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Fruit Quality Characteristics of Different Sweet Cherry (*Prunus avium* L.) Cultivars Grown in Ordu Province of Turkey

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Abstract

In this study, fruit quality characteristics of sweet cherry cultivars (*Prunus avium* L. cvs. 0900 Ziraat, Kordia, Lambert, Regina, Sweetheart) grown in Ordu province in Turkey were investigated. The Kordia cultivar's fruit mass, width, and length were measured higher than Lambert and 0900 Ziraat cultivars. However, it was observed that the fruit mass, width and length of the Kordia cultivar were similar to Regina and Sweetheart. It was determined that the fruit firmness of 0900 Ziraat, Regina and Sweetheart cultivars was similar level. However, firmness values measured in this cultivar were higher than those of Kordia and Lambert cultivars. Also, higher firmness was measured in the Kordia cultivar than in the Lambert. While the highest a* value was measured in Lambert, the lowest a* value was obtained in the Kordia cultivar. A similar soluble solids content (SSC) of 0900 Ziraat, Lambert and Regina's cultivars was determined. However, it was determined that the content measured in the cultivars was higher than the SSC of the Lambert and Sweetheart cultivars. The titratable acidity content of the cultivars (Regina and 0900 Ziraat similar) was different. The highest titratable acidity was measured in Lambert, and the lowest in the Sweetheart cultivar. Similarly, the vitamin C content of all cultivars was found to be different from each other, and the highest vitamin C was measured in Kordia and the lowest in the Sweetheart cherry cultivar

Keywords: Firmness, fruit mass, *Prunus avium*, SSC, Turkish cherry, vitamin C.

Türkiye'nin Ordu İlinde Yetiştirilen Farklı Kiraz (*Prunus avium* L.) Çeşitlerinin Meyve Kalite Özellikleri

Öz

Bu çalışmada, Ordu ilinde yetiştirilen kiraz çeşitlerinin (0900 Ziraat, Kordia, Lambert, Regina, Sweetheart) meyve kalite özellikleri incelenmiştir. Kordia çeşidinin meyve ağırlığı, eni ve boyu, Lambert ve 0900 Ziraat çeşidine kıyasla daha yüksek ölçülmüştür. Ancak Kordia çeşidinin meyve ağırlığı, eni ve boyunun, Regina ve Sweetheart ile benzer olduğu görülmüştür. 0900 Ziraat, Regina ve Sweetheart çeşitlerinin meyve sertliği benzer düzeyde bulunmuştur. Fakat bu çeşitlerden ölçülen sertlik değerlerinin, Kordia ve Lambert çeşitlerinden daha yüksek olduğu belirlenmiştir. Aynı zamanda Kordia çeşidinden, Lambert çeşidine kıyasla önemli derecede daha yüksek sertlik ölçülmüştür. En yüksek a* değeri Lambert çeşidinden ölçülürken, en düşük a* değeri Kordia çeşidinden elde edilmiştir. 0900 Ziraat, Lambert ve Regina çeşitlerinin benzer seviyede suda çözünür kuru madde (SÇKM) içeriği belirlenmiştir. Ancak çeşitlerden ölçülen içeriğin Lambert ve Sweetheart çeşidinin SÇKM içeriğinden daha yüksek olduğu tespit edilmiştir. Çeşitlerin titre edilebilir asitlik içeriği birbirinden (Regina ve 0900 Ziraat benzer) farklı bulunmuştur. En yüksek titre edilebilir asitlik Lambert, en düşük ise Sweetheart çeşidinde ölçülmüştür. Benzer şekilde tüm çeşitlerin C vitamini içeriği birbirinden farklı bulunmuş olup, en yüksek C vitamini içeriği Kordia, en düşük ise Sweetheart kiraz çeşidinde ölçülmüştür.

Anahtar Kelimeler: C vitamini, meyve ağırlığı, *Prunus avium*, Sertlik, SÇKM, Türk kirazı.

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1. Introduction

Cherry (*Prunus avium* L.), one of the temperate climate fruit species, is consumed with pleasure by consumers due to its unique aroma, attractiveness, rich nutritional content, and the lack of enough fresh fruit in the market time of harvest. Our country ranks first in world cherry production. In particular, the 0900 Ziraat sweet cherry cultivar, a standard cultivar known as Turkish cherry in Europe, is the cultivar that is widely cultivated. However, due to pollen incompatibility in sweet cherry, pollinator cultivars or cultivars must be used in commercial cherry orchards in order to obtain a good fruit set (Erdem Öztürk et al., 2013; Öztürk et al., 2013).

In addition, producers want to grow sweet cherry fruit with different harvest periods, spread the harvesting work over a longer period, and market the products at higher prices by preventing product agglomeration. Again, due to the desire of consumers to eat cultivars with different tastes, it is necessary to produce different sweet cherry cultivars. In addition to the 0900 Ziraat cultivar, such as Regina, Sweetheart, Kordia, North Wonder, Royal King, Van, Stella, Bing, Lambert, Lapins and Early Burlat cultivars are preferred in commercial sweet cherry production in our country (Hayaloglu and Demir, 2016; Savaş and Gür, 2021).

With this richness of cultivars, sweet cherry cultivation can be conducted in many regions of our country. It is possible to grow higher quality products by choosing cultivars adapted to the region in production. A high-quality product can be marketed at higher prices in domestic and foreign markets and provides higher profits to the producer. In addition to genetic factors, irrigation, fertilization, pruning system, and the fight against diseases and pests are other factors that affect fruit quality (Öztürk et al., 2013; İmrak et al., 2016; Belen, 2021). In addition, another important factor affecting fruit quality is ecological conditions. Especially in commercial cultivation, it is necessary to choose the appropriate cultivars for the region. This study aims to determine standard sweet cherry cultivars' fruit quality characteristics in the Ordu province.

2. Materials and Methods

This research was carried out in the sweet cherry orchard in the Research and Application Center of the Faculty of Agriculture of Ordu University in Ordu, Turkey (10 m altitude and 40º 96' 51.95"N latitude, 37º 93' 70.60"E longitude). 5 years old 0900 Ziraat, Kordia, Lambert, Regina and Sweetheart sweet cherry (*Prunus avium* L.) cultivars grafted on MaxMa 14 rootstock were selected as plant material. According to the Spanish Bush system, sweet cherry trees were planted in an east-west direction with 4 m row spacing and 3.5 m row spacing and were pruned. All practice management procedures such as pruning, fertilization, spraying and weed control were carried out at

regular intervals. The plants' irrigation was conducted by monitoring the soil moisture content with a double-line drip irrigation system with 20 cm intervals and 2 L/h droppers. The orchard soil was very low calcareous, with clay loam and pH 6.0.

The experiment was designed in a randomized block design with 3 blocks. Each block represented one replicate. Each block had 15 trees, and 45 trees were used in the experiment. In each block, 3 trees were selected for each cultivar.

Each sweet cherry cultivar was hand-harvested (homogeneously colored) at the commercial harvest date (23 June 2021). Approximately 250 g of fruit from each tree of each cultivar was placed in a 500 g perforated chalet (8 holes), and the collected fruits were transported to the Postharvest Physiology Laboratory (24±2 °C and 80±5% relative humidity) of the Department of Horticulture in Ordu University within 30 min. Crushed and damaged fruits are hand-selected and discarded. The following quality characteristics of fruit were examined.

2.1. Fruit Mass, Width, Length and Thickness

Fruit mass (50 fruit) was determined using a digital scale (±0.01 g) (Radwag PS 4500/C/1, Poland) and expressed as gram (g). Fruit length, width and thickness (50 fruit) were measured with a digital caliper (± 0.01 mm) (Model CD-6CSX, Mitutoyo, Japan) and expressed as millimeters (mm) (Ozturk et al., 2018).

2.2. Fruit Firmness

Fruit firmness (N mm^{-1}) was measured with a Texture Analyzer, TA-TX Plus (Stable Microsystems, Godalming, UK), equipped with a 3.0 mm probe and 50 N load cell. The load applied for 5 mm penetration at an operational speed of 10 mm s^{-1} was considered flesh firmness. Flesh firmness was measured on 10 fruit randomly selected from each replicate (Ozturk et al., 2018).

2.3. Color

Color parameters of L*, a* and b* were determined with the aid of a colorimeter (Minolta, CR–400, Tokyo, Japan). Measurements were performed over the opposite sides of each fruit (20 fruit). Three-dimensional color space was generated with the aid of *L**, *a** and *b** values in accordance with the CIE (Commission Internationale de l'Eclairage) color system (McGuire, 1992).

2.4. Soluble Solids Content (SSC), Titratable Acidity and Vitamin C

Fruit taken from each replication was first washed with distilled water, and their stones were separated from the fruit flesh. The fruit were chopped with a stainless-steel knife, cut into parts, and homogenized by a blender (Model No. Promix HR2653 Philips, Turkey). Then the homogenate was filtered through a cheesecloth, and the juice was obtained. Soluble solids content (SSC) was measured with a refractometer (Atago PAL-1, USA) and expressed as a percentage (%). For titratable acidity measurement, 10 mL juice was taken and 10 mL distilled water was added on. Then 0.1 mol L^{-1} NaOH (sodium hydroxide) was added until the pH of the solution reached to 8.1. Based on the amount of NaOH consumed in titration, titratable acidity was determined and expressed as mg malic acid 100 mL^{-1}. About 0.5 ml of extract was supplemented with 0.5% oxalic acid to a final volume of 5 ml. Ascorbic acid test strips were used to determine the samples' vitamin C content (mg 100 g^{-1}) (Ozturk et al., 2018).

2.5. Statistical Analysis

Experiments were performed according to a completely randomized design. Arcsine transformation was applied to percentage values before the variance analysis. Data normality was checked with the Kolmogorov-Smirnov test, and data homogeneity was checked with Levene's test. SAS Version 9.1 (USA) statistical software was used for statistical analyses. Means were compared with Tukey's range test at the 5 % level.

3. Findings and Discussion

Sweet cherry fruit is a fruit consumed by consumers with its attractiveness, color and abundance. Especially fruit size is one of the most important features that attract consumers. The most important factor affecting fruit size is genetics. In addition, ecological conditions, irrigation, fertilization, pruning and maintenance are other factors that affect fruit size (İmrak et al., 2016; Belen, 2021). In our study, when the fruit mass of some sweet cherry cultivars grown in the ecological conditions in Ordu province are examined, it is seen that the Kordia (11.50 g) has the highest fruit mass and the Lambert (7.43 g) has the lowest values. In addition, when the fruit mass of Regina (10.17 g) and Sweetheart (10.66 g) cultivars is examined, it is seen that there is no statistically significant difference between Kordia (11.50 g) and 0900 Ziraat (9.41 g) cultivars (Table 1). In a study conducted under Serbian conditions, the fruit mass of the Kordia cultivar was 13.3 g (Kalajdžić et al., 2019) and 12.08 g (Basile et al., 2021) in Chilean conditions. The fruit mass of the Regina

cultivar was 13.7 g in Serbian conditions (Kalajdžić et al., 2019) and 9.67 g in Chilean conditions (Basile et al., 2021).

Table 1. Physico-mechanical characteristics of different sweet cherry cultivars grown in Ordu

Cultivars	Quality characteristics				
	Fruit mass (g)	Length (mm)	Width (mm)	Thickness (mm)	Firmness (N/mm)
0900 Ziraat	9.41 b	24.24 b	25.67 bc	23.26 a	3.56 a
Kordia	11.50 a	27.37 a	27.99 a	23.28 a	3.23 b
Lambert	7.43 c	22.46 b	24.01 c	20.83 a	2.76 c
Regina	10.17 ab	25.07 ab	27.37 ab	23.16 a	3.64 a
Sweetheart	10.66 ab	24.64 ab	27.70 ab	23.17 a	3.61 a

Means in columns with the same letter do not differ according to Tukey's test at $P<0.05$.

Considering the studies carried out in our country, it was determined that the fruit mass of the Lambert cultivar grown in Van ecological conditions was 6.00 g (Balta and Yarılgaç, 1996). Fruit mass of 0900 Ziraat was determined as 5.52 g in Adana conditions (Sütyemez, 2000), 7.5 g in Tokat conditions (Öztürk et al., 2013), 8.88 g in Şanlıurfa conditions (İkinci et al., 2015). In our study, when the fruit mass of 0900 Ziraat was observed, it was determined that it was significantly higher than those grown in Adana and Tokat conditions. In İzmir conditions, the fruit mass of the Regina cultivar grafted on Mahaleb was 10.81 g, while the fruit mass of 0900 Ziraat was 9.56 g (Erogul, 2016). In another study conducted in the same region, they reported that the fruit mass of the Regina cultivar was 7.35 g, and the fruit mass of the 0900 Ziraat was 11.63 g (Erogul et al., 2020). When our findings are compared with the studies conducted in İzmir province, they are partially similar. It is thought that many factors such as plant age and management conditions, and ecological conditions may affect these differences.

Considering our findings, the highest value in terms of fruit length, width and thickness was obtained in the Kordia cultivar, and the lowest was obtained in Lambert. Fruit length varies between 27.37 mm and 22.46 mm, fruit width varies between 27.99 mm and 24.01 mm, and fruit thickness varies between 23.28 mm and 20.83 mm (Table 1). They stated that while the fruit length of 0900 Ziraat grown in İzmir conditions is 25.63 mm, the fruit width is 28.65 mm, and the fruit length of the Regina is 22.87 mm, the fruit width is 23.80 mm (Erogul et al., 2020).

In Tokat ecology of 0900 Ziraat, fruit length is 20.68 mm, and fruit width is 21.99 mm, fruit thickness is 19.01 mm (Akça et al., 2011). In Şanlıurfa conditions, fruit length is 19.91 mm, fruit width is 21.56 mm (İkinci et al., 2015), while fruit length is 22.22 mm in Çanakkale ecology. Fruit width was 23.22 mm (Savaş et al., 2021). It was stated that the fruit length of the Lambert cultivar was 18.86 mm, fruit width 19.08 mm in Van ecology (Balta and Yarılgaç, 1996), fruit length 21.56 mm, fruit width 22.54 mm and fruit thickness 19.42 mm in Tokat ecology (Akça et al., 2011).

Another important issue that is effective in the preference of consumers is firmness. Consumers prefer cherry fruits with high firmness (Saracoglu et al., 2017; Aglar et al., 2017; Aglar et al., 2019). So much so that the most important factor that determines the shelf life and storage life of fruits is firmness. The high firmness increases the end-harvest life of the products to be stored, and the product is offered to the market for a longer time. Considering our findings, the highest firmness was determined as Regina (3.64 N mm^{-1}), Sweetheart (3.61 N mm^{-1}), 0900 Ziraat (3.56 N mm^{-1}), and Kordia (3.23 N mm^{-1}) and Lambert (2.76 N mm^{-1}), respectively (Table 1). In a study conducted in Serbian conditions, the firmness of the Kordia was 0.85 N, and the Regina was 0.83 N (Kalajdžić et al., 2019). Fruit firmness value of Regina cultivar grafted on 4 different rootstocks in Poland was expressed as the lowest at 0.73 N and the highest at 3.82 N (Dziedzic et al., 2017). When the studies conducted in different ecologies in our country are examined, the fruit firmness of 0900 Ziraat is 4.60 in Yalova conditions (Göksel et al., 2014) and 9.32 N in İzmir conditions (Erogul et al., 2020). It has been reported that the Sweetheart cultivar is 4.35 N and Regina is 4.43 N in Yalova conditions (Göksel et al., 2014). Our study has observed again that ecological differences can affect firmness.

Homogeneously colored sweet cherry fruit is more demanding in the market and can be marketed at higher prices (Aglar et al., 2019; Ozturk et al., 2019). Fruit color varies depending on genetic factors in all species and cultivars. However, it can be effective in many environmental factors such as sunshine duration, light intensity, and location direction. In our study, the L* value of the cultivars varied between 23.16 and 32.92, the a* value between 17.38 and 30.27, and the b* value between 5.42 and 12.36 (Table 2). In studies conducted on similar cultivars; In İzmir ecology, L* value of 0900 Ziraat was 33.01, a* value was 27.88, b* value was 11.26, the L* value of Regina was 36.25, a* value 32.02, b* value 15.71 (Erogul et al., 2020). In a study conducted in Yalova ecology, the L* value of 0900 Ziraat was found to be 32.68, the L* value of Sweetheart to be 38.59, and the L* value of Regina to be 36.01 (Göksel et al., 2014). The L* value of Regina was determined as 18.61 in Çanakkale ecology (Şen et al., 2016). Our findings partially paralleled the findings of the researchers.

Table 2. Color characteristics of different sweet cherry cultivars grown in Ordu

Cultivars	Color characteristics		
	*L**	a*	b*
0900 Ziraat	30.86 a	26.02 ab	10.99 a
Kordia	23.16 b	17.38 d	5.42 b
Lambert	32.92 a	30.27 a	12.36 a
Regina	24.65 b	20.01 cd	6.41 b
Sweetheart	29.83 a	24.79 bc	9.72 a

Means in columns with the same letter do not differ according to Tukey's test at P<0.05.

SSC (%) is an important quality criterion that affects the taste of fruits and is effective in determining the harvest date. When SSC (%) of 5 different cultivars was examined in our study, the highest SSC was founded in Kordia with 15.70%. The Kordia was followed by Regina (14.60%), 0900 Ziraat (14.55%), Lambert (12.75%) and Sweetheart (11.65%), respectively. When titratble acidity was examined, the Lambert (1.30%) cultivar had the highest value, and the Sweetheart (0.88%) cultivar had the lowest value. It was determined that 0900 Ziraat 1.14%, Regina 1.16% and Kordia 1.22% titrable acidity values were found among other cultivars. The highest vitamin C was determined in Kordia (10.70 mg 100 g^{-1}). Then, it was determined in Regina (9.40 mg 100 g^{-1}), Lambert (6.30 mg 100 g^{-1}), 0900 Ziraat (6.00mg 100 g^{-1}) and Sweetheart (5.10 mg 100 g^{-1}) cultivars, respectively. The ripening index varied between 13.20 and 9.77. The ripening index of cultivars was determined as Sweetheart (13.20), 0900 Ziraat (12.90), Lambert (12.81), Kordia (12.65) and Regina (9.77), respectively (Table 3).

Table 3. Biochemical characteristics of different sweet cherry cultivars grown in Ordu

Cultivars	Biochemical characteristics			Ripening index
	SSC (%)	Titratable acidity (% malic acid)	Vitamin C (mg 100 g^{-1})	
0900 Ziraat	14.55 a	1.14 c	6.00 d	12.90 a
Kordia	15.70 a	1.22 b	10.70 a	12.63 a
Lambert	12.75 b	1.30 a	6.30 c	12.81 a
Regina	14.60 a	1.16 c	9.40 b	9.77 b
Sweetheart	11.65 b	0.88 d	5.10 e	13.20 a

Means in columns with the same letter do not differ according to Tukey's test at P<0.05.

SSC (%) of the Kordia cultivar was 17.8% in Serbian conditions (Kalajdžić et al., 2019); In Chilean conditions, it was determined as 18.31% (Basile et al., 2021). In Polish conditions, SSC (%) of Regina grafted on 4 different rootstocks was the lowest at 15.4%, the highest at 16.6% (Dziedzic et al., 2017); It was measured at 19.8% in Serbian conditions (Kalajdžić et al., 2019) and 18.86% in Chilean conditions (Basile et al., 2021). In studies conducted in different ecologies of Turkey, the SSC of the 0900 Ziraat cultivar was 15.63% in Kemalpaşa-İzmir conditions (Erogul, 2014); 18.48% in Şanlıurfa conditions (İkinci et al., 2015); 15.15% in Çanakkale conditions (Savaş et al., 2021); 19.90% in Adana conditions (Imrak et al., 2018); They reported that it was 16.08% (Akça et al., 2011) grafted on Mahaleb rootstock and 14.2% (Öztürk et al., 2013) grafted on Gisela 5 in Tokat conditions. SSC of Lambert was 17.63% in Van conditions (Balta et al., 1996) and 16.63% in Tokat conditions (Akça et al., 2011). SSC of Regina cultivar is grown in Çanakkale ecology was found to be 15.36% (Şen et al., 2016).

Considering the titratable acidity value of 0900 Ziraat sweet cherry in studies conducted in different regions; 0.73% in Adana (Sütyemez, 2000); In Tokat 1.14% (Akça et al., 2011), 0.63%

(Öztürk et al., 2013), 5.86 % in Yalova (Göksel et al., 2014), 0.54 % in Şanlıurfa conditions (İkinci et al., 2015). It was 1.07% (Erogul et al., 2020) in İzmir. The titratable acidity amounts of Regina cultivar were 0.83% in Çanakkale ecology (Şen et al., 2016); 1.06% in İzmir ecology (Erogul et al., 2020); Titrable acidity value of Lambert was determined as 0.47% (Balta and Yarılgaç, 1996) in Van conditions and 1.13% (Akça et al., 2011) in Tokat ecology.

They determined that the titratable acidity of the Kordia cultivar was 0.49% in Serbian conditions (Kalajdžić et al., 2019). Titratable acidity of the Regina cultivar was 0.48% in Serbian conditions (Kalajdžić et al., 2019); It was stated that the lowest was 0.58% and the highest was 0.74% in Poland conditions (Dziedzic et al., 2017). In a study conducted for 2 years to investigate the effects of different rootstocks in Suşehri-Sivas ecology, they reported that the vitamin C of 0900 sweet cherry was 7.08 mg $100g^{-1}$, while the vitamin C of Regina was 8.87 mg $100g^{-1}$ (Belen, 2021). Vitamin C of 0900 Ziraat was 9.0 mg $100g^{-1}$ in those grown in Suşehri ecology (Faizy et al., 2022); they found it to be 37.83 mg L^{-1} grown in Iğdır ecology (Pehluvan et al., 2012). In a study conducted in Italy ecology, they stated that the vitamin C of Regina was 202.67 (mg kg^{-1}) (Matteo et al., 2016).

4. Conclusions and Recommendations

As a result, it has been revealed that there are differences between the quality characteristics of standard sweet cherry cultivars grown in the Ordu province of Turkey. In Ordu ecology, in terms of fruit size and vitamin C content, Kordia; In terms of fruit firmness, 0900 Ziraat cultivar was found to have higher values. In this context, it can be recommended to cultivate Kordia and 0900 Ziraat cultivars as the main cultivars in Ordu ecology.

Authors' Contributions

The authors contributed equally to the study.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The author declares that this study complies with Research and Publication Ethics.

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