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Effect of harvesting time and storage period on quality and storability of Hayward Kiwifruit

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ABSTRACT

Postharvest fruit quality is so affected by harvest time in Hayward kiwifruit. The aim of the present study was to characterize the effects of harvest time and storage period on quantitative and qualitative traits of kiwifruit. Tests were carried out with four harvesting times (Based on the total soluble solids (TSS) index), i.e., 5, 6.5, 8 and 9.5 °Brix and four storage time, i.e., 0, 30, 60 and 90 days. The experiment was done as factorial in a completely randomized design with three replications. The results showed that the interaction of treatments on all traits was significant except for the activity of SOD. Means comparison showed that during 90 days of storage, juice percentage, TSS/TA and starch content in all harvesting treatments were reduced compared to other storage levels (0, 30 and 60 days). With increasing storage period (60 and 90 days), total phenol content, TA%, chlorophyll a, total sugars, non-reducing sugars increased significantly in all harvesting treatments. The protein content and vitamin C increased significantly during the 60-day storage compared to other storage levels in all harvesting treatments. Under 90 days of storage, TSS, chlorophyll b, antioxidant capacity and PG activity increased significantly in all harvesting. This study showed that storage in 60 and 90 days could play a role in increasing the traits such as total phenol content, TA%, chlorophyll pigments, total sugar content, non-reducing sugars, vitamin C, fruit protein, antioxidant capacity, antioxidant enzyme activity and TSS.

Key words: *Actinidia deliciosa*, chlorophyll a, TSS, vitamin C, antioxidant capacity.

INTRODUCTION

Kiwifruit (*Actinidia deliciosa* cv. Hayward) is a vine crop that has good storage qualities. This fruit is an important source of vitamin C, antioxidants (such as carotenoids), phenols and ascorbic acid. Regular consumption of kiwifruit leads to reducing cardiovascular disease, cancer as well as maintaining the balance of acid and alkali in the body. Kiwifruit is also recommended to improve the digestive system because of its various nutrients and vitamins. The harvest time in Kiwifruit is very important so that harvesting at the best time will lead to an increase in storage life and fruit quality (Strik and Hummer, 13). Studies have shown that the harvest of kiwifruit at maturity stage increases its storage life and chemical composition. The chemical composition of kiwifruit depends on several factors such as genotype, pre-harvest weather conditions, fruit maturity at harvest time and storage conditions. Fruit maturity at harvest time is an important factor that plays a role in determining the nutritional value and fruit storage. Harvesting of unripe fruit reduces fruit flavor by increasing fruit acid content and susceptibility to disease. On the other hand, late harvesting of fruits also results in the aging of fruits and shortens their storage life. Therefore, harvesting at an appropriate maturity stage is essential for having higher quality and nutritional value fruits and longer storage life (Amodio *et al*., 1). The total soluble solids (TSS) are one of the best indicators for harvesting and identifying the maturity stage in kiwifruit. The refractometer is used to measure TSS such as sugars, organic acids, phenolic compounds and pectins. Some studies reported that the fruits harvested with TSS less than six did not have a good taste and the fruits harvested with the TSS more than six had the best quality and long storage life. On the other hand, it was observed that the kiwifruit harvested with TSS = 12 did not have commercial and marketable qualities (Amodio *et al*., 1). A study showed that vitamin C, antioxidant capacity, fruit juice, soluble sugars, phenols and carotenoids were higher in early harvested, but at the end of the storage period, these properties decreased significantly. However, the fruits harvested at maturity stage had a much better quality after a long storage period (Tavarini *et al*., 14).

Considering the high levels of kiwi cultivation in Iran and the nutritional and economic value of this

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fruit, it is necessary to determine the appropriate harvest time for having fruits with longer storage life and better nutritional value. Each year in Iran and other countries, the inappropriate harvesting time of kiwi fruit, leads to bad taste and reduced storage period. In this research, the effects of harvest index (TSS) and storage time on qualitative and quantitative characteristics of kiwifruit were evaluated.

MATERIALS AND METHODS

In order to investigate the effects of harvest time and storage period on kiwifruit quality indices, an experiment was conducted as factorial based on a completely randomized design (CRD) with three replications in the north of Iran. The first treatment included: harvest time (Based on the TSS index) in four levels, 5, 6.5, 8 and 9.5 °Brix. For this purpose, 100 healthy fruits from Kiwi trees were selected and based on the treatments, they were harvested at the right time. The fruits were immediately transferred to the refrigerator. In the refrigerator, the fruits were kept at 0°C with a humidity of 90%. The second treatment was a storage period of 0, 30, 60 and 90 days, respectively.

Juice percentage was determined by calculating the ratio of juice weight to fruit weight (Fisk *et al*., 6). The TSS index was measured using a refractometer (ATC-20E, Atago, Tokyo, Japan). To determine the titratable acidity, the titration method was used with NaOH (0.1 N) in the presence of phenol-phthalene (an indicator of the end of the reaction). Titratable Acidity is calculated based on the percentage of citric acid. The ratio TSS to TA was determined using the above indicators. The starch content was calculated according to the method of Hedge and Hofreiter (7). In this method, extraction was carried out using perchloric acid (52%) and finally, the absorption of samples was recorded at 620 nm. Starch content was calculated using a standard glucose graph (mg/g DW). Protein measurements were performed using Lowry's method, based on protein hydrolysis and the release of amino acids that form complexes with the Fulvin reagents. Finally, the absorption of the samples at the 660 nm wavelength was recorded by spectrophotometer. Vitamin-C (ascorbic acid) fruits were determined by titration 2,6-dichlorophenolindophenol (Mazumdar and Majumder, 10). Total phenol content was measured using the Folin-Cicalteu method.

Antioxidant activity assay was determined according to the method cited in Dudonné *et al.* (4). The assay is based on the measurement of the scavenging capacity of antioxidants towards it. Polygalacturonase (PG) activity was determined by measuring the reducing groups released after incubation of the reaction medium at 30ºC for 10 min (pH 5.0) by dinitrosalicylic acid method (Miller, 12). A calibration curve was made with galacturonic acid as standard. Activity of superoxide dismutase activity (EC 1.15.1.1, SOD) was evaluated by first preparing a phosphate buffer (50 mM, pH = 7.3). Then the following additions were made; EDTA (0.1 mM, X mL), NBT (75 mM, X mL), methionine (13 mM, X mL), and riboflavin (4 mM, X mL). Finally, the reaction was started by adding enzyme extract (100 mL), under fluorescent light. The reaction was allowed to proceed for 15 min and was then stopped by switching off the light. Absorbance was determined at 560 nm. One unit of SOD was defined as the amount of enzyme that produced 50% inhibition of NBT reduction under assay conditions.

The method proposed by Lichtenthaler (9) was used to measure the chlorophyll and carotenoids. The 0.4 g of fruit tissue was mixed with 4 ml acetone 80%. After centrifugation at 3000 rpm for 5 minutes, the absorption of supernatant was read by spectrophotometer at 647, 664, 470 nm wavelength. The total of chlorophyll (TChl), chlorophyll a (Chl a) and b (Chl b), and carotenoid was calculated by equations (1) to (4)

Equation (1) $Chl_a = 12.21(A_{664}) - 2.79\ (A_{647})$

Equation (2) $Chl_b = 21.21\ (A_{647}) - 5.1\ (A_{664})$

Equation (3) $Carotenoid = (1000A_{470} - 1.8\ Chl_a - 85.02\ Chl_b) / 198$

Equation (4) $Chl_T = Chl_a + Chl_b$

In order to measure the total sugar content, McCready *et al*. (11) method was used. 2 ml of extract and 3 ml of anthrone reagent were mixed. Then the solution was transferred to a bath at 100°C for 20 minutes. After cooling, the absorbance at 620 nm was recorded. The total sugar content in each sample was determined using the standard curve of glucose. Evaluation of the non-reducing sugars was determined by using the anthrone reagent according to the Van Handel (16) method.

A two-way ANOVA was performed with SAS 9.1.3 software (SAS, Cary, NC, USA) and the means compared with a least significant difference (LSD) test at $P < 0.05$.

RESULTS AND DISCUSSION

Analysis of variance of data showed that the interaction effects of harvesting time and storage period were significant on the percentage of fruit juice, TSS, TA%, TSS/TA, starch content and protein content (Table 1). Mean comparison showed that the percentage of fruit juice in the higher TSS index significantly increased so that the highest percentage of fruit juice was allocated to T_4S_1 and T_4S_2 treatments, which had a significant difference compared to

Table 1. Effects of total soluble solids (TSS) and storage time on qualitative characteristics of kiwifruit.

TSS treatments (°Brix)	Storage time (days)	Juice percentage (%)	TSS (%)	TA (%)	TSS/TA	Starch content (mg/g)	Protein content (mg g^{-1}DW)
5 (T_1)	0 (S_1)	61.52 bc	5 i	0.573 k	8.69 bc	101.8 h	11.89 h
	30 (S_2)	60.57 bc	5.1 i	0.697 j	5.68 d	102 h	27.45 e
	60 (S_3)	64.62 abc	5.2 i	0.896 fg	6.02 d	84.83 i	37.44 d
	90 (S_4)	57.06 cd	12.4 de	1.083 d	3.88 e	47.0 j	11.39 h
6.5 (T_2)	0 (S_1)	57.95 cd	7.5 fgh	0.613 k	10.62 a	199.6 a	21.86 f
	30 (S_2)	60.76 bc	7.4 fgh	0.789 hi	10.61 a	141.0 e	41.17 cd
	60 (S_3)	56.69 cd	12.1 e	0.892 fg	9.17 b	124.9 fg	50.99 a
	90 (S_4)	39.76 f	15.0 c	1.476 a	3.84 e	116.8 g	22.09 f
8 (T_3)	0 (S_1)	58.58 cd	7.6 fgh	0.691 j	10.70 a	185.6 b	30.95 e
	30 (S_2)	50.33 de	8.2 fg	0.737 ij	11.06 a	145.4 de	38.15 d
	60 (S_3)	43.16 ef	13.9 cd	0.936 ef	8.28 bc	141.3 e	46.62 b
	90 (S_4)	42.07 ef	16.9 b	1.322 b	2.92 e	140.5 e	21.15 f
9.5 (T_4)	0 (S_1)	74.35 a	9.0 f	0.979 e	7.59 c	162.6 c	38.85 d
	30 (S_2)	72.05 a	13.0 de	0.969 ef	6.32 d	157.4 cd	37.33 d
	60 (S_3)	44.52 ef	19.1 a	1.161 c	2.86 e	148 de	42.93 bc
	90 (S_4)	45.37 ef	18.1 ab	1.324 b	0.99 e	136.2 ef	17.39 g
Significance	TSS	**	**	**	**	**	**
	Storage time	**	**	**	**	**	**
	T×S	**	**	**	**	**	**

Means followed by the same letter are not significantly different ($P < 0.05$) according to LSD test (n = 6). **$P < 0.01$.

other levels. As the storage period increased, the percentage of juice declined significantly. The lowest percentage of juice was attributed to T_2S_4 treatment, which was not significantly different from other treatments such as T_3S_4, T_4S_4, T_4S_3 and T_3S_3 (Table 1). The results indicated that increasing the storage period from 0 to 90 days resulted in a significant increase of TSS index at all levels of fruit harvest. The highest TSS was observed in T_4S_3 treatment, which had a significant difference with other treatments, except T_4S_4 treatment. The lowest level of TSS index belonged to the levels of T_1S_1, T_1S_2 and T_1S_3, which had a significant reduction compared to other levels (Table 1).

Comparison of the means on the TA% index showed that with increasing storage period (60 and 90 days) in all harvesting treatments, TA% increased significantly. The highest TA% was observed in T_2S_4 treatment. However, the lowest level of TA% was observed in T_1S_1 and T_2S_1 treatments (Table 1). The results showed that the ratio of TSS/TA decreased with increasing storage time at all harvesting levels so that the lowest ratio was observed in T_4S_4 treatment. T_2S_1, T_2S_2, T_3S_1 and T_3S_2 treatments had the highest ratio of TSS/TA and had no significant difference compared to each other (Table 1). The TSS is an important indicator that has a direct relation with the quality of the fruit and consumers tend to use kiwifruit with high TSS rates. The results of this study showed that increasing the storage period leads to an increase in the TSS and TA% in all harvest indexes. It has been reported in several studies that the main reason for increasing the TSS level is starch hydrolysis to soluble sugars (Amodio *et al*., 1). During storage period, some soluble pectins and phenolic compounds also play an important role in increasing TSS and TA% (Amodio *et al*., 1). Fruit flavor is directly related to the TSS/TA ratio, increasing this ratio leads to a sweet taste of the fruit (Fisk *et al*., 6). The results of this study showed that T_1S_1, T_1S_2, T_2S_1 and T_2S_2 treatments had the highest ratio, which had a sweeter taste compared with other treatments. The percentage of juice is directly related to the size of the kiwifruit so that the larger fruits contain more juice (Amodio *et al*., 1). The results of this study showed that with increasing storage time, the fruit size and percentage of fruit juice decreased in all harvest indexes (5, 6.5, 8 and 9.5 °Brix). Increasing the TSS during storage period can also play an important role in reducing the percentage of fruit juice (Tavarini *et al*., 14).

Comparison of mean of data on the interaction effects of harvesting time × storage period on starch content showed that increasing storage period in all harvesting treatments resulted in a significant decrease in starch content. The lowest and the highest starch content were observed in T_1S_4 and T_2S_1 treatment respectively (Table 1). Starch has high content at the beginning of harvest, but after harvesting and during storage, starch is hydrolyzed to soluble sugars and increases the soluble sugars and sweetness in the fruit. The sucrose-phosphate synthase enzyme (SPS) is responsible for the decomposition of starch into glucose and is activated by ethylene hormone (Boquete *et al*., 3). The results of this study showed that the content of starch significantly decreased with increasing storage period. A similar study reported that the main reason for increasing the TSS during storage period was the decomposition of starch into hexose sugars, and this transformation plays a very important role in the softening of fruits (Fattahi Moghadam and Halajisani, 5).

The results related to protein content showed that the 60 days storage period (S_3) compared with the 0, 30, and 90 days (S_1, S_2 and S_4) periods in all harvesting treatments increased protein content significantly. The lowest content of fruit protein was attributed to T_1S_1 and T_1S_4 treatments, which had a significant difference compared with other levels (Table 1). Expression of some proteins is increased during storage time. The most important protein compound in kiwi is the proteolytic enzyme actinidin. Actinidin is the predominant enzyme in kiwifruit and can play a role in aiding the digestive process. There is also a wide range of enzymes involved in the ripening of kiwifruit, particularly enzymes involved in polysaccharide and oligosaccharide metabolism and in the development of flavor and aroma compounds. The results of this study showed that increasing the storage period from 0 to 60 days increased the protein content, but the storage period of 90 days reduced the protein content significantly.

Analysis of variance of data showed that the interaction effects of harvesting time and storage period were significant on the total phenol content and vitamin C (Table 2). The results of the means comparison showed that increasing the storage period (60 and 90 days) resulted in a significant increase in phenol content in all harvesting. The harvest of kiwifruit in T_4 treatments resulted in an increase in total phenol content in all storage period. The highest and lowest rates of total phenol content were observed in T_4S_4 and T_1S_1 treatments, respectively (Table 2). The content of phenol in Kiwifruit depends on the type of variety, harvest time and storage conditions. During the storage period, it was reported that increased activity of the enzyme phenylalanine ammonia (PAL) increases the total phenol content. Increasing the activity of this enzyme is due to changes in the metabolism of phenols. In an experiment on apples, the total phenol content increased at the end of the storage period (Leja *et al*., 8). The results of this study showed that fruit harvest in higher TSS indices during the storage period increases phenolic content.

Means comparison showed that vitamin-C had a significant increase in T_2S_2 and T_2S_3 treatments compared to other levels. The lowest of vitamin C was observed in T_3S_1 treatment, which had no significant difference compared to T_3S_2 treatment but had a significant reduction compared to other levels (Table 2). Vitamin C is one of the most water-soluble compounds and the most important antioxidant. It is required for the functioning of several enzymes and is important for immune system function. In during storage, vitamin C changes depend on environmental factors, postharvest conditions, and harvest time. Some studies reported that stress in the storage period reduces the amount of vitamin-C in the fruit. The ascorbate peroxidase enzyme (APX) needs vitamin C. This enzyme reduces oxidative stress in fruits by using vitamin C (Fattahi Moghadam and Halajisani, 5). Factors such as proper harvesting time, controlling environmental conditions during storage and minimizing stress can prevent vitamin C reduction. The results of this study showed that with increasing storage time, vitamin C content increased in all harvest indexes.

Analysis of variance showed that interactions of treatments were significant on antioxidant capacity and polygalacturonase enzyme, but not significant on SOD activity (Table 2). The results showed that with increasing storage period, antioxidant capacity increased significantly in all harvesting. The highest antioxidant activity was observed in T_4S_4 treatment, while the lowest antioxidant capacity was observed in T_3S_1 treatment (Table 2). The results showed that storage of kiwifruit in 90 days resulted in increased activity of the PG enzyme in all harvesting treatments (T_1, T_2, T_3 and T_4). The highest activity of PG enzyme was observed in T_3S_4 treatment, which had no significant difference with T_1S_4, T_2S_4 and T_4S_4 treatments (Table 2). SOD activity in treatments of 6.5, 8 and 9.5 °Brix had a significant decrease compared to 5 °Brix treatment (Fig. 1A). Simple effects of storage period on this trait showed that, with increasing storage time, the activity of SOD decreased, so that the highest and lowest activity was assigned to 0 and 90 days treatments, respectively (Fig. 1B).

Table 2. Effects of total soluble solids (TSS) and storage time on antioxidant traits of kiwifruit.

TSS treatments (°Brix)	Storage time (days)	Total phenolic content (%)	Vitamin-C (mg/g)	Antioxidant capacity	Polygalacturonase (µmol/g FW)
5 (T_1)	0 (S_1)	363.6 i	453.6 e	56.83 ef	74.50 cde
	30 (S_2)	409.9 g	462.7 de	57.31 ef	77.23 cd
	60 (S_3)	489.1 f	550.5 b	67.55 cd	72.59 de
	90 (S_4)	564.7 d	571.7 b	72.16 b	87.27 ab
6.5 (T_2)	0 (S_1)	380.6 ghi	503.0 cd	58.65 e	76.71 cd
	30 (S_2)	386.9 ghi	669.5 a	54.57 ef	68.32 e
	60 (S_3)	584.6 d	669.7 a	75.36 ab	74.92 cde
	90 (S_4)	648.4 c	533.3 bc	78.18 a	85.47 ab
8 (T_3)	0 (S_1)	381.9 ghi	252.4 g	50.58 f	80.35 bc
	30 (S_2)	394.7 gh	288.2 fg	55.80 ef	77.42 cd
	60 (S_3)	492.7 f	306.1 f	65.73 d	75.28 cde
	90 (S_4)	638.9 c	327.3 f	75.38 ab	89.05 a
9.5 (T_4)	0 (S_1)	534.7 e	436.7 e	66.32 d	77.41 cd
	30 (S_2)	590.2 d	461.3 de	66.03 d	76.39 cd
	60 (S_3)	739.9 b	530.9 bc	68.76 bcd	72.24 de
	90 (S_4)	851.0 a	532.5 bc	80.59 a	89.02 a
Significance	TSS	**	**	**	**
	Storage time	**	**	**	**
	T×S	**	**	**	NS

Means followed by the same letter are not significantly different ($P < 0.05$) according to LSD test (n = 6). NS not significant; **$P < 0.01$.

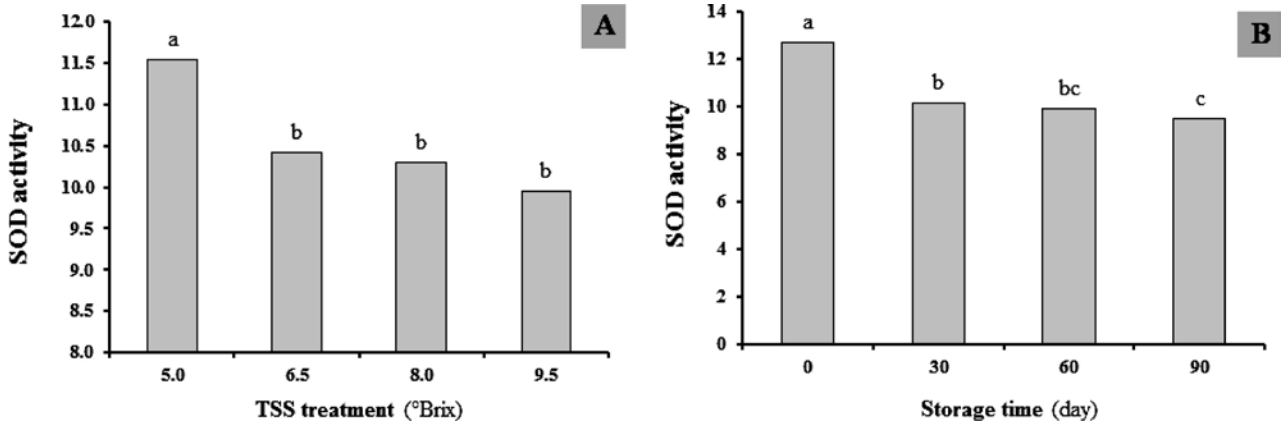

Fig. 1. Effect of TSS and storage time on SOD activity.

Antioxidant enzymes play an important role in stress during the fruit maturing process. Studies have shown that the activity of the SOD and CAT delays aging processes in fruits (Asbahi *et al*., 2). Products with higher antioxidant activity exhibit better resistance to various environmental stresses, these fruits have high nutritional quality and high storage. SOD is the first step of defense against Oxygen reactive species (ROS) and thus the activity of superoxide (O_2^-) turns to hydrogen peroxide (H_2O_2) and oxygen (O_2). Kiwifruit has the high antioxidant capacity and its major components are phenol and vitamin-C. The antioxidant capacity is directly related to the content of phenol, vitamin C and antioxidant enzymes activity (Asbahi *et al*., 2). The results of this study showed that antioxidant capacity increases during storage, which is probably due to a significant increase in phenolic, vitamin C and antioxidant activity (SOD and PG) during storage.

Analysis of variance of data showed that the interaction effects of harvesting time and storage period were significant on the content of chlorophyll a, b, carotenoids and total chlorophyll (Table 3). The results showed that increasing the storage period (S_3 and S_4) resulted in a significant increase of Chl a in all harvesting treatments. The highest and the lowest of Chl a content were observed under T_2S_4 and T_1S_1 treatments, respectively (Table 3). The results showed that the storage period in the 90-day (S_4) significantly increased Chl b at all harvesting levels (T_1, T_2, T_3 and T_4). The highest content of Chl b was observed in T_1S_4 and T_2S_4 treatments (Table 3). Comparison of meanings on carotenoids content showed that T_1S_1 and T_1S_2 treatments had the least amount of this trait, which was significant in comparison with all treatments (Table 3). Results related to the TChl showed that 60 and 90 days storage in all harvesting treatments (T_1, T_2, T_3 and T_4) significantly increased the TChl compared to 0 and 30 days of storage. The highest TChl was observed in T_2S_4 treatment, but the lowest content of TChl was attributed to T_1S_1 treatment (Table 3). Kiwifruit (Hayward cultivar) has a green colour and unlike other fruits, it does not change color at maturity. This green color is due to the presence of photosynthetic pigments such as chlorophylls. Chlorophyll pigments in Kiwifruit are considered as indicators of quality assessment during the storage period and have a direct relation to conditions of the storage environment. The researchers reported that a significant reduction in photosynthetic pigments in kiwifruit leads to a decrease in the quality of fruit. These researchers reported that the main reason for the reduction of chlorophyll content is poor storage conditions such as low light, heat stress, and antioxidant activity (Tombesi *et al.*, 15). The results of this study showed that the content of photosynthetic pigment (Chl a, Chl b, TChl and Carotenoid) increased during the storage period.

The results of analysis of variance showed that the interaction effects of harvesting time and storage period were significant on the total sugar content and sugars recovered in kiwifruit (Table 3). Means comparison showed that in all harvesting treatments, increasing the storage period significantly increased the total sugar content. The highest total

Table 3. Effects of total soluble solids (TSS) and storage time on photosynthetic pigment, total sugars and non-reduced sugars of kiwifruit.

TSS treatments (°Brix)	Storage time (days)	Chl a mg g^{-1}(FW)	Chl b mg g^{-1}(FW)	Tchl mg g^{-1}(FW)	Carotenoeids mg g^{-1}(FW)	Total sugars (mg/g)	non-reduced sugars (mg/g)
5 (T_1)	0 (S_1)	13.73 h	0.980 efg	14.72 f	0.350 e	0.185 i	0.125 f
	30 (S_2)	17.07 fg	1.577 cd	18.64 e	0.355 e	0.342 h	0.330 ef
	60 (S_3)	23.37 abc	1.537 d	24.90 abc	0.445 de	1.129 e	1.112 b
	90 (S_4)	24.73 ab	2.530 a	27.26 a	0.547 cd	1.926 b	1.565 a
6.5 (T_2)	0 (S_1)	14.53 gh	0.440 i	14.97 f	0.608 bcd	0.429 h	0.143 f
	30 (S_2)	18.60 ef	0.513 i	19.11 de	0.589 bcd	0.537 g	0.486 de
	60 (S_3)	21.87 bcd	0.610 hi	22.48 bc	0.653 abc	1.138 e	0.512 de
	90 (S_4)	25.50 a	2.543 a	28.04 a	0.824 a	1.488 c	1.228 b
8 (T_3)	0 (S_1)	16.53 fgh	0.766 gh	17.30 ef	0.714 abc	0.536 g	0.503 de
	30 (S_2)	16.48 fgh	0.900 fg	21.87 cd	0.730 ab	0.941 f	0.533 de
	60 (S_3)	22.17 bcd	1.190 e	23.36 bc	0.742 ab	1.118 e	0.754 cd
	90 (S_4)	24.53 abc	1.977 b	26.51 a	0.811 a	1.542 c	1.216 b
9.5 (T_4)	0 (S_1)	17.43 fg	0.963 efg	18.40 e	0.538 cd	0.625 g	0.536 de
	30 (S_2)	16.50 fgh	1.133 ef	17.63 ef	0.666 abc	1.354 d	0.966 bc
	60 (S_3)	21.43 cde	1.503 d	22.94 bc	0.673 abc	1.316 d	1.140 b
	90 (S_4)	23.37 abcd	1.777 bc	25.14 ab	0.704 abc	2.086 a	1.643 a
Significance	TSS	*	**	NS	**	**	**
	Storage time	**	**	**	**	**	**
	T×S	*	**	**	**	**	**

Means followed by the same letter are not significantly different ($P < 0.05$) according to LSD test (n = 6). NS not significant; *$P < 0.05$; **$P < 0.01$.

sugar content was in T_4S_4 treatment, which increased significantly compared with other treatments. The lowest sugar content was observed at T_1S_1 treatment (Table 3). The results of non-reducing sugars were similar to those of total fruit sugar content. In all harvesting treatments (T_1, T_2, T_3 and T_4), 90-day storage treatment (S_4) significantly increased non-reducing sugars compared to other levels (S_1, S_2 and S_3). The highest and lowest levels of non-reducing sugars were observed in T_4S_4 and T_1S_1 treatments, respectively (Table 3). Studies on kiwi fruit showed that increasing carbohydrates during storage could lead to the activation of cell wall polysaccharide-degrading enzymes. These enzymes are activated by the hormone ethylene during storage and play an important role in fruit softening. In other studies, a significant increase in total carbohydrates during the storage period was attributed to increased TSS and starch hydrolysis to simple sugars. Saccharose phosphate synthase is responsible for the conversion of starch into simple carbohydrates such as glucose, and studies have shown that kiwifruit storage can increase the activity of this enzyme (Amodio *et al*., 1).

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