differences foreach treatment during the storage and the lowercase letters show significant differences among treatments for each sampling date. Means of treatments and storage time also show capital letter. Data are the mean ± SE of three replicates.

Total Chlorophyll Content

Chlorophyll degradation in the postharvest period has a significant impact on visual quality and biochemical contents. For this reason, it is of great importance to examine the changes in the chlorophyll content during storage. The changes of the chlorophyll content of florets during storage are examined in Table 2, and it is seen that all treatments (AA, FA and SA) are effective in preventing chlorophyll degradation when compared to the control group. In addition, the presence of DayxTreatment interaction was determined ($p<0.01$).

At the 2nd, 3rd and 4th days of storage, the highest total chlorophyll content was detected in folic acid-treated florets. On the 4th day of storage, the average of total chlorophyll content in the control group was 0.08mg/g, the amount of total chlorophyll content in the florets treated with folic acid was more than 2 times (0.20 mg/g). Similar to these findings, Xu et al. (2021) reported that folic acid treated broccoli had 2 times higher total chlorophyll content compared to control group.

Conclusion

It is of great importance to investigate practices for maintaining the shelf life quality of broccoli. In this context, this study was conducted to determine the effects of folic, ascorbic and salicylic acid treatments on the shelf life quality of broccoli florets.

In the study, it was determined that all treatments compared to the control group had a preventive effect on the change in all the investigated features. According to the findings, ascorbic acid treatment is recommended to researchers to prevent changes in weight loss, TSS, pH and TA amount, and folic acid treatment is recommended to prevent changes in color values and total chlorophyll amount.

During the shelf life conditions, ascorbic and folic acid was the most prominent treatment to maintain the quality of broccoli florets (cv. Belstar F1). However, it is thought that the effects of ascorbic acid, salicylic acid and folic acid should be investigated in detail in molecular and biochemical studies for more concrete data.

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Conflict of Interest

The author declares no competing interests.

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