

Determining Fruit Characteristics Turkish Sweet Cherry (*Prunus avium* L.) Grown in Afyonkarahisar: Local Cultivars and Genotypes

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Abstract

Sweet cherry (*Prunus avium* L.) is one of the most widely produced and consumed stone fruit species in the world and Turkey. Due to this agricultural importance, breeding studies are carried out in cherry for various purposes. The main breeding objective is to increase self-sufficiency and fruit quality in cherry worldwide. In this study, we aimed to determine the relationship between fruit cracking, which is a serious problem in fruit quality, and fruit characteristics, which are the morphological characteristics of the fruit, with genotypes and local cultivars and to determine the cracking resistance of cherry fruits. Annual temperature, relative humidity and precipitation data, which are known to be highly related to cracking in ripening fruits until harvest, were also taken. Differences were found in fruit weight, fruit width, seed weight, fruit stem weight, TA, pH, L*, a*, b*, hue, chroma and crack resistance characteristics between genotype and local cultivars. Among the traits examined, fruit weight was 4.05–5.14 g, width was 20.47–22.80 mm, length was 18.49–19.06 mm, seed weight was 0.58–0.68 g, peduncle length was 31.79–36.44 mm, and peduncle thickness was 1.09–1.17 mm, peduncle weight 0.08–0.11 g, TA 7.62–9.37%, pH 4.20–4.37, SSC 13.53–15.05%, L* 28.55–33.05, a* 9.44–22.92, b* 2.18–8.23, hue 11.98–20.15, chroma 9.71–24.26 and cracking index 6–12.40. It was determined that there was a low negative correlation between the cracking index and fruit weight, fruit length, seed weight, TA, pH and L* and a low positive correlation between fruit width, fruit stem length, thickness and weight, SSC, a*, b*, h° and chroma. According to the results of the heatmap clustering analysis, three of the local cultivars were clustered together (A), while the other local cultivars and genotypes were clustered in a separate arm (B). Similarly, fruit weight, seed weight, peduncle thickness, SSC, peduncle weight, TA, fruit length, peduncle length and cracking indexes were categorized as the first group, and other components were categorized as the second group. As a result of the research, local cultivars and genotypes with high fruit weight and cracking resistance were identified. We believe that these genotypes can be employed in both breeding and breeding research.

Introduction

Cherry (*Prunus avium* L.) is one of the most popular stone fruits in the world and in Turkey. This species is used as a table fruit, and some of them are also used in the food industry as frozen fruit and fruit juice. The suitability of cultivars as tables or industrial cultivars varies according to the colour and physical and biochemical properties of the fruit (Bandi et al. 2010). In the classical sense, cherry breeding studies begin by selecting the best ones among local cultivars. In fact, the very popular 'Bing' cultivar emerged in this way (Jayasankar and Kappel 2011). In the breeding programmes carried out, countries have set priorities to solve their own problems. In general, the main objectives of cultivar breeding studies in cherry are incompatibility, fruit size, taste-aroma, fruit flesh firmness, fruit colour, resistance to fruit cracking, fruit stem length, productivity, early or late ripening, a long harvest period, extending shelf life, tolerance and resistance to diseases and pests, dwarfism, product with colourless juice and small seeds for industry, frost resistance and improvement in climatic adaptation such as chilling requirements (Brown et al. 1996; Saunier 1996).

Increasing environmental factors such as excessive rainfall, high humidity, and rapid temperature changes due to climate change, which have become increasingly influential in recent years, may have a significant impact on fruit cracking (Ruiz-Aracil et al. 2023). Thinner-skinned fruits such as cherries tend to be more susceptible to cracking than thick-skinned fruits such as other stone fruits (Moing et al. 2004; Pantelidis et al. 2021). Apart from climatic conditions, fruit size and shape, cultural practices, genetic factors and sugar content of the fruit are the parameters that play a role in cherry cracking (Measham et al. 2002; Correia et al. 2018; Blanco et al. 2022). In cherry cultivation, cracking of fruits due to rainfall before or during harvest is an important problem. In recent years, some cultural measures and chemicals have been used for fruit cracking. However, the use of chemicals is not preferred by consumers due to their negative effects on human health, and it cannot be a solution because these chemicals have an effect up to a point (Corkley et al. 2022). The most permanent solution to fruit cracking is seen as a resistant cultivar. For this reason, crack-resistant cultivars should be grown in regions with high humidity or rainy weather at harvest time (Knoche and Peschel 2006; Correia et al. 2018; Devasirvatham and Tan 2022).

Fruits that are cracked allow infections to enter and quickly deteriorate while being transported and stored. There are substantial variances among cherry varieties in terms of susceptibility to cracking. Most early cultivars, in particular, are prone to cracking. Breeding cultivars that are resistant to cracking takes on added significance in this regard. It is crucial to demonstrate this trait in breeding research.

In this study, we aimed to determine the relationship between fruit cracking, which is a serious problem in fruit quality, and fruit characteristics, genotypes and local varieties and to determine the resistance of cherry fruit to cracking.

Material and Methods

Trial Area and Features

This study was carried out on local cherry cultivars and genotypes in Sultandağı/Kırca town in 2023. In this study, genotypes grafted on *Prunus mahaleb* and local cherry cultivars ("Karaballı", "Gilli", "Akçilli") were used. The tree age of local cherry cultivars was between 21–25 years, and the trees were 7.0 m between rows and 4.0 m above rows. All trees in the study were not subjected to cultural practices such as pruning, irrigation and fertilization.

The monthly average precipitation, monthly average temperature and monthly average relative humidity values of the study area are presented in Fig. 1 and Fig. 2 (TSMS 2023).

Measurements and Analyses

Fruit weight (g), by weighing 50 fruits; fruit width and length (mm), by measuring the widest and narrowest parts of the equatorial part of the fruit with the help of a digital caliper and taking the average of the two values; seed weight (g) by weighing the washed and cleaned seeds; fruit stem weight (g) by weighing the fruit stems; fruit stem length (mm) by measuring the stems on a flat surface and fruit stem thickness (mm) by measuring the thickness in the centre of the stems with a digital caliper with a precision of 0.01 mm; water soluble dry matter content (%) in homogenised juice by digital hand refractometer (Greinorm 0–

80 Brix, Germany); pH in homogenised juice by digital pH meter (Hanna HI9124, Romania) and titratable acid content (% malic acid) by titration method; fruit colour was measured with a colourimeter (PCE Instruments Colorimeter, model PCE-CSM 1, Manchester, UK) by taking measurements at 2 different points on the peel surface of the fruit and fruit peel colour characteristics (L*, a*, b*, chroma and hue°);

In the cracking test, the fruit stems were first cut at the level of the stem pit without damaging the fruit. The fruits with cut stems were placed in beakers and filled with pure water to cover them completely. The fruits were removed from the water after 2, 4 and 6 hours, and the cracked fruits were counted. Immediately afterwards, those that did not crack were immersed in water again. This process was repeated 3 times. The cracking index was calculated according to the formula.

Cracking index = [(5a + 3b + c) × 100]/250

a: Fruit cracking after 2 hours; b: Fruit cracking after 4 hours; c: The number of fruits that crack after 6 hours. 5: Multiplication factor for the number of fruits cracking after 2 hours; 3: Multiplication factor for the number of fruits cracking after 4 hours; 1: Number of fruits cracking after 6 hours (Yıldırım and Koyuncu 2010).

According to the cracking index, genotypes and local cultivars were classified as resistant, medium resistant, sensitive and very sensitive. The cracking index class values were determined as resistant (≤ 10), moderately sensitive (≥ 10–≤ 20), sensitive (≥ 20–≤ 40) and very sensitive (≥ 40) (Greco et al. 2008).

Data Analyses

Correlation analyses were performed to determine the relationships between genotypes and local cultivars in terms of fruit characteristics. JMP® Pro 16.0.0 (Copyright © 2021 SAS Institute Inc.) software was used in the analyses. R Studio 2022.07.1 (© 2009–2022 RStudio, PBC) statistical software was used for heatmap hierarchical cluster analysis and correlation analysis. The open source data visualization package "ggplot2" (Wickham 2016) was used for analysis with R.

Findings

Significant variations were obtained in local cultivars and genotypes in terms of fruit weight (Table 1). The highest fruit weight was determined in the local cultivar "Akçilli" (5.14 g), followed by the local cultivar "Karaballı 1" (4.82 g), which was statistically in the same group. The lowest fruit weight was found in the local cultivar "Karaballı 2" (4.05 g). The highest fruit width was determined in the local cultivar "Karaballı 3" (21.96 mm), which was in the same group as "Genotype 3", "Genotype 4", and "Gilli 1". The lowest fruit width was determined in the "Karaballı 2" local cultivar (20.47 mm). When the fruit lengths of local cultivars and genotypes were compared, it was determined that there was no difference between cultivars and genotypes; the highest fruit length was found in the local cultivar "Gilli 2" (19.06 mm), and the lowest was found in the local cultivar "Akçilli" (18.49 mm). In this respect, all fruit shapes have a kidney shape according to the characteristics defining cherry fruit shape in the UPOV criteria.

The highest seed weight was found in the local cultivars "Akçilli" and "Karaballı 3" in the same statistical group (0.68 g), and the lowest was found in the local cultivar "Karaballı 2" (0.58 g) (Table 1).

Similarly, there was no difference between local cultivars and genotypes in fruit stem length and fruit stem thickness (Table 1). The highest fruit stem length was found in the local cultivar "Karaballı 3" (36.44 mm), and the lowest was found in the genotype "Genotype 2" (31.79 mm); the highest fruit stem thickness was found in the genotype "Genotype 2" (1.17 mm), and the lowest was found in the local cultivar "Gilli 1" (1.09 mm). The local cultivar "Akçilli" (0.11 g) was found to have a significant fruit stem weight compared to other local cultivars and genotypes (Table 1). The lowest fruit stem weight was found in the "Genotype 2", "Genotype 3", "Gilli 2" and "Karaballı 1" local cultivars and genotypes (0.08 g), which had the same fruit stem weight and were in the same statistical group.

Table 1. Fruit weight, width, length, seed weight, fruit stem length, fruit stem thickness and fruit stem weight of local cherry cultivars and genotypes.

Local cherry cultivars and genotypes	Fruit weight	Fruit width	Fruit length	Seed weight	Fruit stem length	Fruit stem thickness	Fruit stem weight
Akçilli	5,14±0,38a	21,63±0,21abc	18,49±0,31	0,68±0,02a	34,46±2,12	1,15±0,06	0,11±0,01a
Genotip-1	4,60±0,37ab	22,25±0,63ab	18,72±0,29	0,65±0,04ab	32,95±1,92	1,11±0,05	0,09±0,01bc
Genotip-2	4,53±0,55ab	22,25±0,37ab	18,69±0,38	0,66±0,02ab	31,79±1,92	1,17±0,11	0,08±0,01c
Genotip-3	4,78±0,22ab	22,40±0,71a	18,88±0,31	0,66±0,04ab	36,10±1,50	1,14±0,03	0,08±0,01c
Genotip-4	4,81±0,45ab	22,80±0,21a	18,86±0,35	0,63±0,00ab	34,40±4,08	1,14±0,06	0,09±0,01bc
Gilli-1	4,64±0,10ab	22,58±0,19a	18,83±0,10	0,66±0,02ab	34,14±2,94	1,09±0,02	0,09±0,01bc
Gilli-2	4,64±0,07ab	22,17±0,62ab	19,06±0,66	0,65±0,02ab	33,84±1,75	1,14±0,08	0,08±0,01c
Karaballı-1	4,82±0,19ab	20,92±0,75bc	19,04±0,58	0,66±0,03ab	33,10±1,08	1,13±0,07	0,08±0,01c
Karaballı-2	4,05±0,14b	20,47±0,18c	18,93±0,27	0,58±0,06b	33,74±1,25	1,15±0,07	0,10±0,01ab
Karaballı-3	4,20±0,17b	21,96±0,55a	18,62±0,36	0,68±0,01a	36,44±1,06	1,11±0,06	0,09±0,01bc
LSD _{0,05}	0.31*	0.50***	0.39 ns	0.03*	2.17 ns	0.07 ns	0.01***

*: p<0.05; ***: p<0.001, ns: not significant

The TA content analysed in the fruit samples was found to differ among local cherry cultivars and genotypes (Table 2). Among the local cherry cultivars and genotypes, the highest TA content was found in the "Gilli 2" local cultivar (9.37%), followed by the "Genotype 1" (9.32%), "Genotype 4" (9.25%) and "Akçilli" (9.13%) local cultivars and genotypes in the same statistical group. The lowest TA was found in "Genotype 3" (7.62%) and "Gilli 2" (7.66%).

When the SCC contents of local cultivars and genotypes were compared, it was found that there was no difference between them, and the SCC content varied between 13.53% and 15.05%. The genotype "Genotype 3" had the highest SCC content of 15.05%. The local cultivar "Karaballı 3" had the lowest SCC content of 13.53%. On the other hand, there was a significant difference in the fruit juice pH of cherry genotypes and cultivars, which varied between 4.20 and 4.37.

Genotypes "Genotype 1" (33.05) and "Genotype 3" (32.96) ranked first in terms of the L* value from the fruit colour value. The lowest L* values were found in the "Karaballı 2", "Karaballı 1" and "Karaballı 3" local cultivars, with 28.55, 28.70 and 28.97 values, respectively. Similarly, a*, b*, hue^o and croma values varied between genotypes and local cultivars. In the measurements made on the fruit samples, it was determined that the genotypes named "Genotype 3", "Genotype 1", "Genotype 2" and "Genotype 4" had the highest a* values of 22.92, 21.17, 20.74 and 20.71, respectively, while the lowest a* values were 9.44, 9.68 and 11.94 in the local cultivars "Karaballı 3", "Karaballı 1" and "Karaballı 2", respectively. When the b* values of the samples were analysed, it was determined that the highest value was found in the genotype named "Genotype 3" (8.239), and the lowest values were 2.18 and 2.52 in the local cultivars "Karaballı 3" and "Karaballı 1", respectively. The hue^o values of local cultivars and genotypes varied between 11.98-20.15. The highest hue^o value was determined in "Genotype 3" (20.15), while the lowest hue^o values were determined in "Karaballı 1" (11.98) and "Karaballı 3" (12.06) local cultivars. The highest croma value was determined in the "Genotype 3" (24.26), "Genotype 1" (22.32) and "Genotype 2" (22.04) genotypes in the same statistical group, while the lowest was determined in the "Karaballı 3" (9.71) and "Karaballı 1" (10.06) local cultivars.

Significant variations were obtained in local cultivars and genotypes in terms of the cracking index (Table 2). The lowest cracking index was determined in genotype "Genotype 1" and local cultivars "Gilli 1" and "Karaballı 1" (6.00), which were in the same group statistically. The highest cracking index was determined in the "Genotype 3" genotype (12.40), followed by the "Karaballı 3" local cultivar (11.60) in the same statistical group.

When the local cultivars and genotypes examined in the study were grouped according to their susceptibility classes, it was determined that "Genotype 1", "Genotype 2", "Gilli 1", "Gilli 2", "Karaballı 1" and "Karaballı 2" local cultivars and genotypes were resistant; "Genotype 3", "Genotype 4" and "Karaballı 3" local cultivar genotypes were in the medium cracking sensitivity class.

Table 2. TA, pH, SCC, L*, a*, b*, hue^o, croma, cracking index and sensitivity class depending on local cherry cultivars and genotypes.

Sweet Cherry	TA	pH	SSC	L*	a*	b*	hue ^o	croma	Crackin
Akçilli	9,13±0,64a	4,37±0,05a	15,04±0,52	30,59±1,45ab	17,73±1,89ab	5,87±0,75abc	17,80±0,65ab	18,69±2,02abc	7,73±3,1
Genotip-1	9,32±0,33a	4,35±0,06ab	14,19±0,42	33,05±2,49a	21,17±4,36a	6,97±2,07ab	17,54±1,58ab	22,32±4,78a	6,00±0,1
Genotip-2	9,03±0,27ab	4,32±0,06ab	14,54±0,91	31,85±1,10ab	20,74±4,56a	7,44±2,85ab	19,25±2,94ab	22,04±5,20a	9,73±1,1
Genotip-3	7,62±0,41b	4,33±0,06ab	15,05±0,80	32,96±2,40a	22,92±4,51a	8,23±1,92a	20,15±1,62a	24,26±5,08a	12,40±1
Genotip-4	9,25±0,74a	4,26±0,05bc	14,03±0,51	30,02±1,17ab	20,71±2,28a	6,79±1,23ab	17,69±1,05ab	21,82±2,55ab	10,93±1
Gilli-1	7,66±0,22b	4,25±0,01bc	13,87±0,67	31,29±0,49ab	16,93±1,80ab	5,01±0,81abc	16,09±1,01abc	17,83±1,67abc	6,00±3,1
Gilli-2	9,37±0,26a	4,32±0,077ab	14,13±0,46	30,98±0,19ab	17,46±1,24ab	5,22±0,47abc	16,22±0,88abc	18,40±0,97abc	6,13±2,1
Karaballı-1	8,88±0,20ab	4,20±0,05c	14,87±0,90	28,70±0,67b	9,68±2,61b	2,52±1,02c	11,98±2,60c	10,06±2,75c	6,00±1,1
Karaballı-2	8,59±1,02ab	4,28±0,07abc	14,40±1,11	28,55±0,45b	11,94±2,16b	3,31±0,83bc	14,73±1,39bc	12,40±2,29bc	9,87±3,1
Karaballı-3	8,64±0,20ab	4,20±0,12c	13,53±0,12	28,97±0,54b	9,44±2,17b	2,18±0,79c	12,06±1,69c	9,71±2,30c	11,60±2
LSD_{0,05}	0.50***	0.06*	0.70 n.s.	1.34**	3.00***	1.46***	1.69***	3.29***	2.24**

*: P<0.05, **: P<0.01, ***: P<0.001, n.s.: not significant

The dark blue dots in Figure 3 indicate strong positive correlations, and the dark red dots indicate strong negative correlations. Other circles show the strength and direction of the correlation according to their colour and size.

There was a low-level negative correlation between fruit weight and fruit stem thickness and cracking index and a low-level positive correlation between fruit width, fruit length, seed weight, fruit stem length, fruit stem weight, TA, pH, L* and hue^o. There was a moderate positive correlation between SCC, a*, b*, and croma. Similarly, a low-level negative correlation was found between the cracking index and fruit weight, fruit length, seed weight, TA, pH and L*; a low-level positive correlation was found between fruit width, fruit stem length, thickness and weight, SSC, a*, b*, hue^o and croma.

When the dendrogram is analysed, it is seen that local cherry cultivars and genotypes are clustered in two main groups as A and B. Group A is divided into A1 and A2 sub-groups, and sub-group A1 includes "Karaballı 1" and "Karaballı 2", and sub-group A2 includes "Karaballı 3" local cultivars. Similarly, group B is divided into subgroups B1 and B2, and subgroup B1 includes local cultivars "Gilli 1", "Gilli 2", "Genotype 1", "Genotype 2", "Genotype 3" and "Genotype 4", and subgroup B2 includes the local cultivar "Akçilli 1". The 16 variables analysed were divided into two main groups (X and Y). There were 6 traits in the X1 subgroup, 3 traits in the X2 subgroup, 1 trait in the Y1 subgroup and 6 traits in the Y2 subgroup. When the map is analysed, it is seen that SSC, fruit stem length, cracking index, L*, a*, b*, chroma and hue of "Genotype 3" and fruit weight, seed weight, fruit stem thickness, SSC, fruit stem weight, TA and pH of "Akçilli 1" increased compared to other local cultivars and genotypes.

Discussion

Genotype, cultivar, rootstock, cultural practices, environmental factors and harvest time have an effect on fruit size. (Olmstead and Lezzoni 2007; Nacouzi et al. 2023; Martins et al. 2021; Singh et al. 2020). The most significant increase in fruit size and weight of cherries occurs just before harvest. Up to 25% of the final fruit yield is added in the last week before harvest (Blažková et al. 2002). In our study, fruit weight values varied significantly according to local cultivars and genotypes. The average fruit weights of local cherry cultivars and genotypes varied between 4.20–5.14 g. Although, according to Olmstead et al. (2007), the fruit weights of the cultivated varieties varied between 6 and 13 g, the genotypes and local varieties we examined were below these figures. This is thought to be due to the lack of any cultural intervention on the trees and their late incompatibility with the *P. mahaleb* rootstock. From a commercial point of view, the main quality characteristics of cherry fruit are fruit size, fruit colour, firmness and sweetness (Kazantzis et al. 2011). Therefore, the price of a cherry varies according to its size, firmness, fruit colour and sweetness. In breeding studies, a fruit width of 28 mm and above is one of the most sought-after characteristics for cherry cultivars (Csihon et al. 2018). In this study, there was a significant difference between local cultivars and genotypes in terms of fruit width, but no difference was detected in terms of fruit length. The average fruit width values varied between 20.47–22.80 mm. These values are below the export values. Menzies (2004) reported that a 24 mm fruit width is acceptable by consumers. It is thought that "Genotype 3", "Genotype 4" and "Gilli 1" local cultivars and genotypes will have larger fruit widths under good care conditions.

In this study, significant differences were found between local cherry cultivars and genotypes in terms of seed weight. The seed weight of local cherry cultivars and genotypes varied between 0.58–0.68 g. Bolsu and Akça (2011a) reported that the seed weight of "0900 Ziraat", "Vista", "Stella", "Lambert" and "Salihli" cultivars grafted on *P. mahaleb* rootstock varied between 0.47–0.62 g. In another study conducted on *P. mahaleb* rootstock with "Bing", "Early Burlat", "Early Lory", "Napoleon", "Sapikisa", "Stella", "Regina" and "0900 Ziraat" cultivars, it was measured between 0.19–0.67 g (Eroğul 2016). Our results are similar to the literature.

Due to the increase in cherry production and trade in recent years, prevention of quality losses during storage and marketing, preservation of shelf life and road saturation are of great importance. Due to these issues, thick and green stem colour expresses freshness, while fruit stem length and mass play an important role (Sarısu et al. 2019). In addition, stem length is desirable in cherries because it reduces labour costs. In our study, the fruit stem length of local cherry cultivars and genotypes varied between 31.79–36.44 mm, fruit stem thickness between 1.09–1.17 mm and fruit stem weight between 0.08–0.11 g. These results were consistent with the literature. Bolsu and Akça (2011a) reported a fruit stem length of 29.16–54.36 mm, a fruit stem thickness of 0.62–0.94 mm and a fruit stem weight of 0.06–1.12 g for 5 cherry cultivars grafted on *P. mahaleb*.

The deep red colour is an important characteristic for consumer appeal (Crisosto et al. 2002). For the consumer, this colour is associated with cherries that are ripe and ready to eat, whereas a pale colour is less preferred by the consumer (Kappel et al. 1996). However, in recent years, lighter shades of red have also been included in consumer preferences. L*, a* and b* values were found to be significant among local cultivars and genotypes. The L*, a* and b* values varied between 28.55–33.05, 9.44–22.92 and 2.18–8.23, respectively. Similarly, the chroma value was measured between 9.71–24.26, and the hue° was between 11.98–20.15. Çelik and Hepaksoy (2021) reported fruit colour values of L* 24.54–32.69, a* 21.38–37.29, b* 7.18–28.86, C* 22.56–41.16 and h° as 17.65–25.58 in the "0900 Ziraat" cultivar grafted on *P. mahaleb* rootstock. Eroğul (2016) reported that the chroma value varied between 22.81–40.27 and the hue° value varied between 16.44–24.07 in his study with 8 cherry cultivars grafted on *P. mahaleb*. Similarly, Göksel and Aksoy (2014) determined the C* value of "0900 Ziraat" cherry fruits as 24.82 and the h° value as 21.84, and the C* value of the "Regina" cultivar as 25.85 and the h° value as 22.02. It is thought that these differences in fruit colour parameters of cherry cultivars and genotypes are due to environmental and growing conditions.

SSC, pH and titratable acidity are important fruit quality characteristics that affect consumer preferences. These characteristics are highly affected by ecological and growing conditions (Wang 2006). Cherries are considered slightly acidic fruits with pH values between 3.7 and 4.2 (Serradilla et al. 2016). Acidity plays an important role in the formation of flavour and taste in products and is one of the ripeness criteria of fruits (Karaçalı 2009). In our study, the effect of local cultivars and genotypes on SSC, pH and TA was found to be significant. SSC values ranged between 13.53–15.05%, pH between 4.20–4.37% and TA between 7.66–9.37%. Our results were consistent with previous studies. In previous studies, the SSC content in cherry cultivars was 13–20% depending on the variety and maintenance conditions (Moing, et al. 2004; Muskovics et al. 2006; Bolsu and Akça 2011a; Stojanović et al. 2012; Çetinbaş et al. 2012; Sarısu et al. 2016). Again, Eroğul (2016) reported SSC between 9.86–16.13%, TA between 0.43–1.11% and pH between 3.68–4.52, Bolsu and Akça (2011b) reported SSC content of "0900 Ziraat" cultivar grafted on *P. mahaleb* as 16.08%, pH as 4.21 and TA as 1.14%.

The causes and mechanisms behind cracking have been investigated for at least 75 years but have not yet been fully elucidated. The process of fruit cracking is generally considered complex and depends on a wide range of different factors. It has been reported that many factors, such as cultivar, rootstock, growing conditions, irrigation and fertilization regime, fruit size, osmotic potential of the flesh, and anatomy of the fruit skin, are effective in cracking cherry fruit (Khadivi-Khub 2015; Blanco et al. 2022; Blanco et al. 2019; Devasirvatham et al. 2022; Quero-García et al. 2021; Michailidis et al. 2021). As a general rule, harvesting is uneconomical if the tree contains over 25% cracked fruit (Looney 1985). In this study, there were significant differences between local cultivars and genotypes in terms of the cracking index, and the cracking index ranged between 6.00 and 12.40. In our study, all of the local cultivars and genotypes showed significantly lower cracking levels than the "0900 Ziraat" cultivar. Yıldırım and Koyuncu (2010) determined the cracking index value of the "0900

Ziraat" cultivar as 25.50. Similarly, Güçlü et al. (2023) reported that the cracking index of the "0900 Ziraat" cultivar grafted on *P. mahaleb* was 15.90. In our study, in terms of cracking sensitivity, 5 of the local cultivars were in the "resistant" group, 1 of them was in the "medium sensitive" group, 2 of the genotypes were in the "resistant" group and 2 of them were in the "medium sensitive" group.

Result

The "0900 Ziraat" variety has an important place in cherry cultivation in our country and in the world due to its many features, such as high resistance to cracking, transportation and storage. In our study, all landraces and genotypes showed significantly lower cracking levels than the "0900 Ziraat" variety. Among the local cherry varieties and genotypes examined in this study, it was determined that the crack resistance of "Genotype 1", "Gilli 1" and "Karaballı 1" local varieties was high, and the "Akçilli" local variety was the highest. We think that these local varieties and genotypes can be used as parents in breeding programs to increase resistance to fruit cracking.

Declarations

Author contributions All authors contributed to this study. Material preparation and study design were planned by LK and AG. Data collection and analysis were carried out by LK and AG. From the first draft to the final draft, the authors wrote and approved the manuscript together.

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Figures

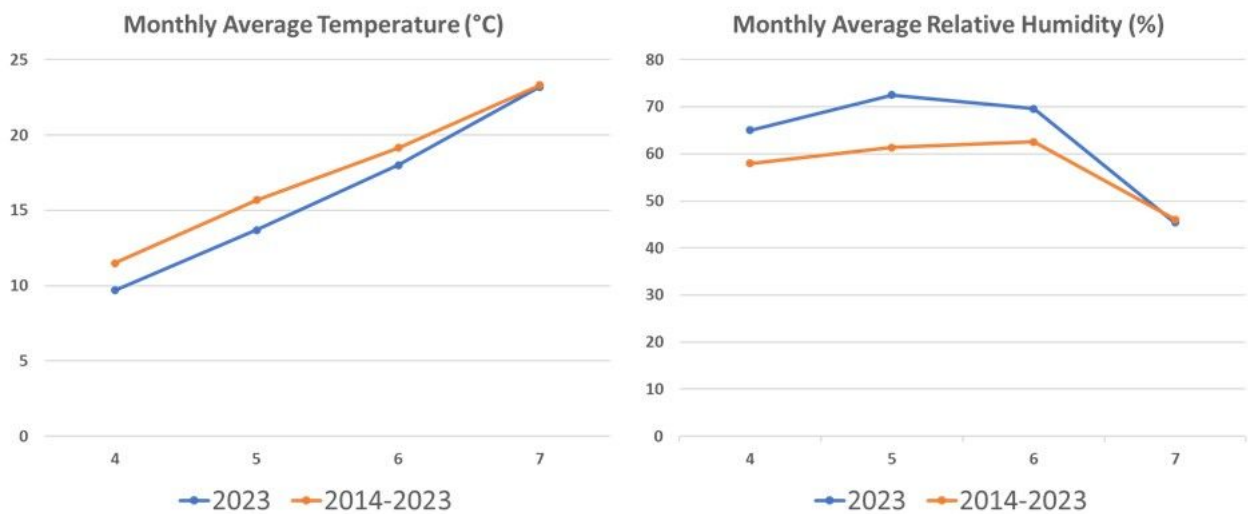


Figure 1

Monthly average temperature (°C) and monthly average relative humidity (%) between April and July.

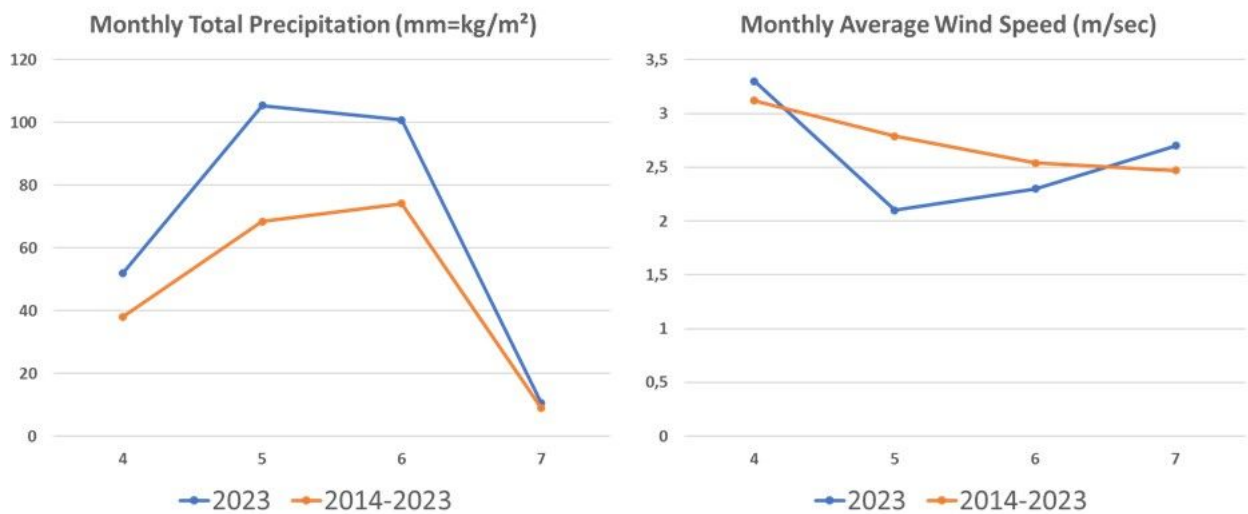


Figure 2

Monthly total precipitation (mm=kg/m²) and monthly average wind speed (m/sec) between April and July.

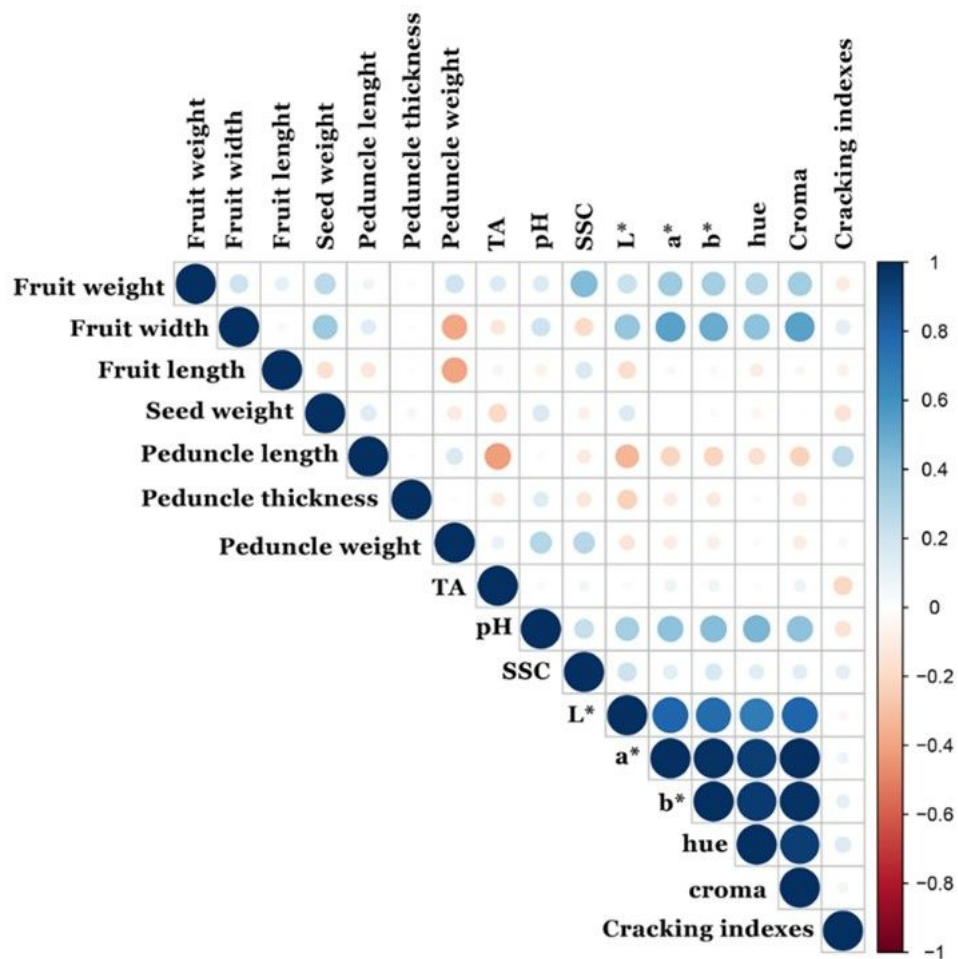


Figure 3
Relationships between characteristics of local sweet cherry cultivars and genotypes.

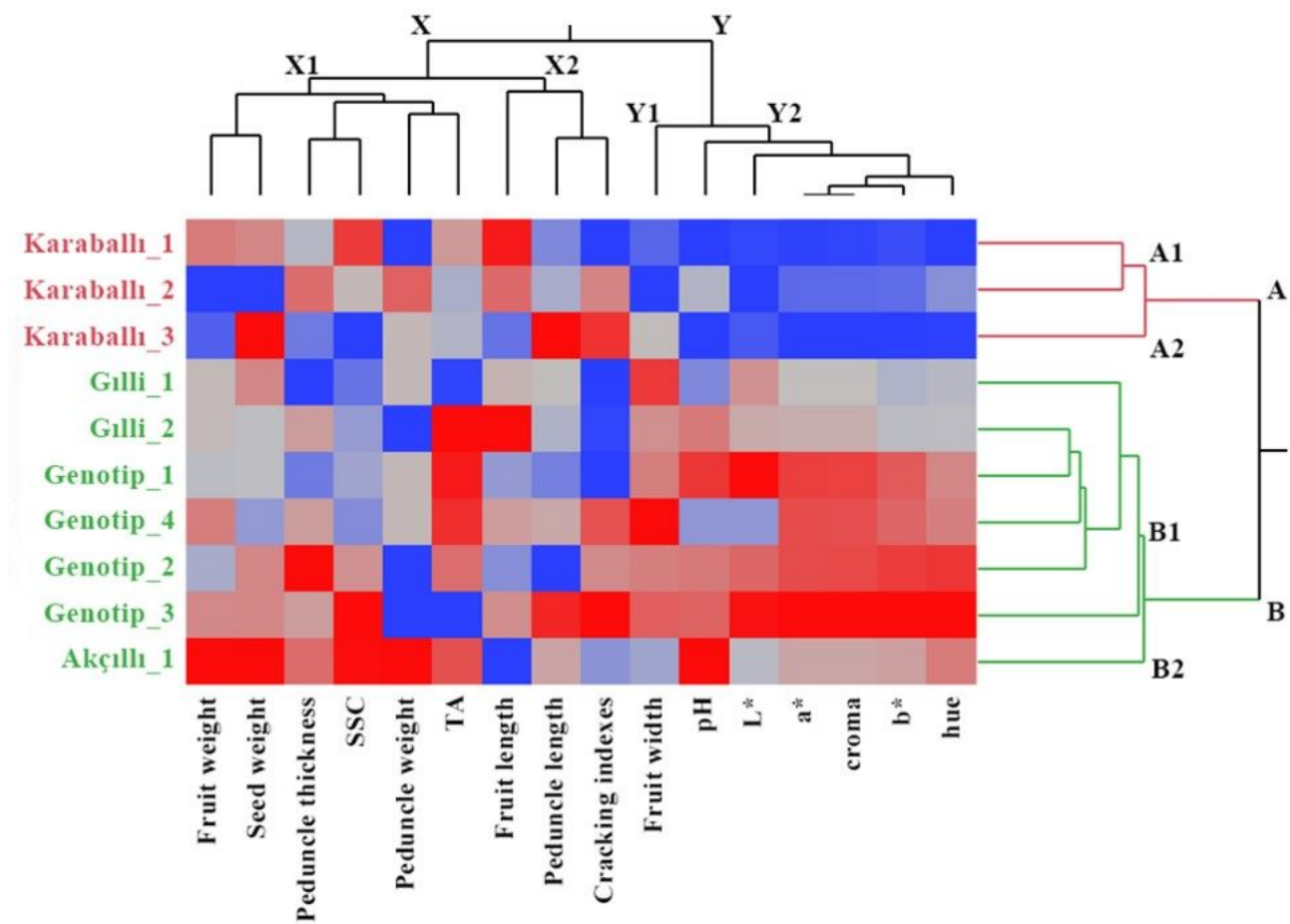


Figure 4

Hierarchical clustering and heatmap analysis between local cherry cultivars and genotypes and the studied characteristics (on the temperature scale, colours shifting to red indicate an increase, and colours shifting to blue indicate a decrease).