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FRUIT QUALITY AND BIOCHEMICAL CHARACTERISTICS OF DIFFERENT STRAWBERRY TREE (*Arbutus unedo L.*) GENOTYPES GROWN IN GIRESUN

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Abstract: This study was conducted to examine fruit quality, chemical and biochemical properties of 20 strawberry tree (*Arbutus unedo* L.) genotypes that naturally spread in Bulancak district of Giresun province. In this context, fruit size, pH, SSC (Solible Solid Content), color indices, specific sugars, Vitamin C, citric and malic acids were detected in the fruit samples of the evaluated genotpes. Fruit weight varied between 2.33 and 4.69 g, fruit width 16.85 and 20.62 mm, fruit length 14.52 and 17.93 mm, pH 3.36 and 3.88, SSC 11.60 and 19.60%. The range of the results of glucose, sucrose, fructose and total sugars were 2.32-8.34 g 100 g^{-1}, 0.02-1.93 g 100 g^{-1}, 3.08-17.93 g 100 g^{-1} and 7.17-27.18 g 100 g^{-1}, respectively. The amount of vitamin C contained in the fruits of strawberry tree was determined as 13.53-126.60 mg 100 g^{-1}, the amount of citric acid was 0.16-0.69% and the amount of malic acid was 0.27- 1.30%.

Keywords: Strawberry tree, *Arbutus* spp., Fructose, Vitamin C, Fruit quality

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1. Introduction

Türkiye, in terms of its geographical location, is considered as the origin of many fruit species cultivated worldwide. The favorable ecological conditions contribute significantly to the presence of numerous species and varieties in the country. Out of 138 fruit species globally adopted, 80 can be cultivated in Türkiye, along with numerous wild fruit species known for their high nutritional value (Özbek, 1988; Sakaldaş, 2012). One such species naturally occurring in the Turkish flora is the strawberry tree, also known as strawberry tree (*Arbutus unedo* L.) which is also referred to as Dal çileği, Çilek ağacı, Enderek, and Sandal ağacı in Anatolia (Karadeniz, 2004). Belonging to the Heath family (Ericaceae), *Arbutus unedo* L. is utilized both as a fruit and an ornamental plant (Karadeniz et al., 1996; Pekdemir, 2010).

Recognized in some countries as the strawberry tree due to the resemblance of its fruits to strawberries, its native habitat includes Greece, Lebanon, Ireland, and Southern Europe, which encompasses Anatolia (Anonymous, 2003a, b, c; Anşin and Özkan, 1993; Karadeniz and Şişman, 2004). It has a distribution across the Mediterranean Region, Northwest, and Central America, with 12 species, among which *Arbutus unedo* L. and *Arbutus andrachne* L. are the most significant (Torres et al., 2002; Anonymous, 2016a, b; İslam and Pehlivan, 2016). Some commercially valuable cultivars include Compacta, Elfin King, and Rubra (Christman, 2011; Islam and Pehlivan, 2016).

Although strawberry tree has a wide geographical distribution area, it grows together with oaks, wild olive trees, shrubs and many other tree and shrub species in red pine forests and maquis vegetation in regions where the Mediterranean climate prevails (Karadeniz et al., 1996; Sakaldaş, 2012).

In addition to being used as table food, the fruits of strawberry tree are used in jelly, marmalade and cake decoration, as well as in the production of some wines and liqueurs in European countries (Zenginbal and Gündoğdu, 2016; Şanlıdere Aloğlu et al., 2018). Additionally, the trees of this species are employed in landscaping, and their branches and leaves are valued in flower arrangements (Islam and Pehlivan, 2016). Due to its hard wood texture, it is also used as handicraft material and fuel (Onursal and Gözlekçi, 2007).

The fruits of strawberry tree possess significant potential in terms of carbohydrates, organic acids, vitamin C, phenolic compounds, flavonoid content, and antioxidant capacity (Ates et al., 2022; Balta et al., 2023). They contain approximately 14% sugar, high levels of vitamin C (15-8 mg) and tannins, and various compounds such as tannins leaves, sucrose, arbutin, methyl arbutin, and urson in the leaves, and tannins in the roots (Karadeniz, 2004).

Being a rich source of dietary fiber, strawberry tree fruits exhibit protective effects against various diseases, including cancer and cardiovascular diseases, due to their abundant antioxidants. They strengthen the body, provide protection against microbes, and prevent illnesses. Moreover, they aid in the healing of kidney and bladder inflammations, alleviate gastrointestinal sluggishness, benefit liver insufficiency, assist in the expulsion of gallstones, and fortify nerves. In addition to its effects on lowering high blood pressure and relieving arteriosclerosis, it gives freshness to the skin and its fruits can be consumed by diabetics (Karadeniz, 2004; Zenginbal and Gündoğdu, 2016; Şanlıdere Aloğlu et al., 2018)

The aim of this study was determining fruit quality and some biochemical properties of fruit samples taken from 20 arbutus genotpes selected from the naturally growing strawberry tree population in Bulancak District of Giresun province, Türkiye.

2. Materials and Methods

2.1. Plant Material

The materials used in this study were naturally grown populations of the strawberry tree (Arbutus unedo L.) with 20 different genotypes, located in the village of Pazarsuyu, Bulancak district, Giresun province. Randomly 500 g fruit samples were taken during the period when the fruits of these naturally growing plants turned red and the taste of the fruits was at its peak. The selected trees were both labeled and marked on their trunks with spray paint for identification purposes. The collected fruit samples were placed in storage containers, labeled, and promptly transported to the Pomology Laboratories of the Department of Horticulture at Ordu University Faculty of Agriculture, maintaining the cold chain to prevent deterioration. Various parameters such as fruit weight (g), fruit width (mm), fruit length (mm), color measurement, pH, and soluble solid content (%) were determined in the strawberry tree fruits. Genotypes collected from Bulancak are coded between B1-B20.

2.2. Fruit External and Internal Characteristics

Ten fruits were randomly selected from each plant, and their average fruit weight was determined by weighing them on a scale with a precision of 0.01 mg. The fruit width was measured using a digital caliper by assessing the widest distance perpendicular to the central axis of the fruits. Additionally, the fruit height was measured by determining the distance between the style tip and the fruit stalk using the same caliper. Ten fruit samples from the identified strawberry tree plants were homogenized for one minute using a hand blender after the addition of 40 ml of distilled water. The prepared fruit juice was then filtered, and a drop of the filtered juice was measured using a portable digital refractometer. The amount of soluble solid content (SSC) was determined by calculating the Brix value with the formula (equation 1) given below.

$$SSC\ (\%) = \frac{B x V}{M} \qquad (1)$$

B= brix degree determined in diluted sample (%), V= dilution volume of the sample (mL), M= weight of sample (g)

To measure the acidity of the prepared fruit juice, the pH-meter electrode was immersed in 10 ml of fruit juice. After waiting until the value stabilized, the reading was recorded as pH value.

Using a Konica-Minolta colorimeter, measurements were conducted on fruit peels with 2 replicates, and for each replicate, 5 fruits were measured for *L*, a**, and b* values. The L* value represents the brightness, with 0 indicating black and 100 indicating white. 'a' indicates redness (-a for green), and 'b' indicates yellowness (-b for blue)."

2.3. Extraction of Sugars and Liquid Chromatographic Analysis of Sugars

Harvested fruits were frozen at -21 °C until sugar analysis. Glucose, sucrose, fructose and total sugar contents of fruit samples thawed at room temperature were determined using HPLC (HP-1100 series) RID (Refractive Index Detector) and Shim-Pack HRC NH2 (300x7.8 mm, 5m) column according to the extraction method developed by Miron and Scahffer (1991). Sugar contents in the samples were established using an external standard and determined qualitatively and quantitatively based on calibration curves and retention time of the standard.

2.4. Extraction and Liquid Chromatographic Analysis Organic Acid and Ascorbic Acid

Harvested fruits were frozen at -21 °C until organic acid analysis performed. Fruit samples thawed at room temperature were determined by HPLC technique (HP-1100 series) using a UV detector and HPX 87H (300x7.8 mm, 5µm) column, according to the method developed by Bozan et al. (1997).

2.5. Statistical Analysis

The data were analyzed using the JMP 16.0 software (trial). Principal components and cluster analysis were performed based on physical and chemical properties of investigated strawberry tree genotypes.

3. Results and Discussion

3.1 Fruit External and Internal Quality

3.1.1. Fruit external quality

In strawberry tree genotypes; fruit weight, fruit width, fruit length, and fruit color are given in Table 1. Fruit weight values of the genotypes varied between 2.33 g and 4.69 g. Among the 20 selected genotypes, the largest fruits were found in type B20 with 4.69 g, and the smallest fruits were found in types B13 and B14 with 2.33 g. Among the genotypes, the highest fruit width was found in type B20 with 20.62 mm, and the lowest was in type B13 with 16.85 mm. Similarly, the genotype with the longest fruit length was determined as type B20 with 17.93 mm, and the shortest was determined as type B15 with 14.52 mm (Table 1).

Table 1. External and internal fruit quality of the strawberry tree genotypes

Genotypes	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	pH	SSC (%)	L*	a*	b*
B-1	3.59	19.23	16.61	3.71	16.40	36.26	24.62	33.42
B-2	2.96	17.50	15.98	3.80	16.80	31.35	34.18	31.56
B-3	3.81	18.38	15.25	3.73	14.00	30.55	32.10	31.89
B-4	3.15	18.07	16.70	3.56	17.60	32.21	30.01	35.54
B-5	3.71	18.79	16.11	3.68	19.60	35.39	28.45	31.93
B-6	3.61	19.23	16.72	3.88	16.80	30.38	28.68	36.44
B-7	3.85	19.55	16.78	3.57	15.20	34.24	32.82	31.54
B-8	4.54	20.48	17.51	3.61	19.20	37.15	33.90	35.42
B-9	3.48	19.34	16.38	3.67	14.80	32.63	37.38	28.77
B-10	2.95	18.50	15.65	3.36	14.40	37.90	31.67	36.51
B-11	2.92	19.80	16.66	3.88	13.20	30.52	34.78	34.50
B-12	3.72	20.26	17.14	3.84	13.20	35.51	35.38	34.39
B-13	2.33	16.85	14.70	3.78	14.80	30.45	34.69	27.86
B-14	2.33	17.62	14.81	3.86	11.60	34.10	35.68	34.41
B-15	3.41	17.14	14.52	3.76	14.40	33.13	34.25	30.50
B-16	2.75	18.18	15.67	3.77	15.20	34.29	30.97	33.57
B-17	3.60	19.55	16.45	3.67	16.80	30.20	36.40	30.46
B-18	2.98	19.36	16.83	3.75	15.60	34.13	31.51	35.07
B-19	4.20	20.32	17.41	3.82	17.20	30.86	34.84	31.87
B-20	4.69	20.62	17.93	3.66	15.20	30.87	34.88	30.01

In their study conducted in the central district of Giresun, Karadeniz and Şişman (2004) determined the fruit weight as 10.71 g, the fruit width as 27.96 mm and the fruit length as 24.37 mm. Yarılgaç and İslam (2007) found that strawberry tree types growing naturally in Ünye and its surroundings have fruit weights between 5.25 g and 10.30 g, fruit widths between 16.10 mm and 24.23 mm, and fruit lengths between 16.42 mm and 22.16 mm; Çelikel et al. (2008) found that the fruit weights of 5 promising types they selected from the local strawberry tree population growing in the Central Black Sea Region were 11.08, 8.06, 6.95, 6.30 and 6.17 g, respectively; Pekdemir, (2010) reported that the strawberry tree grown in Bulancak and Espiye districts of Giresun province has fruit weights between 2.28 g and 11.00 g, fruit width between 16.51 mm and 28.05 mm, and fruit length between 13.06 mm and 22.03 mm; in their study in Zonguldak province, Zenginbal and Gündoğdu (2016) determined fruit weight as 3.39 g to 7.25 g, fruit width as 17.75 mm to 23.18 mm, fruit length as 17.57 mm to 23.18 mm; in their study conducted on the Marmara island, İslam and Pehlivan (2016) reported that fruit weights were between 1.14 g and 8.19 g, fruit width was between 12.81 mm and 25.64 mm, and fruit length was between 10.87 mm and 27.64 mm. Sakaldaş (2012) found that strawberry trees selected from two regions in Çanakkale had a fruit width of 17.39 mm and a fruit length of 16.48 mm in the Atikhisar region; in the Umurböy region, they determined the fruit width as 16.57 mm and the fruit length as 15.69 mm. The fruit weight, width and length results we obtained in our study appear to be close to the literature reports. Climatic conditions and genetic factors can affect fruit weight, fruit width and length. Furthermore, this high variation can be explained by the rich genetic diversity of strawberry trees resulting from natural seed dispersal in the Black Sea region.

As a result of the examinations, it was determined by the color measurement values that the strawberry tree genotypes differed in size and appearance, but all the collected fruits were ripe, they generally had a red color in the color evaluations, and especially the B9, B17 and B13 genotypes were more clearly red than the others. In shell color measurements, L*, a* and b* values were measured as 37.90-30.20, 36.40-24.62, 36.51-27.86, respectively (Table 1). It can be thought that this variation in coloration is due to the high genetic diversity due to the genotypes being propagated by seeds. In a previous study conducted in the Black Sea region, it was reported that the skin color was dark-light red and the fruit flesh color was light orange (Toy, 2019).

3.1.2. Fruit internal quality

In strawberry tree genotypes, pH contents range between 3.36 and 3.88, with the highest pH value of 3.88 observed in B6 and B11 types, and the lowest pH value of 3.36 in B10 type. In a study by Karadeniz and Şişman (2004), the pH value in a strawberry tree type grown in the central district of Giresun was reported as 3.5;

Yarılgaç and İslam (2007) found pH values ranging from 3.70 to 4.01 in naturally grown strawberry tree types in Ünye and its surroundings. Koca et al. (2008) reported pH values between 3.80 and 3.99 in a study conducted in the Black Sea Region. Pekdemir (2010) determined pH contents of strawberry grown in the Bulancak and Espiye districts of Giresun province to be in the range of 3.64 to 4.10. The pH results obtained in our study align with the literature findings.

The SSC in genotypes varies between 11.60% and 19.60%, with the highest SSC value of 19.60% found in B5 type and the lowest SSC value of 11.60% in B14 type (Table 1). Karadeniz and Şişman (2004) reported an SSC of 22.9% in a strawberry tree type grown in the central district of Giresun. Yarılgaç and İslam (2007) found SSC values ranging from 16.62% to 24.02% in naturally grown strawberry tree types in Ünye and its surroundings. Koca et al. (2008) reported a range of 20.50% to 25.80% for soluble solid content in a study conducted in the Black Sea Region. Pekdemir (2010) reported SSC values ranging from 24.0% to 31.0% in strawberry tree grown in the Bulancak and Espiye districts of Giresun province. Sakaldaş (2012) found SSC contents of strawberry tree selected from two different regions in Çanakkale to be an average of 20.47% in Atikhisar and 23.74% in Umurbey. İslam and Pehlivan (2016) reported SSC values ranging from 12.00% to 24.00% in a study conducted in Marmara Island. Zenginbal and Gündoğdu (2016) stated an SSC ratio of 25.50% in a study conducted in the Western Black Sea Region. The SSC ratios obtained in this study were found to be lower than those reported by previous researchers. This situation can be explained mainly by genotype differences or climatic differences (Ates et al., 2022; Kurnaz et al., 2023).

3.1.3. Biochemical compounds

3.1.3.1. Sugar composition of strawberry tree genotypes

The sugar composition results of the selected strawberry tree genotypes' fruit juices are presented in Table 2. The most prevalent sugars found in the fruit juice were determined to be fructose, glucose, and sucrose. Among the selected strawberry tree genotypes, the highest glucose content was 8.34 g/100 g in B2 type, while the lowest was 2.32 g/100 g in B15 type. In a study conducted by Ayaz et al. (2000), the glucose content in strawberry tree fruits was reported as 21.50% of the dry weight. Gündoğdu et al. (2018) found the glucose content in strawberry tree fruits in the western part of Türkiye to be 6.10 g/100 g. Sagbas et al. (2020) reported glucose content ranging from 3.85 to 6.07 g/100 g. Ait Lhaj et al. (2021) determined the glucose content of selected strawberry tree from various regions in Morocco to be between 11.6 and 15.2 g/100 g.

Table 2. Sugar compositions (g 100g^{-1}) of the strawberry tree genotypes

Genotypes	Sucrose (g 100g^{-1})	Glucose (g 100g^{-1})	Fructose (g 100g^{-1})	Total Sugars (g 100g^{-1})
B-1	0.20	6.75	8.40	15.35
B-2	0.48	8.34	14.00	22.82
B-3	0.27	6.65	12.32	19.24
B-4	0.25	6.83	9.82	16.90
B-5	0.02	4.21	8.83	13.06
B-6	0.40	7.08	14.15	21.63
B-7	0.35	6.81	9.67	16.83
B-8	0.25	7.71	13.69	21.65
B-9	0.42	5.00	4.85	10.27
B-10	0.21	7.00	11.80	19.01
B-11	0.43	5.35	10.54	16.32
B-12	0.72	4.32	8.30	13.34
B-13	0.22	6.05	7.48	13.75
B-14	1.19	8.06	17.93	27.18
B-15	1.22	2.32	3.63	7.17
B-16	1.43	3.72	3.08	8.23
B-17	0.43	5.93	11.72	18.08
B-18	1.93	8.08	12.47	22.48
B-19	1.58	7.09	15.37	24.04
B-20	1.56	8.04	17.13	26.73

The fructose content in the fruits ranged from 3.08 g/100 g in B16 type to the highest value of 17.93 g/100 g in B14 type. Ayaz et al. (2000) reported fructose content as 27.80% of the dry weight of strawberry tree fruits. Gündoğdu et al. (2018) determined fructose content as 11.63 g/100 g in soluble sugars. Sagbas et al. (2020) found fructose content to range from 6.09 to 10.56 g/100 g. Ait Lhaj et al. (2021) reported fructose content in selected strawberry tree from various regions in Morocco as between 8.7 and 13.1 g/100 g.

Sucrose levels in the strawberry tree types ranged from 0.02 g/100 g in B5 type to the highest value of 1.93 g/100 g in B18 type. Ayaz et al. (2000) identified and determined sucrose sugar in strawberry tree fruits as 21.50% of the dry weight. Koca et al. (2008) reported sucrose levels ranging from 0.00 to 28.02 g/100 g. Gündoğdu et al. (2018) found sucrose content in fruits to be 1.44 g/100 g. Sagbas et al. (2020) identified sucrose content ranging from 0.78 to 1.56 g/100 g. The literature findings align with our study results, supporting the observed sucrose levels. Ait Lhaj et al. (2021) determined sucrose content in selected strawberry tree from various regions in Morocco to be between 4.2 and 8.1 g/100 g.

Total sugar contents in the selected strawberry tree types exhibited a variation between 7.17 and 27.18 g/100 g, with the highest total sugar content found in B14 type and the lowest in B15 type. Alarco-E-Silva et al. (2001) reported that strawberry tree fruits have a high sugar capacity, accounting for 42% of the fruit. Koca et al. (2008) found reducing sugar levels in the range of 108.82 to 182.80. The sugar content results in strawberry tree from previous studies align with our literature findings, supporting and validating our results.

3.1.3.2. Organic acid composition of strawberry tree genotypes

Organic acids play a significant role in fruits and are primarily composed of citric, malic, and tartaric acids in most fruit types. These organic acids play a crucial role in preserving the quality of products derived from fruits. Fruit ripening, aging, taste, and various other characteristics are significantly influenced by the content of organic acids (Saradhuldhat and Paull, 2007; Etienne et al., 2013). The organic acid content in the fruit juice of strawberry tree genotypes was determined, and the amounts of citric, L-ascorbic, and malic acids in the fruit juice were identified (Table 3). The C vitamin (L-ascorbic acid) content of the examined strawberry tree types ranged from the highest of 126.60 mg/100 g in B6 type to the lowest of 13.53 mg/100 g in B12 type. Koca et al. (2008) determined the ascorbic acid content to be in the range of 223.60 mg to 395.20 mg per 100 g of fruit in their study. Çelikel et al. (2008) reported that the C vitamin content of selected strawberry tree genotypes from the Central Black Sea Region ranged from 97.83 to 280.00 mg/100 g. Ruiz-Rodriguez et al. (2011) identified an average vitamin C content of 202.60 mg/100g in strawberry tree from two different regions in Spain. Sakaldaş (2012) detected vitamin C content in strawberry tree from two locations in Çanakkale as 154.65 mg/100g in Atikhisar region and an average of 143.50 mg/100g in Umurbey region. Ulloa et al. (2015) determined the ascorbic acid content as 18.85 mg/100 g in strawberry tree grown in Portugal. Gündoğdu et al. (2018) reported an average vitamin C content of 56.22 g/100g in strawberry tree genotypes naturally grown in the western part of Türkiye, while Sagbas et al. (2020) reported vitamin C content ranging from 58 to 93 mg/100 g FW in strawberry tree genotypes. The results of our study on ascorbic acid content align with the literature findings. While the C vitamin content is mainly determined by the genotype, factors such as harvest date, growing region, etc., also significantly affect the vitamin C content (Ruiz-Rodríguez et al., 2011; Çelik et al. 2019 Ates, 2023).

Table 3. Organic acid compositions of the strawberry tree genotypes

Genotypes	L-Ascorbic asid (mg 100 g^{-1})	Citric acid (%)	Malic asid (%)
B-1	58.68	0.32	0.71
B-2	67.00	0.50	0.51
B-3	39.55	0.19	0.55
B-4	35.24	0.31	0.62
B-5	16.08	0.23	0.54
B-6	126.60	0.21	0.90
B-7	50.51	0.52	0.77
B-8	41.10	0.55	1.09
B-9	32.14	0.19	0.56
B-10	61.12	0.69	1.30
B-11	50.89	0.42	0.94
B-12	13.53	0.18	0.27
B-13	64.13	0.16	0.93
B-14	16.04	0.34	0.65
B-15	57.57	0.37	0.49
B-16	38.70	0.36	0.73
B-17	38.34	0.38	0.77
B-18	14.96	0.20	0.76
B-19	101.61	0.38	0.55
B-20	60.94	0.29	0.42

Malic and citric acids have been reported as the main organic acids contributing to the pleasant sour taste of strawberry tree fruits in previous studies (Vidrih et al., 2013). In our study, the citric acid content of strawberry tree types ranged from 0.16% to 0.69%, with B10 containing the highest citric acid and B13 the lowest (Table 3). Ayaz et al. (2000) reported the presence of citric acid in strawberry tree fruits in their study. Gündoğdu et al. (2018) investigated phenolic compounds, biochemical characteristics, and pomological features in strawberry tree genotypes naturally grown in the western part of Türkiye, determining citric acid content in the range of 0.25 to 0.87 g/100 g. Sagbas et al. (2020) found citric acid content in strawberry tree genotypes' fruit juice ranging from 1.03 to 0.44 g/100 g FW. Regarding malic acid levels, the strawberry tree types analyzed in our study showed B10 as the type with the highest malic acid content at 1.30% and B12 as the type with the lowest malic acid content at 0.27% (Table 3). Ayaz et al. (2000) determined the malic acid content, classified under the non-volatile acids group, as 0.84 mg/g in strawberry tree fruits. Gündoğdu et al. (2018) investigated phenolic compounds, biochemical characteristics, and pomological features in strawberry tree genotypes naturally grown in the western part of Türkiye, determining malic acid as the main organic acid and measuring its content in the range of 0.67 to 2.33 g/100 g. Sagbas et al. (2020) found malic acid content in strawberry tree genotypes' fruit juice ranging from 1.12 to 0.37 g/100 g FW. Plant genotypes (Mikulic Petkovsek et al., 2007) and environmental conditions (Wu et al., 2007) affect the organic acid content of fruits. Additionally, horticultural practices such as irrigation, pruning, and soil type have been reported to influence organic acid content (Hudina et al., 2006).

3.1.4. Principal components analysis

Out of the 14 principal components, 5 PCs had eigenvalue higher than 1.0 these components explained 78.9% of total variation. PC1 was mainly related to fruith width, fruit height, glucose, fructose and total sugars, explaining 26.1% of total variability. PC2, which explained 19.0% of total variability, was related to pH, L, sucrose, citric acid and malic acid. Explaining 15.0% of total variability, PC3 was related to fruith weight (Figure 1).

According to cluster analysis results, strawberry genotypes divided into two main group. The first group included five strawberry genotypes (B-9, B-12, B-13, B-15 and B-16). The second group divide into two sub-cluster. First sub-cluster consisted of two strawberry genotypes (B-8 and B-10). The second sub-cluster incleded 13 strawberry genotypes (B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-11, B-14, B-17, B-18, B-19 and B-20) (Figure 2).

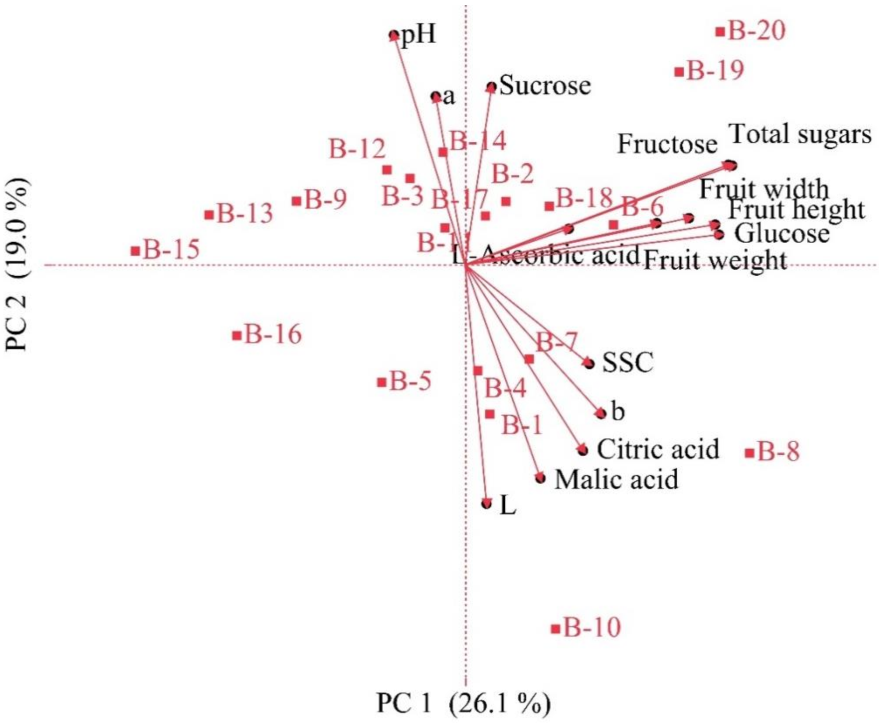

Figure 1. Component plot of the first two principal components in the strawberry genotypes

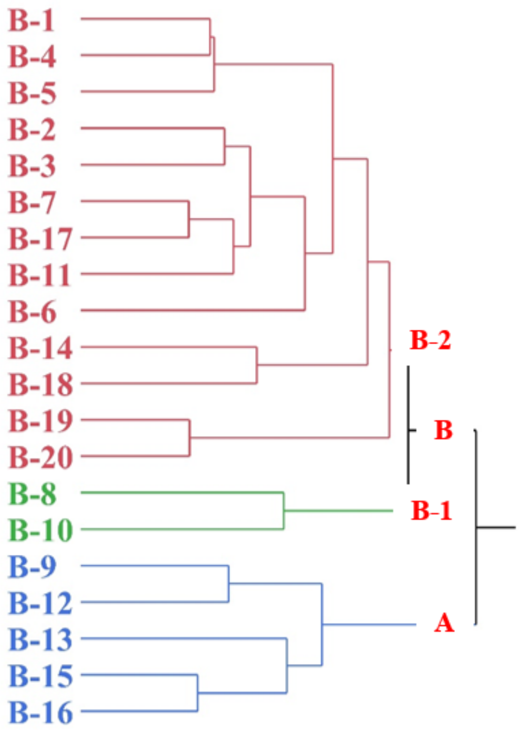

Figure 2. Dendrogram grouping of strawberry genotypes based on fruit quality characteristics

4. Conclusion

The strawberry tree (*Arbutus unedo* L.) and its fruits are not widely recognized in terms of horticultural characteristics. However, there are limited studies suggesting that the fruit content possesses important health-related properties. Based on the results obtained in our study, it is considered to have significant contents beneficial for human health, and it could serve as an important natural resource in the market. The genotype-based horticultural characteristics and fruit contents obtained in this study could make a substantial contribution to the development of the food and pharmaceutical sectors. In addition, it can make significant contributions to the development of both the food and pharmaceutical industries with its unique taste and rich bioactive content. Moreover, the observed wide variation in the examined traits may be valuable for future consideration by plant breeders as a genetic resource.

Author Contributions

The percentage of the author(s) contributions is present below. All authors reviewed and approved final version of the manuscript.

	S.Ç.	M.Y.
C	10	90
D		100
S		100
DCP	80	20
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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