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Research Article

Determination of changes in some biological properties during storage of some conventional sorbets

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ABSTRACT

In this study, the evil eye, engagement, linaria, rose, unripe grape and sirkencubin from traditional Turkish sorbets were stored at different temperatures (4, 20 and 37 °C) for 90 days after they were concentrated to 62 ± 1 °Brix. The effects of storage temperature and time on color parameters and the bioactive properties of traditional sorbets were investigated. Although slight differences were observed, it was determined that total phenolic content, antioxidant and antiradical activities tended to decrease during storage in general. Storage temperature and time were found to be effective on color parameters and the biological characteristics of sorbets tested. The changes in the phenolic compound profiles of the concentrated sorbets during storage (at 0^{th} and 90^{th} days) were detected by LC-MS / MS. The observed results show that the bioactive properties and color of the sorbets are better when low temperatures for storage are preferred.

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INTRODUCTION

Sorbet is derived from the word "Şariba" which means to drink in Arabic. It is a diluted version of mixed syrups resulting from sugar to flowers, fruits, shells, roots or seeds of various plants [1,2]. The word sorbet is called scherbett in German, sorbetto in Italian, sorbet in French and sorbet-sherbet in English [3]. The Turkish kitchen has an extremely rich sorbet culture [4].

Rose sorbet is a beverage that is made with boiling after rose flowers with sugar are scrubbed. It has been used as antiseptic, peptic, and for alleviating tonsil disturbance [5]. The rose (*Rosa damascena*) that gives the name of sorbet is a fragrant plant from the *Rosa* genus, Rosaceae family [6]. Unripe grape sorbet is a traditional beverage made by mixing the unripe grape juice with sugar on important days and engagements. Engagement sorbet is a traditional beverage

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made by a mixture of sugar, black raisins with poppy flower (*Papaver rhoeas*) at the engagement ceremony on Friday. Evil eye sorbet is a traditional beverage originating from evil belief in Istanbul and around. It is made by mixture of rose water, seizure sugar with saffron (*Crocus sativus*). Linaria sorbet is a traditional beverage made by a mixture of saffron, filtered honey with yellow wheat (*Triticum aestivum*). It is conventionally produced in the spring (March), the day before Nevruz in Eastern Anatolia [7]. Another sorbet examined in this study is sirkencubin sorbet, which is traditionally consumed in Mevlevi lodges. The name sirkencubin consists of words "angabin" (honey) and "serke" (vinegar) in Persian. In the Western languages, the equivalence of this sorbet, which is one of the hippocrates' most preferred medications, is oxymel [8].

In the present study; it has been aimed to i) study the functional properties, ii) study the changes in bioactivity and color when they stored at different temperatures and times, iii) study the changes in the phenolic profiles at the onset and end of storage, of six different sorbets including the evil eye, engagement, linaria, rose, unripe grape and sirkencubin. For this purpose, the sorbets were concentrated to 62 ± 1 °Brix and stored at three different temperatures (4, 20, and 37 °C). Samples were taken at 0, 30, 60, and 90th days of the storage period, and the changes in some bioactivity property and the color of the sorbets were determined. The changes in the phenolic substance profile during storage were detected by LC-MS / MS assay.

MATERIAL AND METHOD

Materials

In the present study, the unripe grape was collected from Bunyan Region (Kayseri, Turkey). It was cleaned and stored at –18 °C. All other materials necessary for making sorbet, as reported below, were obtained from local markets at Kayseri, Turkey, and stored in the dark at room temperature.

Production of Sorbets

The preparation of sorbets studied was carried out at Food Engineering Department Laboratory, Erciyes University.

Evil eye sorbet: Seizure sugar (110 g), saffron (12 g), and rose water (20 mL, Rosense, Isparta) were mixed into 1 L of water and boiled for 25 min. Then, the mixture was filtered with a clean cheesecloth [5].

Engagement sorbet: Firstly, dry black grapes (300 g) was mixed with 1 L of water, and stored for 6 h at room temperature. Then, sugar (100 g) and grinded corn poppy flowers (10 g) were mixed with this solution and boiled during 30 min. For separation of the solid and liquid portions from each other, the obtained mixture was filtered. The abstracted grapes were pressed by a colander to obtain grape juice. Then, all grape juice was collected and boiled for 10 min. At the end, the mixture was filtered. The sorbet was made available for consumption [5].

Lineria sorbet: Firstly, seed of yellow wheat (250 g) was put into 1 L of water in the pot and germinated for 5 days in the dark at room temperature. The germinated seeds were filtered and crushed by a colander. Water (1 L) was added to the obtained grinded material and boiled for 40 min. Then, saffron (10 g) was added and the mixture was boiled for another 20 min. Drained honey (130 g) was added after the mixture was cooled to room temperature. The sorbet was made available for consumption after filtration with a clean cheesecloth [5].

Rose sorbet: Rose leaves (*Rosa damascena*) were dried and washed to clean from dust. Drained rose leaves (20 g) were rubbed with sugar (100 g) until sugar melts. The mixture was stored for 3 hours in the refrigerator. Then, it was boiled with water (1 L) for 10 min [5, 9].

Sirkencubin sorbet: To prepare sirkencubin sorbet, honey (300 g) and vinegar (100 mL) were mixed in water (1 L) [8].

Unripe grape sorbet: Unripe grapes (*Vitis vinifera*) were washed and filtered. They were stored at –18 °C until analyzed. To prepare sorbet, unripe grapes (450 g), which were brought to room temperature, were mixed with sugar (120 g) and water (1 L). The mixture was boiled for 30 min and filtered to separate from unripe grapes. Separated unripe grapes were pressed by a colander to obtain grape juice. All of the liquids were collected and boiled for another 20 min [5].

Investigation of Some Bioactive Properties of Sorbet Samples

Concentrated sorbets were mixed with a suitable ratio of water before being consumed. In order to determine the changes in the bioactivity properties of the evil eye, engagement, linaria, rose, sirkencubin and unripe grape sorbets during storage at different temperatures, the sorbets were concentrated to 62 ± 1 °Brix under atmospheric pressure in lid open boiler.

Concentrated sorbets were bottled and stored at temperatures of 4, 20, and 37°C for 90 days. Refrigerator (Vestel, Turkey) was used for storage at 4 °C, while Nüve ES 110 and JeioTech IB-11 (Korea) model incubators were used for storage at 20 °C and 37 °C, respectively. Total phenolics, antioxidant properties, and color parameters of stored samples were determined on 0, 30, 60, and 90th days. Phenolic compounds of sorbets were detected by LC-MS/MS to determine the change in phenolic compositions of the samples at 0th and 90th days.

The Brix

Brix degree of the sorbets were determined using a refractometer (Reichert AR 700, US) at 20 °C.

Phenolic compositions of sorbets

The phenolic composition analysis was performed using LC-MS/ MS as described by Ertas et al. [10]. The sorbets were diluted 10-fold with ddH_2O and then filtered through a 0.2 μm microfiber filter to prepare for LC-MS/ MS assay. UHPLC

(Nexera, Shimadzu) and two tandem mass spectrometry were used for determination of the phenolic composition. Liquid chromatography contains an LC-30AD tandem pump, a CTO-10ASvp colonic oven, a SIL-30AC auto sampler and a DGU-20A3R degasifier. Chromatographic separation was accomplished by C18 reverse phase Inertsil ODS-4 (3 μm, 150 mm × 4.6 mm) analytical column. The column degree was fixed at 40 °C. Solvent injection volume and flow rate were adjusted to be 4 μL and 0.5 mL/min, respectively. The elution consisted of mobile phase A (5 mM ammonium formate, 0.1% formic acid and water) and mobile phase B (5 mM ammonium formate, 0.1% formic acid, and methanol). The gradient program with proportions of solvent B was manipulated t (min), B% (0, 40), (20, 90), (23.99, 90), (24, 40), (29, 40) [10].

Total phenolic contents

The amount of total phenolic contents of sorbet samples was detected using Folin-Ciocalteu assay [11]. The absorbance of the sorbets was read at 765 nm. The data are exhibited as the average of triplicate analyses. Results were expressed as mg of gallic acid (GAE) equivalents/kg.

Antioxidant and antiradical activity

The antioxidant properties of the sorbets were investigated using the phosphomolybdenum assay [12]. The total antioxidant activity of sorbets was estimated as mg of ascorbic acid equivalents (AAE)/g.

The antiradical activity of sorbets was determined using DPPH method [13].

The antiradical properties of the sorbets were calculated by the following formula:

$$I\% = 100 \times \left(1 - \frac{AS}{AC}\right)$$

I: DPPH inhibited by the sorbet, %, *AS*: Absorbance for sorbet, *AC*: Absorbance of control

Total anthocyanin contents

The anthocyanin content of sorbets was determined by pH differential method [14]. The anthocyanin content of sorbets was estimated as cyanidine-3-glucoside (cyn-3-glu) (molar absorbance ε = 26.900, MW: 5449.2).

Determination of color

The L*, C* (chroma) and h° (hue) values from the color parameters of the concentrated sorbets samples brought to room temperature were detected by a Konica Minolta Chroma Meter [15].

Statistical analysis

Data from the present study were assayed by two factor variance analyzes using SAS statistical program (SAS version 8.2). Analyzes were made in 2 replications 3 parallel. The difference between the groups was detected by TUKEY multiple comparison test at the significance level of $\alpha = 0.05$ [16].

RESULTS AND DISCUSSION

Brix values

Changes in the brix rates of sorbets concentrated under atmospheric pressure by the open boiler method during the concentration process are given in Figure 1. The target value of 62 ± 1 °Brix was reached at 82th minutes on the sirkencubin sorbet, 85th minutes on the engagement sorbet, 88th minutes on the linaria sorbet, 109th minutes on the unripe grape sorbet, 110th minutes on the evil eye sorbet and 112th minutes on the rose sorbet. In another study conducted by the same concentration method, the time of reaching 62 ± 1 °Brix of the poppy sorbet was determined as 85 minutes [17], and this period was 110 minutes for the tamarind sorbet [18].

Phenolic composition

Changes in the phenolic composition after storage on 0th (initial) and 90th of the sorbets stored at 4, 20 and 37 °C for 90 days by concentrating under atmospheric pressure with open boiling method were detected by LC-MS / MS.

The recovery, measurement limit and detection limit of phenolic standards in LC-MS/MS are shown in Table 1. The correlation coefficient was higher than 0.99 for all standards. The detection limit and the measurement limit for

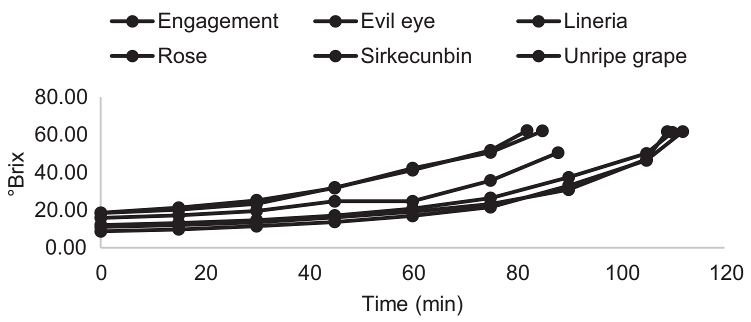

Figure 1. Time-dependent °brix variations of concentrated sorbets.

Table 1. Analytic parameters of the LC-MS/MS method

		RT[a]	r2[b]	RSD(%)[c]	Linearity range(mg/L)	LOD/LOQ (μg/L)[d]	Recovery (%)	U[e]
1	tr-Aconitic acid	4.13	0.9933	0.3908	250–10000	15.6 / 51.9	102.8	4.9
2	Gallic acid	4.29	0.9901	0.4734	25–1000	4.8 / 15.9	102.3	5.1
3	Chlorogenic acid	5.43	0.9932	0.1882	250–10000	7.3 / 24.3	99.7	4.9
4	Protocatechuic acid	5.63	0.9991	0.5958	100–4000	25.8 / 85.9	100.2	5.1
5	Tannic acid	6.46	0.9955	0.9075	100–4000	10.2 / 34.2	97.8	5.1
6	tr-Kaffeic acid	7.37	0.9942	1.0080	25–1000	4.4 / 14.7	98.6	5.2
7	p-Coumaric acid	9.53	0.9909	1.1358	100–4000	15.2 / 50.8	98.4	5.1
8	Rosmarinic acid	9.57	0.9992	0.5220	250–10000	10.4 / 34.8	101.7	4.9
9	Rutin	10.18	0.9971	0.8146	250–10000	17.0 / 56.6	102.2	5.0
10	Hesperidin	9.69	0.9973	0.1363	250–10000	21.6 / 71.9	100.2	4.9
11	Hyperoside	10.43	0.9549	0.2135	100–4000	12.4 / 41.4	98.5	4.9
12	4-OH Benzoic acid	11.72	0.9925	1.4013	25–1000	3.0 / 10.0	106.2	5.2
13	Salicylic acid	11.72	0.9904	0.6619	25–1000	4 / 13.3	106.2	5.0
14	Myricetin	11.94	0.9991	2.8247	100–4000	9.9 / 32.9	106.0	5.9
15	Fisetin	12.61	0.9988	2.4262	100–4000	10.7 / 35.6	96.9	5.5
16	Coumarin	12.52	0.9924	0.4203	100–4000	9.1 / 30.4	104.4	4.9
17	Quercetin	14.48	0.9995	4.3149	25–1000	2.0 / 6.8	98.9	7.1
18	Naringenin	14.66	0.9956	2.0200	25–1000	2.6 / 8.8	97.0	5.5
19	Hesperetin	15.29	0.9961	1.0164	25–1000	3.3/ 11.0	102.4	5.3
20	Luteolin	15.43	0.9992	3.9487	25–1000	5.8 / 19.4	105.4	6.9
21	Kaempferol	15.43	0.9917	0.5885	25–1000	2.0 / 6.6	99.1	5.2
22	Apigenin	17.31	0.9954	0.6782	25–1000	0.1 / 0.3	98.9	5.3
23	Rhamnetin	18.94	0.9994	2.5678	25–1000	0.2 / 0.7	100.8	6.1
24	Chrysin	21.18	0.9965	1.5530	25–1000	0.05 / 0.17	102.2	5.3

[a]RT: retention time; [b]r^2: coefficient of determination; [c]RSD: relative standard deviation; [d]LOD/LOQ (μg/L): limit of detection/ limit of quantification; [e]U (%): percent relative uncertainty at %95 confidence level.

tested components were in the range of 0.05 to 25.8 μg/L and 0.17 to 85.9 μg/L, respectively. The recovery of phenolic substances varied from 96.9% to 106.2% (Table 1).

The phenolic constitutions of the evil eye, engagement, linaria, rose, unripe grape and sirkencubin sorbets which were stored for 90 days at the beginning and at different temperatures are given in Tables 2–7.

The major component of engagement, linaria and sirkencubin sorbets was protocatechuic acid. The major phenolic compound in rose and unripe grape sorbets was gallic acid and it was found that the amount was slightly increased in the samples stored for 90 days. In the literature, since sufficient information about the sorbet is not available, the findings have been compared with samples as close as possible. In this context, it was determined that major components of the tamarind sorbet concentrated by open boiler method were protocatechuic acid and coumarin [9].

It is thought that the increase of gallic acid in the roses and unripe grape sorbets at the storage process is based on tannin hydrolysis. Indeed, it was reported that the increase of gallic acid in the pomegranate wines after storage process might be due to hydrolyzing of tannins [19].

Similarly, it was determined that the hydrolyzed tannins in the *Quercus robur* and *Quercus cerris* degraded by heat treatment and caused to increase in gallic acid [20]. In the same study, it was found that the phenolic content and tannin amount were the lower in the heat treated plants than in the untreated ones [20]. The components and their proportions in the food, their interactions with each other and the phenolic components, and also some reactions as a result of heat treatment can alter the phenolic compound profile of the food [21].

The type and temperature of the heat treatment may cause an increase in the amount of phenolic component [22], on the contrary, it may reduce the amounts of phenolic component by breaking down of some phenolic components.

In general, it is expected that the total amount of phenolic compound will decrease by heat treatment. However,

Table 2. The phenolic compositions of concentrated engagement sorbet

		Parention (m/z)	MS^2	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
1	tr-Aconitic acid	172.85	85 (12), 129 (9)	0.00±0.00	0.03±0.01	0.02±0.00	0.02±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	0.07±0.01	0.23±0.04	0.17±0.03	0.25±0.05
3	Chlorogenic acid	353	191(17)	0.00±0.00	0.00±0.00	0.01±0.00	0.01±0.00
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.27±0.05	0.95±0.09	0.71±0.14	1.08±0.21
5	Tannic acid	182.95	124 (22), 78 (34)	0.00±0.00	0.00±0.00	0.02±0.00	0.01±0.00
6	tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	0.04±0.01	0.11±0.02	0.08±0.02	0.12±0.02
7	p-Coumaric acid	162.95	119 (15), 93 (31)	–*	–	–	–
8	Rosmarinic acid	358.9	161 (17), 133 (42)	–	–	–	–
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	–	–		–
10	Hesperidin	611.1	303,465	0.02±0.00	0.29±0.06	0.19±0.04	0.19±0.04
11	Hyperoside	463.1	300,301	0.01±0.00	0.02±0.01	0.02±0.01	0.02±0.01
12	4-OH Benzoic acid	136.95	93,65	–	–	–	–
13	Salicylic acid	136.95	93,65,75	–	–	–	–
14	Myricetin	317	179,151,137	–	–	–	–
15	Fisetin	284.95	135,121	–	–	–	–
16	Coumarin	146.95	103,91,77	0.01±0.00	0.01±0.00	0.01±0.00	0.03±0.01
17	Quercetin	300.9	179,151,121	–	–	–	–
18	Naringenin	270.95	151,119,107	–	–	–	–
19	Hesperetin	300.95	164,136,108	–	–	–	–
20	Luteolin	284.95	175,151,133	–	–	–	–
21	Kaempferol	284.95	217,133,151	0.01±0.00	0.04±0.01	0.03±0.01	0.03±0.01
22	Apigenin	268.95	151,117	–	–	–	–
23	Rhamnetin	314.95	165,121,300	–	–	–	–
24	Chrysin	253	143,119,107	–	–	–	–

*-: Not Detected

Table 3. The phenolic compositions of concentrated evil eye sorbet

		Parention(m/z)	MS^2	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
1	tr-Aconitic acid	172.85	85 (12). 129 (9)	0.03±0.01	0.02±0.00	0.03±0.01	0.02±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
3	Chlorogenic acid	353	191(17)	0.22±0.05	0.67±0.14	0.56±0.11	0.38±0.08
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.07±0.01	0.23±0.05	0.19±0.04	0.19±0.04
5	Tannic acid	182.95	124 (22), 78 (34)	0.00±0.00	0.01±0.00	0.01±0.00	0.01±0.00
6	tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	0.04±0.01	0.12±0.02	0.14±0.03	0.09±0.02
7	p-Coumaric acid	162.95	119 (15), 93 (31)	1.67±0.08	0.15±0.03	0.16±0.03	0.19±0.04
8	Rosmarinic acid	358.9	161 (17), 133 (42)	–*	–	–	–
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	0.23±0.05	0.01±0.00	0.01±0.00	0.01±0.00
10	Hesperidin	611.1	303,465	0.17±0.03	1.50±0.31	1.25±0.25	0.83±0.17
11	Hyperoside	463.1	300,301	0.24±0.05	0.01±0.00	0.01±0.00	0.01±0.00
12	4-OH Benzoic acid	136.95	93,65	0.01±0.00	0.00±0.00	0.01±0.00	0.00±0.00

(*continues*)

Table 3. Continued

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
13	Salicylic acid	136.95	93,65,75	–	–	–	–
14	Myricetin	317	179,151,137	–	–	–	–
15	Fisetin	284.95	135,121	–	–	–	–
16	Coumarin	146.95	103,91,77	0.00±0.00	0.02±0.00	0.02±0.00	0.02±0.00
17	Quercetin	300.9	179,151,121	–	–	–	–
18	Naringenin	270.95	151,119,107	0.00±0.00	0.02±0.00	0.01±0.00	0.01±0.00
19	Hesperetin	300.95	164,136,108	–	–	–	–
20	Luteolin	284.95	175,151,133	–	–	–	–
21	Kaempferol	284.95	217,133,151	–	–	–	–
22	Apigenin	268.95	151,117	–	–	–	–
23	Rhamnetin	314.95	165,121,300	–	–	–	–
24	Chrysin	253	143,119,107	–	–	–	–

*-: Not Detected

Table 4. The phenolic compositions of concentrated linaria sorbet

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
1	tr-Aconitic acid	172.85	85 (12). 129 (9)	0.03±0.01	0.01±0.00	0.03±0.01	0.01±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	0.00±0.00	0.01±0.00	0.00±0.00	0.01±0.00
3	Chlorogenic acid	353	191(17)	0.02±0.00	0.05±0.01	0.06±0.01	0.04±0.01
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.04±0.01	0.12±0.02	0.13±0.03	0.17±0.03
5	Tannic acid	182.95	124 (22), 78 (34)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
6	tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
7	p-Coumaric acid	162.95	119 (15), 93 (31)	-*	0.00±0.00	0.00±0.00	0.01±0.00
8	Rosmarinic acid	358.9	161 (17), 133 (42)	-	-	-	-
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	-	-	-	-
10	Hesperidin	611.1	303,465	0.02±0.00	0.12±0.02	0.12±0.02	0.07±0.02
11	Hyperoside	463.1	300,301	-	-	-	-
12	4-OH Benzoic acid	136.95	93,65	-	-	-	-
13	Salicylic acid	136.95	93,65,75	-	-	-	-
14	Myricetin	317	179,151,137	-	-	-	-
15	Fisetin	284.95	135,121	-	-	-	-
16	Coumarin	146.95	103,91,77	0.00±0.00	0.01±0.00	0.02±0.01	0.01±0.00
17	Quercetin	300.9	179,151,121	-	-	-	-
18	Naringenin	270.95	151,119,107	0.01±0.00	0.01±0.00	0.01±0.00	0.00±0.00
19	Hesperetin	300.95	164,136,108	-	-	-	-
20	Luteolin	284.95	175,151,133	-	-	-	-
21	Kaempferol	284.95	217,133,151	-	-	-	-
22	Apigenin	268.95	151,117	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
23	Rhamnetin	314.95	165,121,300	-	-	-	-
24	Chrysin	253	143,119,107	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00

*-: Not Detected

Table 5. The phenolic compositions of concentrated rose sorbet

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90. day	20°C 90. day	37°C 90. day
1	tr-Aconitic acid	172.85	85 (12). 129 (9)	0.11±0.02	0.02±0.00	0.02±0.00	0.01±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	2.99±0.57	13.93±2.73	13.55±2.66	26.78±5.25
3	Chlorogenic acid	353	191(17)	0.04±0.01	0.13±0.03	0.12±0.02	0.09±0.02
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.89±0.17	3.78±0.74	0.12±0.02	0.09±0.02
5	Tannic acid	182.95	124 (22), 78 (34)	0.04±0.01	2.91±0.57	2.87±0.56	3.73±0.73
6	Tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	–*	–	–	–
7	p-Coumaric acid	162.95	119 (15), 93 (31)	0.04±0.00	0.03±0.01	0.00±0.00	0.00±0.00
8	Rosmarinic acid	358.9	161 (17), 133 (42)	–	–	–	–
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	0.09±0.02	0.00±0.00	0.00±0.00	0.00±0.00
10	Hesperidin	611.1	303,465	0.08±0.02	0.94±0.19	0.82±0.17	0.70±0.14
11	Hyperoside	463.1	300,301	5.68±1.16	0.09±0.02	0.08±0.02	0.07±0.01
12	4-OH Benzoic acid	136.95	93,65	0.01±0.00	0.02±0.00	0.01±0.00	0.02±0.00
13	Salicylic acid	136.95	93,65,75	0.02±0.00	0.00±0.00	0.02±0.00	0.00±0.00
14	Myricetin	317	179,151,137	–	–	–	–
15	Fisetin	284.95	135,121	–	–	–	–
16	Coumarin	146.95	103,91,77	0.00±0.00	0.04±0.01	0.01±0.00	0.05±0.01
17	Quercetin	300.9	179,151,121	0.00±0.00	0.03±0.00	0.03±0.00	0.06±0.01
18	Naringenin	270.95	151,119,107	–	–	–	–
19	Hesperetin	300.95	164,136,108	–	–	–	–
20	Luteolin	284.95	175,151,133	–	–	–	–
21	Kaempferol	284.95	217,133,151	–	–	–	–
22	Apigenin	268.95	151,117	–	–	–	–
23	Rhamnetin	314.95	165,121,300	–	–	–	–
24	Chrysin	253	143,119,107	–	–	–	–

*ND: not detected.

Table 6. The phenolic compositions of concentrated Sirkencubin sorbet

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
1	tr-Aconitic acid	172.85	85 (12). 129 (9)	0.00±0.00	0.03±0.01	0.02±0.00	0.01±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	0.03±0.01	0.07±0.01	0.08±0.02	0.08±0.01
3	Chlorogenic acid	353	191(17)	0.02±0.00	0.05±0.01	0.05±0.01	0.04±0.01
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.08±0.02	0.21±0.04	0.27±0.05	0.30±0.06
5	Tannic acid	182.95	124 (22), 78 (34)	0.01±0.00	0.03±0.01	0.02±0.00	0.02±0.00
6	tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	0.04±0.01	0.10±0.02	0.10±0.02	0.08±0.02
7	p-Coumaric acid	162.95	119 (15), 93 (31)	0.08±0.01	0.01±0.00	0.01±0.00	0.01±0.00
8	Rosmarinic acid	358.9	161 (17), 133 (42)	–*	–	–	–
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	–	–	–	–
10	Hesperidin	611.1	303,465	–	–	–	–
11	Hyperoside	463.1	300,301	–	–	–	–

(*continues*)

Table 6. (Continued)

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
12	4-OH Benzoic acid	136.95	93,65	–	–	–	–
13	Salicylic acid	136.95	93,65,75	0.02±0.00	0.02±0.00	0.02±0.00	0.02±0.00
14	Myricetin	317	179,151,137	–	–	–	–
15	Fisetin	284.95	135,121	–	–	–	–
16	Coumarin	146.95	103,91,77	0.01±0.00	0.02±0.01	0.02±0.01	0.02±0.01
17	Quercetin	300.9	179,151,121	–	–	–	–
18	Naringenin	270.95	151,119,107	0.02±0.00	0.01±0.00	0.01±0.00	0.01±0.00
19	Hesperetin	300.95	164,136,108	–	–	–	–
20	Luteolin	284.95	175,151,133	–	–	–	–
21	Kaempferol	284.95	217,133,151	–	–	–	–
22	Apigenin	268.95	151,117	0.01±0.00	0.01±0.00	0.01±0.00	0.01±0.00
23	Rhamnetin	314.95	165,121,300	–	–	–	–
24	Chrysin	253	143,119,107	0.01±0.00	0.02±0.00	0.03±0.01	0.02±0.00

*-: Not Detected

Table 7. The phenolic compositions of concentrated unripe grape sorbet

		Parention(m/z)	MS²	Content (mg/kg)			
				0.day	4°C 90.day	20°C 90.day	37°C 90.day
1	tr-Aconitic acid	172.85	85 (12). 129 (9)	0.08±0.02	0.04±0.01	0.03±0.01	0.01±0.00
2	Gallic acid	169.05	125 (14), 79 (25)	0.44±0.09	1.45±0.28	1.57±0.30	0.50±0.11
3	Chlorogenic acid	353	191(17)	0.00±0.00	0.01±0.00	0.00±0.00	0.01±0.00
4	Protocatechuic acid	152.95	109 (16), 108 (26)	0.01±0.00	0.04±0.01	0.05±0.01	0.05±0.01
5	Tannic acid	182.95	124 (22), 78 (34)	0.07±0.01	0.17±0.03	0.19±0.04	0.01±0.00
6	tr-kaffeic acid	178.95	135 (15), 134 (24), 89 (31)	0.09±0.02	0.26±0.50	0.31±0.60	0.53±0.10
7	p-Coumaric acid	162.95	119 (15), 93 (31)	0.11±0.02	0.01±0.00	0.01±0.00	0.01±0.00
8	Rosmarinic acid	358.9	161 (17), 133 (42)	–*	–	–	–
9	Rutin	609.1	300 (37), 271 (51), 301 (38)	0.06±0.01	0.00±0.00	0.00±0.00	0.00±0.00
10	Hesperidin	611.1	303,465	0.05±0.01	0.51±0.01	0.48±0.01	0.15±0.03
11	Hyperoside	463.1	300,301	0.26±0.05	0.00±0.00	0.00±0.00	0.00±0.00
12	4-OH Benzoic acid	136.95	93,65	–	–	–	–
13	Salicylic acid	136.95	93,65,75	–	–	–	–
14	Myricetin	317	179,151,137	–	–	–	–
15	Fisetin	284.95	135,121	–	–	–	–
16	Coumarin	146.95	103,91,77	0.00±0.00	0.03±0.01	0.01±0.00	0.04±0.01
17	Quercetin	300.9	179,151,121	0.00±0.00	0.08±0.01	0.07±0.01	0.02±0.00
18	Naringenin	270.95	151,119,107	0.02±0.00	–	–	–
19	Hesperetin	300.95	164,136,108	–	–	–	–
20	Luteolin	284.95	175,151,133	–	–	–	–
21	Kaempferol	284.95	217,133,151	–	–	–	–
22	Apigenin	268.95	151,117	–	–	–	–
23	Rhamnetin	314.95	165,121,300	–	–	–	–
24	Chrysin	253	143,119,107	–	–	–	–

*-: Not Detected.

liberation of bound phenolic compounds as a result of heat treatment applied to food may cause an increase in the amount of individual or total phenolic components as well as the degradation of large molecular weight substances to low molecular weight antioxidant compounds [23].

Total Phenolics

While the highest amount of total phenolic was found in 0th day samples of the rose sorbet with 3790.91 mg GAE/kg, the least amount was found on 0th day samples of the sirkencubin sorbet with 122.73 mg GAE/kg. The decrease in the total phenolic amount of all sorbets stored at different temperatures were determined depending on the increasing of storage temperature and time. Among samples, the loss of total phenolic content in the linaria sorbet was found to be 29.97, 43.17, and 47.58% at 4, 20 and 37 °C, respectively (Table 8).

The reduction in the amount of phenolic substance occurring during storage may be due to the polymerisation of phenolic substances [24, 25]. In previous studies,

Table 8. Changes in the total phenolic contents of concentrated shorbets (mg GAE/kg)

Sorbets	Storage Time (Day)	Temperature (°C)		
		4	20	37
Engagement	0	1237.88^{Aa}±297.84	1237.88^{Aa}±297.84	1237.88^{Aa}±297.84
	30	1234.85^{Aa}±143.56	1223.03^{Aa}±64.28	1222.73^{Aa}±66.43
	60	1228.79^{Aa}±49.28	1218.18^{Aa}±37.14	1186.36^{Aa}±147.85
	90	1222.73^{Aa}±23.57	1190.91^{ABa}±8.57	1172.73^{Ba}±8.57
Loss %		**1.22**	**3.79**	**5.26**
Evil Eye	0	1239.39^{Aa}±77.14	1239.39^{Aa}±77.14	1239.39^{Aa}±77.14
	30	1218.18^{Aab}±0.95	1203.03^{Aab}±38.57	1193.94^{Aa}±94.28
	60	1162.12^{Aab}±49.28	1154.55^{Aab}±77.14	1057.58^{Bb}±60.00
	90	1134.85^{Ab}±2.14	1124.24^{Ab}±17.14	1046.97^{Bb}±36.43
Loss %		**8.44**	**9.29**	**15.53**
Linaria	0	343.94^{Aa}±6.43	343.94^{Aa}±6.43	343.94^{Aa}±6.43
	30	331.82^{Aa}±32.14	313.64^{Aa}±75.00	290.91^{Ab}±34.28
	60	325.76^{Aa}±49.28	281.82^{Aa}±34.28	277.27^{Ab}±23.57
	90	240.91^{Ab}±40.71	195.45^{Ab}±62.14	180.30^{Ac}±45.00
Loss %		**29.97**	**43.17**	**47.58**
Rose	0	3790.91^{Aa}±51.43	3790.91 ^{Aa} ±51.43	3790.91 ^{Aa} ±51.43
	30	3743.94^{Aa}± 182.13	3660.27^{Aab}±149.99	3526.86^{Aab}±218.56
	60	3593.94 ^{Aab}±90.00	3416.67^{Abc}±267.84	3398.48^{Ab}±362.12
	90	3498.48^{Ab}± 147.85	3383.33^{ABc}±242.13	3222.73^{Bb}±173.56
Loss %		**7.71**	**10.75**	**14.99**
Sirkencubin	0	122.73^{Aa}±2.14	122.73^{Aa}±2.14	122.73^{Aa}±2.14
	30	112.12^{Aab}±12.86	101.52^{Aab}±15.00	95.45^{Ab}±6.43
	60	109.09^{Aab}±17.14	100.72^{Aab}±2.14	89.39^{Abc}±10.71
	90	100.00^{Ab}±0.00	98.48^{Ab}±15.00	71.21^{Bc}±6.43
Loss %		**18.52**	**19.76**	**41.98**
Unripe Grape	0	2554.55^{Aa}±12.86	2554.55^{Aa}±12.86	2554.55^{Aa}±12.86
	30	2489.39^{Aa}±216.42	2336.37^{Aa}±64.28	2136.36^{Ba}±77.14
	60	2474.24^{Aa}±584.97	2307.58^{Aa}±302.13	2419.70^{Aa}±507.83
	90	2463.64^{Aa}±535.67	2350.00^{Aa}±430.69	2186.36^{Aa}±567.83
Loss %		**3.56**	**8.01**	**14.41**

^{ab}For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p > 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p > 0.05$).

the total phenolic contents of the concentrated poppy sorbet [17] and the concentrated tamarind sorbet have been shown to decrease depending on the storage temperature and time [18].

There are a lot of literature on the effect of storage temperature and time on phenolic substances in different samples. For example, in a study in which quince nectars were stored at different temperatures for 9 months, losses in the total phenolic content occurred at the end of storage were found to be 11.3%, 23.2%, 29.2%, and 43% at 5, 20, 30, and 40 °C, respectively (total phenolic content was 7888 mg GAE / L at the beginning of storage). In the same study, it was found that the storage time and temperature were involved in degradation of the phenolic substances [26].

Antioxidant and Antiradical Activities

The antioxidant properties of the evil eye, engagement, linaria, rose, unripe grape and sirkencubin sorbets were detected by the phosphomolybdenum method. The effect of storage time on antioxidant activity (except for evil eye stored at 4 °C, linaria stored at 4 °C, and sirkencubin stored at 4 and 20 °C) was statistically significant ($p < 0.05$).

It can be said that antioxidant activity of all sorbet samples tends to decrease in general although there are fluctuations in the antioxidant change of the sirkencubin sorbet deposited for 90 days at different temperatures.

The antioxidant activity values of the sorbets at the 0^{th} day were in the following order: rose (134.57 mg AAE / g)> evil eye (124.14 mg AAE / g)> engagement (123.86 mg AAE/g)> unripe grape (121.05 mg AAE / g) > sirkencubin (109.51 mg AAE/g) > linaria (82.69 mg AAE / g). During storage, the loss in the antioxidant activities of the sorbets was found to accelerate depending on increasing temperature. As seen in Table 9, at all three storage temperatures, the loss in the antioxidant activity was found to be highest in the rose sorbet, while the least loss was found in sirkencubin sorbet. The losses in the antioxidant capacity of rose sorbet stored for 90 days at 4, 20, and 37 °C were found to be 14.31%, 14.33%, and 17.43%, respectively, while these losses in the sirkencubin sorbet were found to be 1.09%, 2.18% and 1.79%, respectively. There are a lot of data about the reduction of antioxidant capacity during storage. For example, in a study carried out by Ekici [17], the antioxidant activity losses of poppy sorbets stored for 90 days at 4, 20, and 37 °C were determined as 10%, 15% and 18%, respectively. In another study, in which the tamarind sorbet was concentrated by conventional method, the antioxidant property losses of the sorbets stored for 90 days at 4, 20 and 37 °C were determined as 8.77%, 8.14% and 20.43% respectively [18].

The determined reduction in the antioxidant property may be related to the breakdown of phenolic substances which are known to have antioxidant activity. As a matter of fact, the antioxidant property of the phenolic compounds is attributed to their hydroxyl groups and it is reported that the antioxidant activity decrease depending on the degradation of phenolic substances [27].

It has been determined that there are small fluctuations in the antiradical activities in the storage process of engagement, evil eye, rose, linaria, sirkencubin and unripe grape sorbets. However, as seen in Table 10, no significant change was observed in the antiradical activities of engagement and sirkencubin sorbets. It was found that the effect of the storage period on the radical scavenging capacity was statistically significant ($p < 0.05$) (except for linaria sorbet stored at 4 °C, sirkencubin sorbet stored at 4 and 37 °C, and rose sorbet stored at 37 °C). While it was shown that the antiradical activity of the evil eye sorbet tendency to increase during storage, the antiradical activities of rose, unripe grape and linaria sorbets exhibited a tendency to decrease. The percent inhibition rates of sorbets at 0^{th} day were determined as 95.78%, 91.61%, 88.67%, 87.23%, 43.86% and 29.96% for unripe grape, engagement, evil eye, rose, linaria and sirkencubin, respectively. The loss in the antiradical activity of sorbets was detected to be the highest in the linaria sorbet related to increase of the storage temperature and decrease in the radical scavenging activity of this sorbet were determined as 9.01%, 18.60% and 23.09% at 4, 20, and 37 °C respectively (Table 10). In the study on the biological properties of poppy sorbet stored at 4, 20, and 37 °C for 90 days, it was reported that antiradical activity was adversely affected with increasing temperature due to decreasing heat sensitive phenolic substance amount in the storage process, especially when high temperatures were selected [17].

The Amount of Total Anthocyanin

In the study, the changes in the amount of total anthocyanin in the rose and engagement sorbet stored for 90 days are given in Table 11. It was determined that the effect of storage time (except for engagement sorbet stored at 4 and 20 °C) and temperature (except for rose and engagement sorbet, 0^{th} day, and rose sorbet, 60^{th} day) on the amount of total anthocyanin was statistically significant ($p < 0.05$).

The amounts of anthocyanin of rose and engagement sorbets on the 0^{th} day were determined to be 24.94 and 120.90 mg cy-3-glu/ kg at 4 °C, respectively. It has been found that there are fluctuates in the amount of total anthocyanin of the rose and engagement sorbets during the storage period. In general, a decrease in total anthocyanin contents of the rose and engagement sorbet during storage was found. The obtained results show that the storage stability of the anthocyanin present in the rose sorbet is lower. Similarly, Ekici [17] determined that the loses in the amount of anthocyanin of poppy sorbet concentrated by the conventional method were 14%, 41% and 64%, respectively after storing for 90 days at 4, 20, and 37 °C [17]. It has been stated that the total anthocyanin losses of concentrated black mulberry stored at 5, 20, 30, and 40 °C for 8 months were 1%, 64%, 89% and 98%, respectively [28].

Table 9. Changes in the antioxidant acitivities of concentrated shorbets (AAE)/g

Sorbets	Storage Time (Day)	Temperature (°C)		
		4	20	37
Engagement	0	123.86^{Aa}±2.75	123.86^{Aa}±2.75	123.86^{Aa}±2.75
	30	118.37^{Aab}±11.30	115.22^{Aab}±18.73	111.79^{Ab}±5.94
	60	113.86^{Ab}±0.65	111.21^{Aab}±1.44	101.92^{Bbc}±11.52
	90	113.30^{Ab}±4.41	109.38^{Ab}±3.80	100.44 ^{Bc}±7.33
Loss %		**8.53**	**11.69**	**11.69**
Evil Eye	0	124.14^{Aa}±4.80	124.14^{Aa}±4.80	124.14^{Aa}±4.80
	30	122.38^{Aa}±15.23	120.15^{Aab}±0.83	111.70^{Ab}±1.09
	60	122.03^{Aa}±1.66	119.11^{Aab}±4.41	109.20^{Bb}±12.40
	90	120.65^{Aa}±0.22	118.43^{Ab}±2.58	106.27^{Bb}±6.11
Loss %		**2.81**	**4.60**	**14.40**
Linaria	0	82.69^{Aa}±10.87	82.69^{Aa}±10.87	82.69^{Aa}±10.87
	30	82.16^{Aa}±11.44	76.23^{ABa}±0.44	74.66^{Bb}±2.10
	60	79.32^{Aa}±8.38	75.52^{Aa}±8.07	73.06^{Ab}±2.58
	90	78.98^{Aa}±8.95	74.30^{ABa}±0.17	72.13^{Bb}±1.79
Loss %		**4.49**	**10.15**	**12.77**
Rose	0	134.57^{Aa}±11.26	134.57^{Aa}±11.26	134.57^{Aa}±11.26
	30	126.45^{Aab}±3.62	122.85^{Ab}±4.02	112.62^{Bb}±4.06
	60	118.89^{Abc}±3.58	115.28^{Ab}±9.30	111.27^{Ab}±12.35
	90	115.31^{Ac}±4.10	113.49^{Ab}±6.15	111.12^{Ab}±2.27
Loss %		**14.31**	**14.33**	**17.43**
Sirkencubin	0	109.51^{Aa}±9.69	109.51^{Aa}±9.69	109.51^{Aa}±9.69
	30	111.02^{Aa}±10.43	110.28^{Aa}±1.53	106.97^{Aab}±3.32
	60	108.98^{Aa}±0.04	107.97^{Aa}±0.26	106.39^{Aab}±3.19
	90	106.33^{Aa}±1.09	107.47^{Aa}±2.18	100.78^{Bb}±1.79
Loss %		**1.09**	**2.18**	**1.79**
Unripe Grape	0	121.05^{Aa}±5.50	121.05^{Aa}±5.50	121.05^{Aa}±5.50
	30	118.82^{Aa}±5.94	115.12^{Aab}±9.43	110.56^{Aab}±11.79
	60	118.09^{Aab}±0.35	112.28^{Aab}±10.56	109.79^{Ab}±8.51
	90	112.69^{Ab}±0.92	109.73^{ABb}±5.28	107.00^{Bb}±4.15
Loss %		**6.91**	**9.35**	**11.61**

^{ab} For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p < 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p < 0.05$).

Similarly, the amount of anthocyanin of red wines reduced by 88-91% as result of storage at 20 °C for 7 months [29]. It is known that the color stability of anthocyanin pigments changes with the pH, temperature, structure and concentration of anthocyanin and metal ions and phenolic compounds in the environment [30].

Color

L* value exhibits brightness (L*0= black, L*100= white). The hue angle [h° =arctan (b*/a*)] is a feature depending on color tone while the C* value [C*=(a*2+b*2)1/2] reveals color intensity or color saturation. The changes in L*, h° ve C* values during storage of engagement, evil eye, linaria, rose, sirkencubin and unripe grape sorbets that is obtained by open boiler method stored at different temperatures for 90 days were determined. The changes in the color parameters of the evil eye, rose and unripe grape sorbets during storage period are shown in Table 12, while the changes in the color parameters of engagement, linaria and sirkencubin sorbet are shown in Table 13.

Table 10. Changes in the antiradical acitivities of concentrated shorbets (% inhibition)

Sorbets	Storage Time (Day)	Temperature (°C)		
		4	20	37
Engagement	0	91.61^{Aa}±0.21	91.61^{Aa}±0.21	91.61^{Aa}±0.21
	30	91.28^{Aa}±0.15	90.08^{Bb}±0.37	89.25^{Bc}±1.09
	60	90.66^{Ab}±0.55	89.87^{Abc}±0.74	90.01^{Abc}±0.41
	90	90.46^{Bc}±0.06	89.35^{Cc}±0.05	90.61^{Ab}±0.16
Loss %		**1.26**	**2.47**	**1.10**
Evil Eye	0	88.67^{Ab}±1.16	88.67^{Ab}±1.16	88.67^{Ac}±1.16
	30	88.13^{Ab}±1.43	89.04^{Ab}±0.23	89.36^{Abc}±2.13
	60	89.56^{Bab}±0.19	90.63^{Aa}±0.30	90.92^{Aab}±0.05
	90	90.67^{Ba}±0.09	91.29^{ABa}±0.07	91.65^{Aa}±0.44
Increase %		**2.26**	**2.95**	**3.36**
Linaria	0	43.86^{Aa}±1.04	43.86^{Aa}±1.04	43.86^{Aa}±1.04
	30	41.97^{Aa}±2.56	39.83^{ABab}±0.38	36.44^{Bab}±5.71
	60	40.94^{Aa}±3.10	36.88^{Ab}±5.17	35.26^{Ab}±5.16
	90	39.90^{Aa}±3.00	35.70^{Ab}±7.04	33.73^{Ab}±7.31
Loss %		**9.01**	**18.60**	**23.09**
Rose	0	87.23^{Aa}±0.14	87.23^{Aa}±0.14	87.23^{Aa}±0.14
	30	86.35^{Aab}±1.42	84.94^{Aab}±2.15	87.32^{Aa}±1.47
	60	84.07^{Ab}±2.41	83.96^{Ab}±2.04	85.11^{Aa}±3.02
	90	84.72^{Bab}±0.34	85.23^{Bab}±1.17	83.98^{Aa}±0.07
Loss %		**2.88**	**2.30**	**0.09**
Sirkencubin	0	29.96^{Aa}±1.11	29.96^{Aab}±1.11	29.96^{Aa}±1.11
	30	30.47^{Aa}±1.18	31.17^{Aa}±1.05	30.29^{Aa}±4.97
	60	30.64^{Aa}±0.50	28.74^{Bbc}±0.83	29.87^{ABa}±0.87
	90	29.11^{Aa}±1.28	28.34^{Ac}±0.49	30.07^{Aa}±1.28
Increase %		**2.85**	**5.39**	**0.36**
Unripe Grape	0	95.78^{Aa}±0.21	95.78^{Aa}±0.21	95.78^{Aa}±0.21
	30	94.87^{Ab}±0.41	94.47^{Ac}±0.15	93.25^{Bb}±0.81
	60	94.87^{Ab}±0.86	93.08^{Ab}±0.36	93.25^{Bb}±0.28
	90	95.68^{Aa}±0.08	95.20^{Bb}±0.12	93.18^{Cb}±0.29
Loss %		**0.10**	**0.61**	**2.71**

^{ab} For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p < 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p < 0.05$).

Although the fluctuates in the L* values of rose, linaria, evil eye, sirkencubin and engagement sorbets were observed during the storage period, significant changes were not found. The greatest change was observed in unripe grape sorbet. As a matter of fact, the unripe grape with the initial L* value of 22.36 showed a tendency to decrease and L* values were recorded to be 15.57, 14.36, and 13.0 at 4, 20, and 37 °C, respectively. In the study which in concentrated poppy sorbet was stored, it has been detected that L* value of sorbet samples which concentrated with conventional method after storage was 16.28 and reduced after storage [17]. Similarly, it has been reported that the L* values of tamarind sorbets which was stored at 4, 20 and 37°C for 90 days decreased [18].

The h° values of rose, evil eye and engagement sorbets tended to increase during storage. It was determined that there was no significant change in the h° value of unripe grape sorbet having an initial value of 77.24 after stored at

Table 11. Changes in the anthocyanin contents of concentrated shorbets (mg cyn-3-glu/kg)

Sorbets	**Storage Time (Day)**	**Temperature (°C)**		
		4	**20**	**37**
	0	120.90^{Aa}±15.90	120.90^{Aa}±15.90	120.90^{Aa}±15.90
Engagement	**30**	128.37^{Aa}±24.40	106.43^{Ba}±16.85	96.96^{Ba}±7.24
	60	128.14^{Aa}±5.67	105.82^{Ba}±12.83	97.47^{Bb}±8.27
	90	128.36^{Aa}±7.40	103.59^{Ba}±3.38	67.85^{Cc}±0.39
Change%		**6.17 (+)**	**14.32 (-)**	**43.88 (-)**
	0	24.94^{Aa}±2.20	24.94^{Aa}±2.20	24.94^{Aa}±2.20
Rose	**30**	19.20^{Ab}±4.72	17.76^{ABb}±0.55	15.52^{Bb}±3.15
	60	20.43^{Aab}±2.13	17.62^{Ab}±2.83	15.81^{Ab}±0.94
	90	18.28^{Ab}±1.50	17.53^{Ab}±3.38	11.47^{Bb}±0.16
Loss%		**26.70**	**29.70**	**54.02**

^{ab}For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p < 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p < 0.05$).

Table 12. Changes in the L^*, h^o and C^* values of concentrated evil eye, rose and unripe grape sorbets during storage

Temperature (°C)	**Storage Time (Day)**	**Evil Eye**			**Rose**			**Unripe Grape**		
		L^*	h^o	C^*	L^*	h^o	C^*	L^*	h^o	C^*
4	**0**	9.62^{Aa}±0.02	41.54^{Ac}±1.61	1.46^{Ab}±0.61	10.13^{Aa}±0.50	35.69^{Ab}±3.08	1.24^{Ac}±0.40	22.36^{Aa}±1.95	77.24^{Aa}±8.71	10.83^{Aa}±2.33
	30	9.46^{Aa}±0.31	49.01^{Ab}±5.53	1.47^{Bb}±0.61	9.96^{Ca}±0.09	43.94^{Aa}±0.02	1.63^{Cb}±0.05	16.81^{Ab}±0.11	66.60^{Aab}±5.98	5.04^{Bb}±1.14
	60	9.12^{Aa}±1.11	60.50^{Aa}±15.56	2.16^{Ca}±1.07	9.96^{Aa}±2.12	45.12^{Aa}±1.46	2.93^{Ba}±0.39	14.08^{Bd}±0.10	62.70^{ABb}±16.72	3.39^{Bc}±1.77
	90	9.62^{Aa}±0.02	59.50^{Ba}±7.16	1.54^{Bb}±1.13	9.99^{Ca}±2.12	46.38^{Aa}±1.47	3.08^{Ba}±0.41	15.57^{Ac}±2.04	72.31^{Aab}±13.52	5.16^{Bb}±2.40
20	**0**	9.62^{Aab}±0.02	41.54^{Ad}±1.61	1.46^{Ab}±0.61	10.13^{Ab}±0.50	35.69^{Ac}±3.08	1.24^{Ab}±0.04	22.36^{Aa}±1.95	77.24^{Aa}±8.71	10.83^{Aa}±2.33
	30	9.54^{Aab}±0.16	49.92^{Ac}±3.81	1.47^{Bb}±0.47	10.23^{Bab}±0.17	43.17^{Aa}±0.59	1.76^{Bb}±0.06	16.83^{Ab}±0.84	67.10^{Ab}±0.14	5.63^{Ac}±0.14
	60	9.32^{Ab}±1.16	64.28^{Ab}±9.86	2.18^{Ba}±0.73	10.65^{Aa}±1.23	39.82^{Bab}±7.02	2.83^{Ba}±1.57	16.99^{Ab}±2.85	69.77^{Ab}±12.86	8.11^{Ab}±5.01
	90	9.72^{Aa}±0.18	73.25^{Aa}±4.43	2.02^{Ba}±0.04	10.53^{Bab}±0.24	35.02^{Bc}±11.45	2.50^{Ca}±0.46	14.36^{Bc}±1.91	61.64^{Bc}±3.54	4.82^{Bc}±2.05
37	**0**	9.62^{Aa}±0.02	41.54^{Ad}±1.61	1.46^{Ab}±0.61	10.13^{Ac}±0.50	35.69^{Ac}±3.08	1.24^{Ac}±0.40	22.36^{Aa}±1.95	77.24^{Aa}±8.71	10.83^{Aa}±2.33
	30	9.58^{Aa}±0.20	50.85^{Ac}±1.59	1.82^{Ab}±0.35	11.01^{Ab}±0.26	40.79^{Bb}±0.71	2.69^{Ab}±0.16	13.91^{Bb}±1.28	61.53^{Bb}±5.53	5.00^{Bc}±0.70
	60	8.75^{Ac}±0.87	63.19^{Ab}±15.97	2.74^{Aa}±1.48	10.79^{Ab}±0.47	42.22^{Ba}±0.70	5.58^{Aa}±1.44	11.09^{Cd}±0.81	49.29^{Bc}±8.84	4.64^{Bc}±2.10
	90	9.21^{Bb}±0.07	70.01^{Aa}±6.27	2.59^{Aa}±0.15	11.57^{Aa}±0.12	41.86^{Aab}±2.02	5.68^{Ab}±0.25	13.00^{Cc}±0.82	28.97^{Cd}±16.36	7.48^{Ab}±3.94

L^*: Brightness, C^*: Color density, h^o: Color tone. ^{ab}For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p < 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p < 0.05$).

4°C for 90 days while it had a tendency to decrease at 20 and 37 °C. It was determined that h° value of linaria sorbet showed a tendency to decrease during storage. Also a decrease was reported for sirkencubin sorbet at 4 and 37 °C, but there was no significant change during storage at 20 °C. h° values ranging from 0° to 90° indicate that the samples have a color tone between red and yellow. Decreasing h° values are considered to be indicative of the color of the samples turn from the orange-red to red. In a previous study, it was determined that h° value of the tamarind sorbet with an initial h° value of 48.51 decreased at the end of the store time [18]. In another study, it was determined that h° values of rose hip nectars with an initial h° value of 62.30 were found to be in the order of 61, 60, 58 and 50 at the end of storage for 8 months at 5, 25, 35, and 45 °C, and showed a tendency to decrease [31]. Similarly, the decreasing in the h° values of quince nectars at the end of storage for 9 months at 5, 20, 30 and 40 °C were reported [26].

Table 13. Changes in the L^*, h^o and C^* values of concentrated engagement, linaria and sirkencubin sorbets during storage

Temperature (°C)	Storage Time (Day)	Engagement			Linaria			Sirkencubin		
		L^*	h^o	C^*	L^*	h^o	C^*	L^*	h^o	C^*
4	**0**	$9.15^{Ab}\pm0.06$	$14.69^{Ac}\pm1.04$	$0.73^{Aab}\pm0.24$	$26.14^{Aa}\pm0.64$	$82.05^{Aa}\pm3.00$	$18.65^{Aa}\pm7.24$	$15.36^{Ab}\pm0.12$	$86.08^{Aa}\pm0.8$	3.00 ± 0.48
	30	$9.16^{Bb}\pm0.07$	$24.92^{Bb}\pm0.86$	$0.77^{ABa}\pm0.03$	$23.21^{Bb}\pm1.96$	$71.70^{Ab}\pm1.62$	$11.98^{Bb}\pm1.44$	$16.55^{Aa}\pm0.01$	$85.50^{Aa}\pm0.00$	$5.95^{ABb}\pm0.05$
	60	$9.22^{Ab}\pm0.02$	$22.01^{Bb}\pm3.11$	$0.80^{Aa}\pm0.27$	$26.37^{ABa}\pm0.37$	$67.93^{ABc}\pm7.27$	$13.24^{Bb}\pm0.77$	$15.46^{Bb}\pm0.04$	$84.50^{Ba}\pm0.08$	$6.15^{Bb}\pm0.08$
	90	$9.45^{Aa}\pm0.30$	$30.21^{Ba}\pm3.83$	$0.60^{Cb}\pm0.07$	$25.88^{Aa}\pm4.19$	$68.65^{Ac}\pm4.15$	$13.78^{Ab}\pm2.50$	$15.86^{Ab}\pm1.89$	$79.34^{Bb}\pm12.59$	$7.40^{Aa}\pm3.29$
20	**0**	$9.15^{Ab}\pm0.06$	$14.69^{Ac}\pm1.04$	$0.73^{Aa}\pm0.24$	$26.14^{Aa}\pm0.64$	$82.05^{Aa}\pm3.00$	$18.65^{Aa}\pm7.24$	$15.36^{Ad}\pm0.12$	$86.08^{Ab}\pm0.8$	$4.27^{Ab}\pm0.48$
	30	$9.07^{Cb}\pm0.02$	$21.84^{Cb}\pm3.00$	$0.71^{Ba}\pm0.14$	$23.73^{Bb}\pm2.03$	$71.83^{Ab}\pm1.78$	$12.36^{Bb}\pm0.98$	$16.67^{Ab}\pm0.23$	$87.83^{Aa}\pm0.16$	$6.17^{Aa}\pm0.16$
	60	$9.43^{Aa}\pm0.50$	$26.87^{Bab}\pm15.37$	$0.70^{Aa}\pm0.16$	$27.16^{Aa}\pm0.87$	$70.85^{Abc}\pm4.37$	$14.69^{Ab}\pm9.38$	$17.11^{Aa}\pm0.32$	$87.40^{Aa}\pm1.91$	$6.42^{ABa}\pm3.44$
	90	$9.36^{Aa}\pm0.11$	$28.16^{Ba}\pm1.35$	$0.65^{Ba}\pm0.03$	$26.23^{Aa}\pm4.67$	$69.00^{Ac}\pm4.57$	$13.98^{Ab}\pm3.13$	$15.84^{Ac}\pm1.24$	$88.01^{Aa}\pm0.25$	$6.47^{Aa}\pm3.99$
37	**0**	$9.15^{Aa}\pm0.06$	$14.69^{Ad}\pm1.04$	$0.73^{Aa}\pm0.24$	$26.14^{Aa}\pm0.64$	$82.05^{Aa}\pm3.00$	$18.65^{Aa}\pm7.24$	$15.36^{Ac}\pm0.12$	$86.08^{Aa}\pm0.05$	$4.27^{Ac}\pm0.48$
	30	$9.23^{Aa}\pm0.06$	$30.35^{Ac}\pm1.22$	$0.79^{Aa}\pm0.01$	$26.76^{Aa}\pm1.09$	$70.75^{Ab}\pm3.46$	$14.95^{Ab}\pm0.31$	$16.18^{Bab}\pm1.05$	$80.75^{Bbc}\pm8.99$	$5.69^{Bbc}\pm1.34$
	60	$9.35^{Aa}\pm0.93$	$37.90^{Ab}\pm20.20$	$0.82^{Aa}\pm0.26$	$25.94^{Ba}\pm3.13$	$63.89^{Bc}\pm10.66$	$14.13^{ABb}\pm2.42$	$16.52^{Aa}\pm2.26$	$83.60^{Bab}\pm4.09$	$9.00^{Aa}\pm6.82$
	90	$9.33^{Aa}\pm0.12$	$46.51^{Aa}\pm3.11$	$0.70^{Aa}\pm0.02$	$23.55^{Bb}\pm0.70$	$61.69^{Bc}\pm1.33$	$13.11^{Ab}\pm0.53$	$15.63^{Abc}\pm0.49$	$79.78^{Bc}\pm4.78$	$7.44^{Aab}\pm4.04$

L^*: Brightness, C^*: Color density, h^o: Color tone. ^{ab}For each temperature in each sherbet, the lower case letters in the same column are the comparison of the different storage times, and there is no statistically significant difference between the examples represented by the same letters ($p > 0.05$). ^{AB} The capital letters in the same line are a comparison of different temperatures, and there is no statistically significant difference between the same letters ($p > 0.05$).

It has been detected that the C* values of evil eye, sirkencubin and rose sorbets tended to increase during storage period. It was concluded that the C* values of the unripe grape sorbet with an initial value of 10.83 reduced to 5.16, 4.82 and 7.48, while the C* values of the linaria sorbet with an initial value of 18.67 reduced to 13.78, 13.98 and 13.11 through storage period at 4, 20 and 37 °C, respectively. The C* color parameter of the engagement sorbet with the initial value of 0.73 reduced to 0.60 and 0.65 at the end of 90 days store at 4 and 20 °C, respectively, while there was no significant change in C* color parameter of the engagement sorbet stored at 37 °C. In the study carried out on the tamarind sorbet by Ekici and Ozaltin [18], although some fluctuations were found in samples concentrated by open boiler assay through storage process, it had been observed that the C* values decreased after 90 days. Similarly, it has been indicated that the C* values showed a decrease depend on increased temperature and the prolonged storage time in the study carried out by Ekici [17] on the poppy sorbet. Contrary to these data, it has been reported that the C* parameter of quince nectar [26] and black mulberry water [28] have a slight increase tendency after storage at different temperatures.

CONCLUSION

In this study, the engagement, evil eye, linaria, rose, sirkencubin and unripe grape sorbets from traditional Turkish sorbets were concentrated to 62 ± 1 °Brix by open boiler method and their some bioactive and color properties were investigated. Also, the phenolic composition of the sorbet samples was detected by LC-MS/ MS method. The required times to reach 62 ± 1 °Brix, which is the target value in the engagement, evil eye, linaria, rose, sirkencubin and unripe grape sorbets, were detected to be 112, 109, 110, 88, 85, and 82th minutes, respectively. Protocatechuic acid was identified as major components in the engagement, and linaria and Sirkencubin sorbets, while *p*-hyperoside, coumaric and gallic acids, were the major phenolic components in the rose, evil eye and unripe grape sorbets by LC-MS / MS, respectively.

During storage period, the losses at the biological properties of the sorbets occurred. At the end of 90 days, the highest bioactivity losses were detected in linaria sorbet with 47.58% loss of phenolic substance, in the rose sorbet with 17.43% loss of antioxidant activity, in the linaria sorbet with 23.09% loss of antiradical activity and in the engagement sorbet with 67.85% loss of anthocyanin. The fluctuations had been observed in the color parameters of the sorbet samples during the storage period. Especially, it had been determined that the colors of the unripe grape, linaria and sirkencubin sorbets, which were initially light colored, began to darken.

In this study, it has been found that these sorbets should be drunk as a functional beverage due to their phenolic composition, antioxidant and radical scavenging properties. It is thought that the storage temperature and time are effective on the sorbet concentrates quality.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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