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Determination of Fruit Quality Characteristics of Sweet Cherry Cultivars Grown in Mihalıççık (Eskişehir)

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Abstract

Türkiye is the world's most important producer of sweet cherries. Mihalıççık is important and significant district in terms of export in sweet cherry production in Türkiye. This study is to determine the fruit quality of "0900 Ziraat, Regina and Starks Gold" sweet cherry cultivars, which are widely produced in Mihalıççık. Fruit pomological and phytochemical properties were investigated in the study. The largest fruits were found in the 0900 Ziraat cultivar. The highest values in terms of phytochemical properties (Soluble solids content (SSC=20.17), Ascorbic acid (AsA=35 mg/L), Total phenolics content (TPC=52.67 mg GE/100 g), Anthocyanin=272.33 mg Cyanidin-3-rutinosideED/100g and DPPH=288.67 µmol TE/100 g) were determined in the Regina cultivar. Color and fruit firmness are among the most essential criteria for fruit shelf life and export. The highest fruit firmness was determined in the "Regina" cultivar. As a result of the study, it can be said that the Regina cultivar is very important for the region in terms of both fruit durability and the phytochemical values it contains.

Key words

Sweet cherry, Mihalıççık, Regina, 0900 Ziraat, Anthocyanin, DPPH

Introduction

Sweet cherry (Prunus avium L.), belonging to the Rosaceae family, is one of the world's most important products grown in temperate climates. Sweet cherry's origin is considered the region between Northeastern Anatolia, the Caucasus and the Caspian Sea. In 3000 BC, cherries were traded from Kerasos (in today's Giresun province of Türkiye) to Italy and from there to all of Europe. Today, cherries grow naturally in Europe, Anatolia, North Africa and Western Asia (Ockun et al., 2022).

According to FAO data for 2020, Türkiye ranks first in world sweet cherry production with 724.944 tons. While EU countries rank second with 532.120 tons of sweet cherry production, the United States' cherry production was 294.900 tons (FAO, 2022). Annual sweet cherry production in our country was approximately 689.834 tons from 22.155.412 cherry trees (TÜİK, 2021). Approximately 80% of Türkiye's sweet cherry exports consist of the '0900 Ziraat' cultivar, known as the "Turkish cherry" in foreign markets. The '0900 Ziraat' cultivar, which has found a place in domestic and foreign trade due to its superior fruit quality features, has undesirable characteristics that negatively affect its competitive power in world markets, such as being incompatible with itself and not being able to produce regular products every year. For this reason, fluctuations occur in our country's cherry production and export. This situation is reflected in prices, weakening producer-exporter relations domestically, and in foreign markets, causing gaps in relations with companies with which cooperation is made. In this context, breeding cherry cultivars that are stable in productivity, self-fertile and have high-quality fruits is highly essential for Turkiye's sweet cherry production and trade (Yıldırım & Demirtas, 2021).

In recent years, conscious consumers have been making choices among fruits according to the biochemical substances they contain such as antioxidants, phenolic substances, minerals, vitamins, organic acids, proteins, amino acids, and carbohydrates. It is stated that antioxidant compounds (such as phenolics, vitamin C) that can cleanse free radicals (superoxide and hydroxide) by single-electron transfer have vasodilatory, cardioprotective, anti-thrombotic, antioxidant, antimicrobial, anti-inflammatory, anti-atherogenic and anti-allergic effects on human health. As a result, there is growing interest in consuming fruits high in antioxidants (Crisostoso et al., 2003; Fazzari et al., 2008).

Fruits of sweet cherry are nutrient dense, high in fiber, and accumulate several bioactive compounds during ripening, including potassium, vitamin C, anthocyanins, polyphenols and carotenoids (McCune et al., 2010; Kelley et al., 2018). Given the high concentrations of bioactive compounds (anthocyanins, polyphenols, carotenoids etc.) in sweet cherries, it is not amazing that their eating has a positive effect on health. This information suggests that regular fruit consumption supports health and decreases the risk of illness and age-related health decline (Stoner et al., 2007). Published studies in human and animal issues have suggested that sweet cherry fruit intake may decrease the risk of several chronic inflammatory illnesses and increase cognitive function and sleep. In recent times, sweet cherries have received considerable attention and have been the subject of several reviews due to their health benefits (McCune et al., 2010).

Anthocyanins represent the primary group of phenolic compounds found in sweet cherries and are widely recognized for their role in determining the fruit's color. The most abundant anthocyanin in sweet cherries is cyanidin-3-O-rutinoside, which accounts for most of the total anthocyanin content, ranging from 90% to 92%. Compared to other phenolics, it is believed that anthocyanins in sweet cherries possess a unique ability to neutralize oxygen-free radicals and other reactive species. Since the late 20th century, there has been growing interest in the antioxidant properties of anthocyanins from these fruits (Gao and Mazza 1995, Mozetič et al. 2002, Gonçalves et al. 2007, Serrano et al. 2005, Usenik et al. 2008, Serra et al. 2011). Phenolic compounds can be categorized into groups such as tartaric esters, flavonoids, and anthocyanins (Fukumoto and Mazza 2000). Other research has identified separate classes including flavan-3-ols, flavonols and phenolic acids. Specific compounds within these categories have been thoroughly documented for sweet cherries (Gonçalves et al. 2004, Mozetič et al. 2006, Usenik et al. 2008). Veberič and Štampar (2005) examined the levels of epicatechin, rutin and chlorogenic acid revealing significant variation due to cultivar differences.

Mihalıççık was established in the southeast of the Sündiken Mountains in the Upper Sakarya region. The area of the district is 1650 km2 and the altitude is 1325 m. The total population of Mihalıççık is 18.696, the city population is 4706 and the village population is 13.990 (Yucel et al., 2010). In recent years, sweet cherry orchards have been intensively established in the Mihalıççık (Eskişehir/Türkiye) district. Local farmers and large agricultural companies are establishing sweet cherry orchards in this region. Therefore, this place has become an important area for cherry production in Türkiye. Although the 0900 Ziraat sweet cherry cultivar is common in the region, the Regina cultivar has also begun to be planted intensively in recent years.

In this study, the quality characteristics of Regina, Starks Gold, and 0900 Ziraat sweet cherry cultivars grown in the Mihalıççık district of Eskişehir, which has distinctive ecological conditions and plays a significant role in the global cherry industry, were examined. The primary objective of this study is to contribute to the literature by determining the quality characteristics of cherry cultivars cultivated in this region.

Materials and Method

Plant materials

The plant material used in this study was obtained from the Mihalıççık district of Eskişehir province in 2024. The fruits were collected from a 10-year-old commercial orchard. Maxima 14 rootstock was used for cherry trees. Regular irrigation and fertilization are carried out in the orchard. The sweet cherry cultivars examined in the study include '0900 Ziraat,' known as 'Turkish Sweet Cherry' in Europe, characterized by dark red, heart-shaped fruits with high resistance to transportation and cracking; 'Regina,' recognized for its dark red color, firm and delicate texture, heart shape, and intense aroma; and 'Starks Gold,' a late-ripening, medium-sized cultivar with yellow skin, firm texture, and high commercial demand due to its cracking resistance and transportability.

Pomological properties

Harvested fruits were immediately transferred to the laboratory. Fruit width and length were measured with a digital calliper (Stilson). An electronic scale with 0.001 g-accuracy (Sartorius – CPA 16001S) was used to determine fruit weight, fruit flesh weight and seed weight. Firmness was measured using a handheld penetrometer (LUTRON FR-5120, Taiwan) with a 3-mm probe. Fruit width, fruit length, stem length, stem thickness, seed length, and seed width were measured in millimeters using a digital caliper. Fruit peel and fruit flesh color were determined using a Konica Minolta CR-400 colorimeter by measuring the L*, a*, and b* values. Soluble solids content (SSC) was measured using an ATAGO hand-held refractometer by analyzing a few drops of fruit juice.

The fruit juice pH value was measured using a HANNA desktop pH meter, while titratable acidity (TA) was determined according to the method described by Akçin et al. (2024).

Phytochemical analysis

The total phenolic content was detected using the Folin-Ciocalteau method, as described by Usenik et al. (2008). Results were expressed as gallic acid equivalents (GAE) in milligrams per 100 grams of fresh weight (FW) of edible fruit. To prepare the sample, 6 mL of double-distilled water, 500 µL of Folin-Ciocalteau reagent, and 1.5 mL of sodium carbonate solution (20% w/v) were added to 100 µL of the sample extract (diluted 1:5 (v/v) with methanol). After mixing, the extracts were incubated at 40°C for 30 min and absorbance was measured at 765 nm in the spectrophotometer. A blank solution containing water and reagents was used for calibration.

Antioxidant activity was assessed using the DPPH assay, following the procedure outlined by Kelebek and Selli (2011). A 0.1 mL aliquot of the fruit samples was mixed with 3.9 mL DPPH solution and vortexed. To determine the maximum DPPH absorbance, a control sample was prepared by replacing the extract with the same solvent volume. The samples were then incubated in the dark for 30 minutes, after which absorbance was measured at 515 nm. The results were reported as Trolox equivalent antioxidant capacity.

The vitamin C concentration in fruit juice was measured using a colorimetric technique involving 2,4-dinitrophenylhydrazine (2,4-DNPH), as Souza et al. (2014) outlined. The samples were analyzed in a spectrophotometer at 520 nm absorbance, and the results were reported as milligrams of ascorbic acid per liter of fruit juice.

Total anthocyanin content was measured at 530 nm according to Serrano et al. (2005). Total anthocyanin content was calculated using cyanidin-3-glucoside and the results were expressed as mg 100 g-1.

Statistical Analysis

The raw data of the experiments were summed in Microsoft Excel and then transferred to SPSS 22.0 for further statistical comparison. The analysis of variance (ANOVA) was used to identify significant differences among the cultivars and the mean separation was performed using Tukey's test ($P < 0.05$). The PCA-BiPlot and Pearson correlation analysis were then carried out using the R 3.6.2 statistical program.

Results and Discussions

Pomological values are presented in Figure 1. Pomological characteristics were significantly different among the cultivars ($p < 0.05$). Ziraat 0900 cultivar had the highest values for fruit width, length and weight (Figure 1a). Fruit size is one of the most significant criteria for fruit quality. One of the main research topics in breeding studies is fruit size. Fruit length was close to each other among the cultivars. Fruit width (Figure 1b) was the highest in the Regina cultivar. Fruit weight was higher in Ziraat 0900 and Regina cultivars. Fruit weight (Figure 1c) was the highest in Ziraat 0900 cultivar, seed weight was the highest in Ziraat 0900 cultivar, and seed weight was the highest in Regina. The flesh/seed ratio was calculated to be the highest in the Ziraat 0900 cultivar. Fruit firmness (Figure 1d) is essential for fruit quality. Fruit firmness is one of the most significant criteria for fresh fruit export. Our research determined the highest value in Regina and Starks Gold cultivars. The highest pH values were calculated in the Ziraat 0900 cultivar and the lowest pH in the Regina cultivar. TA was determined highest in the Regina cultivar.

In the study by Eroğul et al. (2021) on cherry cultivars in Kemalpaşa, the average fruit weight was 8.63 g -10.69 g, and the fruit length varied between 22.93 mm and 24.69 mm. The study conducted by Koyuncu et al. (1999) determined that the average fruit length of different cherry cultivars varied between 18.20-23.90 mm. In the study conducted by Savaş (2021) on different cherry cultivars, the fruit length of the Early Burlat cultivar varied between 21.65-22.99 mm. In the study by Eroğlu (2016), the fruit firmness of the Early Burlat cultivar was reported as 5.30 N and the fruit firmness of the Regina cultivar as 8.62 N. In the studies conducted by Güngör and Sağlamer (1995) on different cherry cultivars, it was reported that the lengths varied between 3.4 and 6.1 cm. In the study by Pırlak and Bolat (2001), the lengths of different cherry cultivars varied between 3.63-4.76 cm. In the study conducted by Özbiçerler (2006), it was stated that the average length varied between 2.3-3.7 cm. In the study conducted by Bilginer et al., (1998), it was stated that the amount of soluble solids in fruits of four different cherry cultivars varied between 9.4 and 16.4%. In the study by İlhan and Artık (2021), the soluble solids content varied between 12.8 and 20.16%. In the study conducted by Eroğlu et al. (2021) in Kemalpaşa, the amount of water-soluble dry matter varied between 12.10 and 13.7%. In the study by Eroğlu (2016) in Kemalpaşa, the amount of soluble solids in the Early Burlat cherry cultivar was 9.86%, while it was 14.33% in the Regina cultivar. While the soluble solids content amount of Early Burlat cherry cultivar was found to be the lowest in Kemalpaşa, and was 18.37% in Sicily (Ballistreri et al., 2013), it was determined as 13.5% at high altitudes and 15.5% at low altitudes in Greece (Faniadis et al., 2010). In a study conducted by Eroğul (2016) on different cherry cultivars, the titratable acidity amount was found to be 0.43 g/100 ml in the Early Burlat cultivar, while it was 0.77 g/100 ml in the Regina cultivar. In a study conducted by Ballistreri et al. (2013), the titratable acidity amount of the Early Burlat cultivar in Italy was found to be 0.83 g/100 ml. In a study conducted by Savaş (2021), the titratable acidity amount of the Early Burlat cultivar was found to be 0.43 g/100 ml. In the study conducted by Ouaabou et al., (2020) on different cherry cultivars, the pH value was measured as 3.77 in the Early Burlat cultivar. In the study by Eroğlu (2016), the pH value was measured as 4.43 in the Early Burlat cultivar and 4.21 in the Regina cultivar. In the study conducted by Savaş (2021), the pH value in the Early Burlat cultivar varied between 4.04 and 4.10.

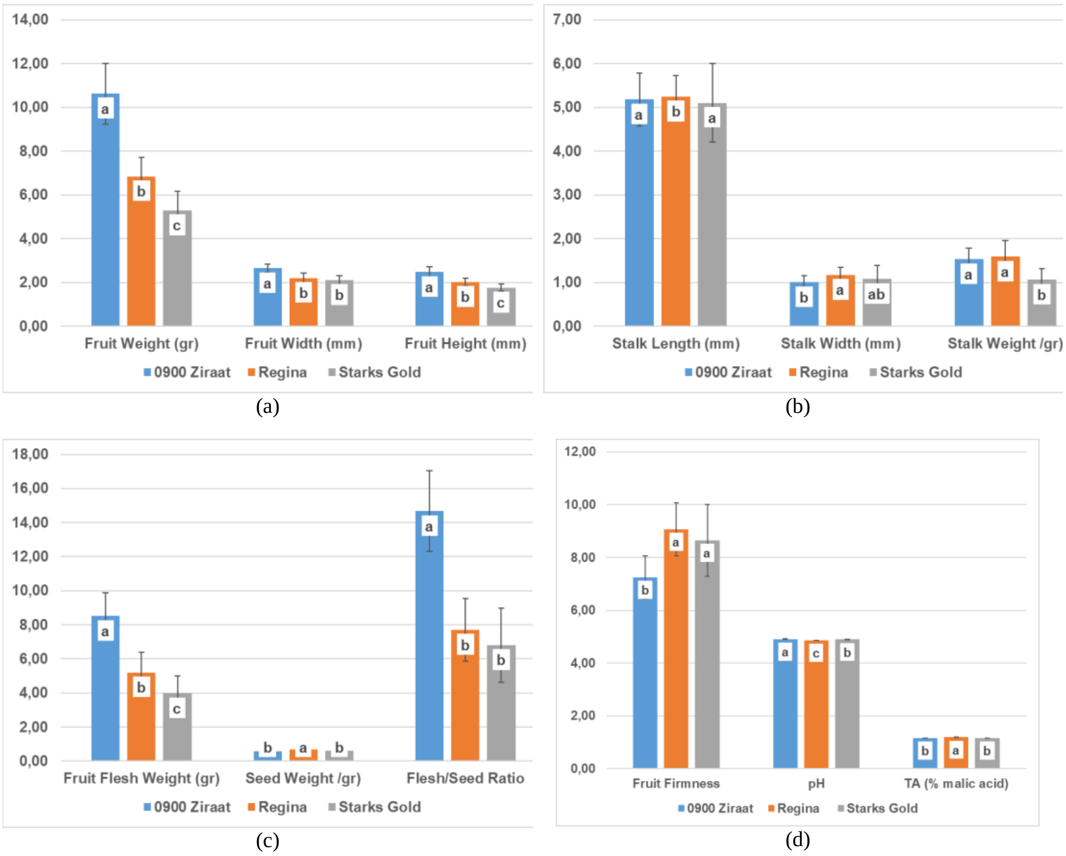
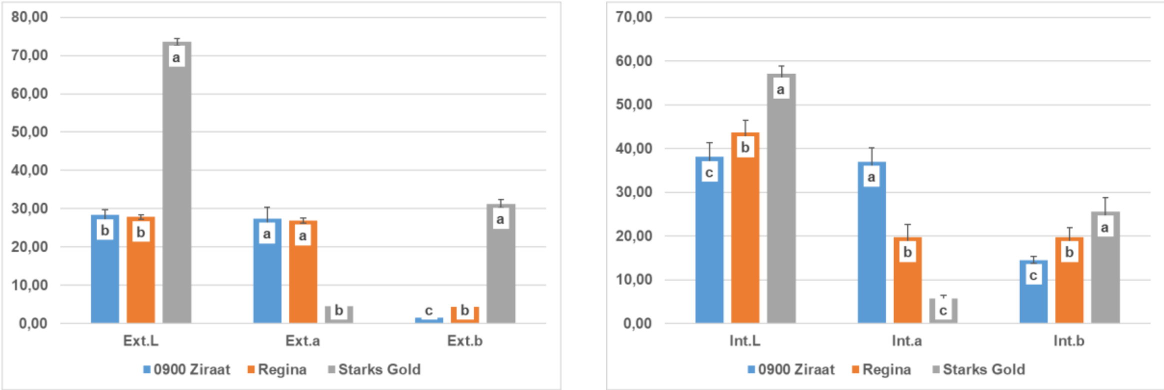


Figure 1. Pomological properties [a= fruit weight, width and height; b=stalk values; c=fruit flesh weight, seed weight and flesh/seed ratio; d= fruit firmness, pH and TA]

The values of the fruit peel and fruit flesh colors of the sweet cherry cultivars are presented in Figure 2. Color values were found to be significantly different among the cultivars ($p < 0.05$). The L* value expresses the changes in the brightness of the color, and the L* value reaches its maximum value as it approaches 100. This color is based on the principle of 100% reflection of the light reflected on the white color. The obtained a* value expresses the color change from green to red, and the b* value from yellow to blue, while the negative value of b* expresses the color blue, and the positive value expresses the color yellow. The positive value of the a* value expresses red, and the negative value express green. The values being negative or positive means that the color gets darker. The red color in sweet cherries is important in terms of attractiveness, and the high a* values indicating the formation of red color in the fruit peel, the L* value expressing brightness, and the b* color value close to blue are quite important in terms of expressing the attractiveness and quality criteria of the fruit. The low b* value indicates that the coloration has increased, and maturity is approaching. For external fruit color, the highest L* value was found in Starks Gold (73.56). The highest a* value was found in Ziraat 0900 (27.41) and Regina (26.90) cultivars. The highest b* value was obtained in Starks Gold (31.27). For internal fruit color, the highest L* value was found in Starks Gold (57.09). The highest a* value was found in Regina (37.01). The highest b* value was determined in Starks Gold (25.56).

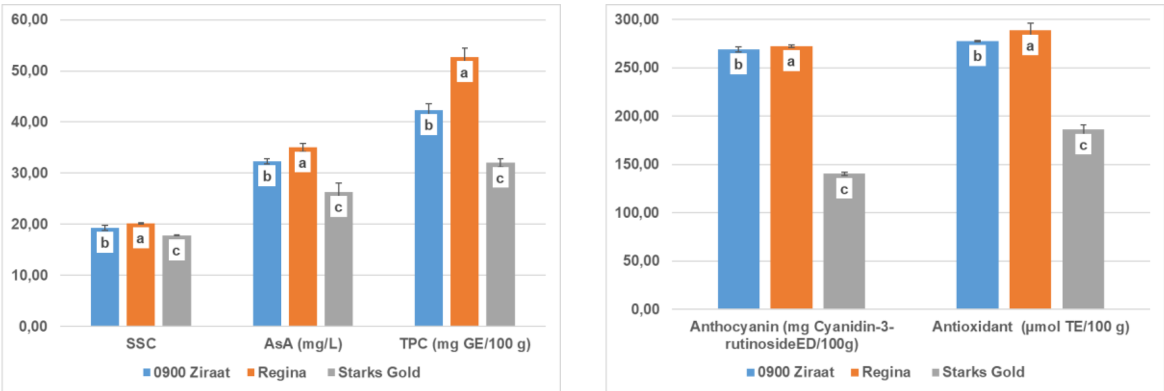


(a) (b)

Figure 2. Fruit peel and flesh color values of fruit [a=peel; b=flesh]

Color and fruit firmness are among the most important criteria for fruit shelf life and export. In the study conducted by Savaş (2021) on different cherry cultivars, the fruit peel L* value of the Early Burlat cultivar varied between 31.98 and 33.55. In the study conducted by Legua et al. (2017), the L* value was found to be 30.33 in the Early Burlat cultivar. In the study conducted by Eroğlu et al. (2021), the L* values of different cherry cultivars varied between 37.00 and 39.86.

Phytochemical properties are given in Figure 3. Phytochemical values were found to be significantly different among the cultivars ($p < 0.05$). SSC value was the highest in Regina (20.17) cultivar and the lowest in Starks Gold (17.83). AsA value was the highest in Regina (35 mg/L) cultivar and the lowest in Starks Gold (26.33 mg/L). TPC was measured the highest in Regina (52.67 mg GE/100 g) cultivar and the lowest in Starks Gold (32 mg GE/100 g). Anthocyanin amount was measured as the highest in Regina (272.33 mg Cyanidin-3-rutinosideED/100g) cultivar and the lowest in Starks Gold (140.33 mg Cyanidin-3-rutinosideED/100g) cultivar. The highest DPPH value was found in Regina (288.67 µmol TE/100 g) cultivar and the lowest in Starks Gold (186 µmol TE/100 g) cultivar.



(a) (b)

Figure 3. Phytochemical values [a= Soluble solids content (SSC), Ascorbic acid (AsA) and Total phenol content (TPC); b=Anthocyanin and DPPH]

Sweet cherries have significant volumes of anthocyanins. Anthocyanins such as peonidin 3-O-rutinoside, cyanidin 3-O-glucoside, cyanidin 3-O-rutinoside, delphinidin, petunidin and malvidin and pelargonidin 3-O-rutinoside are found in cherries (Gonçalves et al., 2004; González-Gómez et al., 2010; Valero and Serrano, 2010). Cyanidin 3-O-glucoside and cyanidin 3-O-rutinoside are the dominant anthocyanins (Tomás - Barberán et al., 2013; Serradilla et al., 2016). The anthocyanin concentration in cherries begins at just a few milligrams and can reach 300 mg (Gao and Mazza, 1995; Wang et al., 1997; Valero and Serrano, 2010). Typically, both light and dark red cherry cultivars contain 2.0 and 2243.0 mg/100 g fresh weight cyanidin 3-O-rutinoside, respectively, and 0.1–35.0 mg/100 g fresh weight (FW) cyanidin 3-O-glucoside, respectively (Gao and Mazza, 1995; Usenik et al., 2008). The levels of phenolics and anthocyanins were assessed in the fruits of 13 sweet cherry cultivars: Ferrador, Vigred, Vesseaux, Sylvia2, Noire de Meched, Lapins, Lala Star, Ferprime, Fernier, Fercer, Early Van Compact, Burlat and Badascony. In the study, it was determined that the total phenolic content varied between 45 and 88 mg gallic acid equivalent/100 g FW and the antioxidant activity varied between 8.0 and 17.2 mg ascorbic acid equivalent/100 g fresh weight (Usenik et al., 2008). A study was conducted in Spain to identify 20 sweet cherry cultivars and determine their quality values. Significant differences were detected among the cultivars regarding total phenolic compounds; in this respect, dark colored cultivars ‘Pico Negro’, ‘Del Valle’, ‘Moracha’ and‘Reondal’ had the highest values as 1.70, 1.69, 1.64 and 1.60 g/100 g dry weight (DW), respectively. The lowest values in terms of polyphenols were in the two cultivars with light skin color; ‘Monzón’ (0.77 g/100 g CA and ‘Blanca de Provenza’ (0.66 g/100 g DW) were determined (Perez-Sanchez et al., 2010). Gündoğdu and Bilge (2012) determined phenolic compounds in the fruits of ‘0900 Ziraat’ and local sweet cherry cultivars ‘Beyrudi’.. The researchers reported that gallic acid content was higher than other phenolic compounds and the highest amount was found in ‘0900 Ziraat’ cultivar (95.512 mg/100 g). In a study conducted in Tokat, the total antioxidant content of the cultivar ‘0900 Ziraat’ was found to be 8.10 µmol trolox equivalent (TE)/g FW (Öztürk et al., 2013). In another study, the antioxidant activity of the cultivar ‘0900 Ziraat’ was determined to be 9.77 µmol TE/g (Eroğul, 2016). Şen et al. (2014) examined the biochemical contents of the cultivars ‘Early Burlat’, ‘Napoleon’ and ‘0900 Ziraat’ grown in İzmir province. The researchers determined the total phenolic values of the cultivars as 101.3, 103.5 and 94.6 mg GAE/100 g FW, respectively, and their DPPH as 9.22, 13.32 and 7.93 µmol TE/g FW.

A PCA analysis was conducted to examine the correlation and relationships between the variables, with the results shown in (Fig. 4). The analysis revealed that the pomological and chemical properties account for a significant portion of the total variation, with two main components explaining 74.9% of the variance. Regarding chemical properties, titratable acidity (TA) and total phenolic content (TPC) exhibited the highest values, whereas anthocyanin levels were the lowest. The PCA graph indicates a positive correlation between fruit width and fruit weight a negative correlation between flavonoids and fruit length.

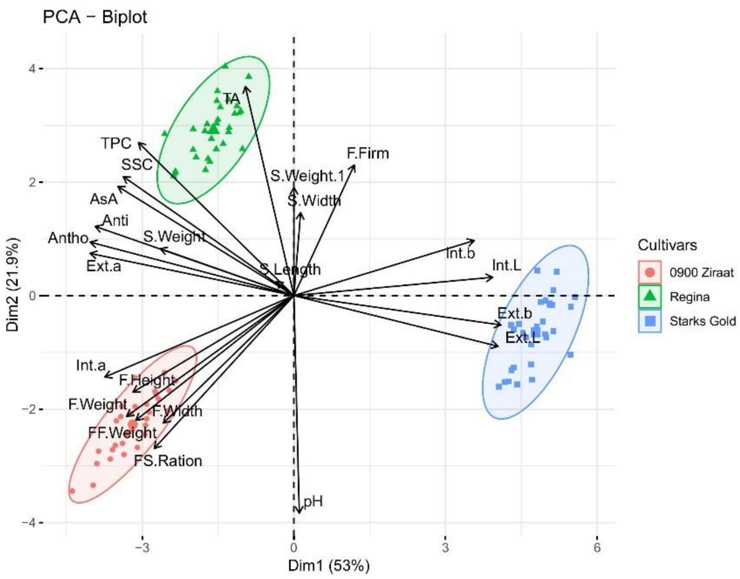


Figure 4. PCA analysis for sweet cherry cultivars

Conclusions

The Mihalıççık region is one of the most important sweet cherry production regions in Türkiye. This region has many advantages such as the climate conditions suitable for sweet cherry cultivation and the late harvest time due to its high altitude (1325m) above sea level. While cherry harvest is over in many sweet cherry production regions, it is just starting in the Mihalıççık region. Although the 0900 Ziraat sweet cherry cultivar is common in the region, the Regina cultivar has also begun to be planted intensively in recent years. In our study, Ziraat 0900 cultivar was important in terms of fruit size. However, Regina sweet cherry cultivar has an advantage due to its higher fruit firmness, darker colored fruits and higher phytochemical components. The Regina cherry cultivar is used in newly established orchards. We predict the Regina cultivar will completely replace the 0900 Ziraat cultivar in this region in the coming years.

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Author Contributions

All authors contributed to the emergence of the manuscript and approved the final version

Conflict of Interest

The authors declare that they have no conflict of interest.

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