

# Identification of Optimum Harvest Time of the Turkish Ziraat 0900 Sweet Cherry (*Prunus avium* L.) Cultivar Using Physico-Chemical Changes During Ripening

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## Abstract

**Bestimmung des optimalen Erntezeitpunkts der türkischen Süßkirschensorte Ziraat 0900 (*Prunus avium* L.) anhand physikalisch-chemischer Veränderungen während der Reifung.** The 0900 Ziraat sweet cherry (*Prunus avium* L.) is the most exported cherry cultivar in Türkiye, valued for its high quality, large size, and rich flavor. This study aimed to determine the optimum harvest period for the 0900 Ziraat cultivar by analyzing the physico-chemical changes occurring during fruit development. In this study, fruit samples were analyzed weekly over a period of 8 weeks for fruit weight, fruit size, total soluble solids content, pH, color values, organic acids (citric acid and ascorbic acid), and phenolics (gallic acid and catechin). The results showed that the color changed from green to deep red, while full ripeness was reached in the 8<sup>th</sup> week. Fruit weight increased from 0.69 g to 9.80 g. Firmness decreased significantly after the 4<sup>th</sup> week and reached its lowest level in the 8<sup>th</sup> week (232.55 g), while elasticity fluctuated. TSS values increased steadily, reaching the highest value of 16.00% in the 8<sup>th</sup> week, while pH values fluctuated during ripening. Citric acid content decreased steadily, while ascorbic acid reached the highest value (255.67 mg 100 g<sup>-1</sup> fw) in the 8<sup>th</sup> week. The contents of gallic acid and catechin decreased over time, with slight fluctuations in the last few weeks. Based on these findings, the optimum harvest time for the 0900 Ziraat sweet cherry cultivar was determined to be between the 7<sup>th</sup> and 8<sup>th</sup> week after full bloom, as this period offers the best balance between fruit size, color, firmness, and sugar-acid ratio. The outcomes of the present study can help producers and retailers collect this sweet cherry cultivar at optimal harvest time with the highest sensory and nutritional properties.

**Keywords:** ripening process, fruit quality, harvest period, biochemical changes, Türkiye

## Zusammenfassung

Die 0900 Ziraat Süßkirsche (*Prunus avium* L.) ist die am meisten exportierte Kirschsorte in der Türkei, die für ihre hohe Qualität, große Größe und ihren reichen Geschmack geschätzt wird. Diese Studie hatte zum Ziel, den optimalen Erntezeitpunkt für die 0900 Ziraat-Sorte durch die Analyse der physikalisch-chemischen Veränderungen während der Fruchtentwicklung zu bestimmen. In dieser Studie wurden Fruchtproben wöchentlich über einen Zeitraum von 8 Wochen auf Fruchtgewicht, Fruchtgröße, Gesamtlösungsgehalt, pH-Wert, Farbwerte, organische Säuren (Zitronensäure und Ascorbinsäure) und Phenole (Gallussäure und Catechin) analysiert. Die Ergebnisse zeigten, dass sich die Farbe von Grün zu Tiefrot veränderte, wobei die volle Reife in der 8. Woche erreicht wurde. Das Fruchtgewicht stieg von 0,69 g auf 9,80 g. Die Festigkeit nahm nach der 4. Woche signifikant ab und erreichte ihren niedrigsten Wert in der 8. Woche (232,55 g), während die Elastizität schwankte. Die TSS-Werte stiegen stetig an und erreichten in der 8. Woche mit 16,00 % den höchsten Wert, während die pH-Werte während der Reifung schwankten. Der Gehalt an Zitronensäure nahm stetig ab, während der Ascorbinsäuregehalt in der 8. Woche mit 255,67 mg 100 g<sup>-1</sup> FW den höchsten Wert erreichte. Die Gehalte an Gallussäure und Catechin nahmen im Laufe der Zeit ab, mit leichten Schwankungen in den letzten Wochen. Basierend auf diesen Ergebnissen wurde der optimale Erntezeitpunkt für die 0900 Ziraat-Sorte von Süßkirschen zwischen der 7. und 8. Woche nach der Vollblüte bestimmt, da dieser Zeitraum das beste Gleichgewicht zwischen Fruchtgröße, Farbe, Festigkeit und Zucker-Säure-Verhältnis bietet. Die Ergebnisse der vorliegenden Studie können Produzenten und Händlern helfen, diese Süßkirschsorte zum optimalen Erntezeitpunkt mit den höchsten sensorischen und ernährungsphysiologischen Eigenschaften zu ernten.

**Schlüsselwörter:** Reifungsprozess, Fruchtqualität, Erntezeitpunkt, biochemische Veränderungen, Türkei

## Introduction

Sweet cherry (*Prunus avium* L.), a member of the Rosaceae family, is highly valued for its early-season production, making it one of the first fresh fruits available each year (Habib et al., 2017). The fruit is known for its exceptional quality, characterized by a bright color, a well-balanced sweetness and acidity, a firm texture, and a rich nutritional profile with numerous health benefits (Esti et al., 2002). Türkiye is one of the leading producers and exporters of sweet cherries, with the 0900 Ziraat cultivar being the most widely grown and exported (TOB, 2020; FAO, 2025). The 0900 Ziraat cultivar is known for its size, deep red color, firm texture, and excellent taste. It plays a crucial role in the Turkish cherry industry and is well competitive on the world market (Engin and Ünal, 2006).

Sweet cherries are non-climacteric fruits that go through three different stages of development during ripening. In the first stage, rapid cell division and growth of mesocarp cells occur immediately after flowering (Andrews & Li, 1994). The second stage is characterized by the lignification of the endocarp and the enlargement of the fruit (Knoche et al., 2004). Finally, the third stage is characterized by changes in the bioactive components and a rapid increase in fruit volume. During the commercial ripening stage, there are significant changes in the pomological and bioactive properties, which are particularly evident in the change in fruit color, which serves as an important indicator of ripeness. In addition, fruit ripening varies within trees and is influenced by variety, climate, agricultural practices, and fertilization (Mineată et al., 2024). Therefore, physicochemical studies are crucial for improving

pre- and post-harvest strategies for sweet cherries worldwide (Hayaloğlu & Demir, 2016).

Fruit ripeness is a key factor in determining fruit quality, and cherries are usually harvested at the end of the commercial ripening stage to obtain optimal nutritional value (Correia et al., 2017). The ideal harvest time varies by cultivar, with the optimal time window being less than five days and requiring immediate post-harvest chilling to avoid mechanical damage (Chauvin et al., 2009). In the early stages of cherry development, there are changes in the color of the fruit skin, the initiation of texture change and a rapid increase in fruit size. As ripening progresses, anthocyanin accumulates in the fruit tissue, which increases the antioxidant properties and leads to a darker color of the fruit flesh (Serrano et al., 2005). Determining the optimal time to harvest fruit is important because it ensures that consumers get the best quality, flavor, aroma and nutritional value. For producers and retailers, harvesting at the right time also helps to extend shelf life and reduce post-harvest losses (Muskovics et al., 2006).

Therefore, this study aimed to investigate the physical, chemical, and morphological changes during fruit development of the 0900 Ziraat sweet cherry cultivar and to determine its optimal harvest time.

## Materials and Methods

### Plant Material

This study was conducted in 2017 during the full yield period of the 0900 Ziraat sweet cherry cultivar of 12 to 15-year-old trees grown in Iğdır (Turkey), grafted onto Mazzard rootstock. Fruit samples were collected at 7-day-intervals from the early fruit development stage (two weeks after full bloom) from the 1<sup>st</sup> week of May to the 3<sup>rd</sup> week of June (Fig. 1). The study was designed with three replications, with each tree representing one replication and 10 fruits examined in each replication.



Fig. 1: The different development stages of the 0900 Ziraat sweet cherry cultivar

## Physical Characteristics of Fruit

The fruit weight was measured using an electronic scale with an accuracy of 0.01 g for groups of 10 fruits, and the results were expressed in grams (g). The width and length of the fruits were measured using a digital caliper, and the results were expressed in millimeters (mm).

To further investigate the physical properties of the fruits, the geometric mean diameter (Dg) and sphericity (S) were determined using specific mathematical equations:

$$Dg = (lwt)^{1/3}$$

$$s = (((lwt)^{1/3})/l) * 100$$

Where Dg (mm) is the geometric mean diameter, S (%) is the sphericity, and l, w, and t represent the fruit's length, width and thickness in millimeters.

## Color measurement

Fruit skin color (CIELAB color space) was measured using a Minolta colorimeter (CR 410, Osaka, Japan) according to the method described by Karabulut et al. (2007). The results were recorded as CIE values for L\* (lightness), a\* (red-green), and b\* (yellow-blue), which were then used to calculate the hue angle (h°) to assess the color changes during ripening:

$$h = \begin{cases} \arctg\left(\frac{b^*}{a^*}\right) & \text{if } a^* < 0 \\ 90^\circ & \text{if } a^* = 0 \\ 180^\circ - \arctg\left(\frac{b^*}{a^*}\right) & \text{if } a^* > 0 \end{cases}$$

In addition, chroma (C\*) was determined using the following formula:

$$C^* = \sqrt{a^2 + b^2}$$

## Firmness and Elasticity

Fruit firmness and elasticity were measured using a TA-XT2 texture analyzer (Stable MicroSystems, UK) with a 2 mm cylindrical probe. The tests were performed at a pre- and final speed of 5 mm/s, a test speed of 1 mm/s, and a penetration depth of 3 mm. Each fruit was measured three times.

## pH Measurement

The pH value of the extracted juice was measured with a pH electrode in combination with a multiparameter device (Consort C3040, Belgium).

## Total soluble solids measurement (TSS)

Ten fruits were pureed with a household blender to produce a fruit paste, which was then filtered through a Whatman No. 4 filter to extract the juice. The total soluble solids (TSS) content of the juice was determined using a digital Abbe refractometer (Germany).

## Sample Extraction

A 5 g fruit sample was transferred to a beaker, followed by the addition of 10 mL of acidified methanol (50% methanol, v/v, 0.1% HCl). The mixture was then homogenized (1300 rpm, 1 min, IKA Ultra Turrax T18, Korea) and kept in the dark at 4°C for 2 hours. After incubation, centrifugation was performed at 10,000 × g, 10°C, for 15 min. The resulting supernatant was collected and filtered sequentially with Whatman paper No. 4, followed by a 0.45-μm filter. The final filtrate was either analyzed immediately or stored at -80°C for later use.

## Organic Acids

The analysis of organic acids was performed isocratically, with slight modifications based on the method described by Akin et al. (2008). An Agilent 1260 series high-performance liquid chromatography (HPLC) system equipped with a diode array detector (DAD) and an ACE GENERIX 5 C18 column (5  $\mu$ m, 4.6 mm  $\times$  250 mm) was used. The mobile phase consisted of 98% Na<sub>2</sub>HPO<sub>4</sub>, adjusted to pH 2.4 with H<sub>3</sub>PO<sub>4</sub>, and was operated at a flow rate of 1 mL/min. Detection was performed at 210 nm for citric acid and 400 nm for ascorbic acid.

## Phenolic Compounds

The phenolic compounds, in particular gallic acid and catechin, were analyzed according to the method of Hussain et al. (2013) with slight modifications. The separation was performed using an Agilent 1260 series HPLC system equipped with a diode array detector (DAD) and a Poroshell 120 EC-C18 column (2.7  $\mu$ m, 4.6 mm  $\times$  150 mm). A gradient mobile phase consisting of 83% phosphoric acid and 17% acetonitrile was used, with a 1 mL/min flow rate and an injection volume of 20  $\mu$ L. The elution gradient was set as follows: 83% A for 1 min, 70% A for 2 min, 60% A for 4 min, and 83% A for 10 min. The system was operated under conditions with a detection wavelength of 210 nm and 300 nm, an injection volume of 20  $\mu$ L, and a column temperature of 20°C.

## Statistical Analysis

Statistical analysis was performed using a one-way analysis of variance (ANOVA) followed by Duncan's multiple range test, with a significance level of  $P < 0.05$ . Data processing was performed using SPSS software (version 18; SPSS Inc., Armonk, NY, USA), and the results were presented as mean  $\pm$  standard deviation.

## Results and Discussion

### Fruit Physical Properties

The physical properties of cherries, such as diameter, height, and firmness, actually affect the overall quality of the fruit (Asanica et al., 2011). In this study, stem length and thickness generally showed a fluctuating trend. The highest stem length was found in the 2<sup>nd</sup> week (46.11 mm) and the lowest in the 6<sup>th</sup> week (37.25 mm). The highest stem thickness (1.47 mm) was shown in the 1<sup>st</sup> week, while the lowest one (1.04 mm) was at the 2<sup>nd</sup> week. Regarding the fruit weight, width, and length in the 1<sup>st</sup> week, they were 0.69 g, 10.47 mm, and 12.28 mm, respectively, and these values reached 9.80 g, 27.43 mm, and 24.87 mm in the 8<sup>th</sup> week. The sphericity generally increased and peaked at week 5<sup>th</sup> (97.68%). Although a slight decrease was observed in the 7<sup>th</sup> week (93.95%), it increased again in the 8<sup>th</sup> week (95.91%) (Tab. 1). Çalhan et al. (2014) reported that in a study with 10 different harvest dates, the cv. Lapins cherry had a fruit weight, width, and length of 9.37 g, 26.91 mm, and 24.97 mm, respectively, at the optimum harvest time. Similarly, in a study with 5 different harvest periods, Valori et al. (2016) found that the cv. Burlat cherry had a fruit weight of 6.71 g and a length of 19.17 mm at its optimum harvest time. These differences can be related to genetics, cultivar variations, cultivation methods, and environmental factors such as climate and soil conditions.

Tab. 1: Changes in physical properties of the 0900 Ziraat sweet cherry cultivar during the ripening period.

Cultivar	Harvest Date	Stem length (mm)	Stem thickness (mm)	Fruit weight (g)	Fruit width (mm)	Fruit length (mm)	Sphericity (%)
0900 Ziraat	02.05.2017	36.35±1.59 <sup>c</sup>	1.47±0.04 <sup>a</sup>	0.69±0.06 <sup>g</sup>	10.47±0.37 <sup>h</sup>	12.28±0.23 <sup>h</sup>	88.36±1.13 <sup>e</sup>
	09.05.2017	46.11±0.85 <sup>a</sup>	1.04±0.03 <sup>c</sup>	1.01±0.07 <sup>fg</sup>	11.60±0.27 <sup>g</sup>	13.48±0.3 <sup>g</sup>	89.78±0.53 <sup>e</sup>
	16.05.2017	42.47±1.78 <sup>ab</sup>	1.15±0.03 <sup>c</sup>	1.45±0.08 <sup>f</sup>	13.35±0.28 <sup>f</sup>	14.91±0.24 <sup>f</sup>	92.07±0.59 <sup>d</sup>
	23.05.2017	40.88±1.51 <sup>abc</sup>	1.28±0.04 <sup>b</sup>	2.44±0.14 <sup>e</sup>	15.69±0.26 <sup>e</sup>	17.11±0.24 <sup>e</sup>	94.40±0.68 <sup>bc</sup>
	30.05.2017	35.63±2.43 <sup>c</sup>	1.25±0.03 <sup>b</sup>	4.40±0.31 <sup>d</sup>	20.55±0.58 <sup>d</sup>	20.16±0.58 <sup>d</sup>	97.68±0.32 <sup>a</sup>
	06.06.2017	37.25±2.11 <sup>bc</sup>	1.18±0.03 <sup>b</sup>	6.31±0.23 <sup>c</sup>	23.94±0.42 <sup>c</sup>	21.58±0.34 <sup>c</sup>	96.26±0.46 <sup>ab</sup>
	13.06.2017	42.44±1.80 <sup>ab</sup>	1.24±0.04 <sup>b</sup>	8.49±0.25 <sup>b</sup>	25.95±0.38 <sup>b</sup>	23.97±0.25 <sup>b</sup>	93.95±0.77 <sup>c</sup>
	20.06.2017	42.12±1.91 <sup>ab</sup>	1.20±0.04 <sup>b</sup>	9.80±0.22 <sup>a</sup>	27.43±0.44 <sup>a</sup>	24.87±0.18 <sup>a</sup>	95.91±0.31 <sup>ab</sup>
Sig <sup>++</sup> .		0.000	0.000	0.000	0.000	0.000	0.000

Values of physical properties represent the mean of three independent experiments, with ten samples per replicate (n = 30). Different letters in the same column indicate statistically significant differences according to Duncan's test (P < 0.001)

## Color Measurement

Color is considered an important indicator for determining physiological changes in fruits (Antal et al., 2013). In addition, color changes are often used to assess food quality during processing (Yusufe et al., 2017). The color values (L\*, a\*, b\*, C\*, and hue) of fruits recorded during the 8-week growth period of the 0900 Ziraat cultivar are presented in Tab. 2. The L\* value was 39.96 in the 1<sup>st</sup> week and showed fluctuations up to the 5<sup>th</sup> week, reaching a peak of 43.91. After that, a downward trend started in the 6<sup>th</sup> week, and the value dropped to 25.59 in the 8<sup>th</sup> week, clearly showing that the fruit is fully mature and has changed from red to a dark purple-black.

The a\* value was negative in the first four weeks (-4.39 to -8.57), indicating a greenish hue. Subsequently, it increased to 12.83 in the 5<sup>th</sup> week, marking the onset of redness, and peaked at 29.82 in the 6<sup>th</sup> week. Its value slightly decreased in the 7<sup>th</sup> week (28.56) and there was a more pronounced decrease in the 8<sup>th</sup> week (14.67), indicating full ripening and a gradual reduction in redness. The b\* value represents the blue-yellow color axis, where -b\* indicates a shift to blue and +b\* to yellow (Waskale & Bhong, 2017). The b\* value increased up to the 4<sup>th</sup> week when it reached its highest value (22.67). From the 5<sup>th</sup> week on, it decreased continuously and reached its lowest value (1.06) in the 8<sup>th</sup> week.

The increase in the b\* value up to the 4<sup>th</sup> week, was followed by a decrease, and indicates that the yellow coloration of the fruit reaches its peak during ripening and decreases at the full maturity stage.

The hue angle (h°) indicates the position of a color on the color wheel in degrees and stands for certain colors: 0° (red), 60° (yellow), 120° (green), 180° (cyan), 240° (blue), and 300° (magenta). It reflects the dominant color tone or wavelength (Kasajima, 2019). The hue value decreased until the 4<sup>th</sup> week (110.71), with a significant decrease in the 5<sup>th</sup> week (52.77). It decreased in the following weeks, reaching 4.08 in the 8<sup>th</sup> week, indicating that the fruits changed from green to red during ripening. The chroma (C\*) describes the intensity or saturation of a color, where higher chroma values indicate vibrant and pure colors and lower chroma values correspond to muted or grayish tones (Wrolstad & Smith, 2017). The chroma value increased until the 6<sup>th</sup> week (33.53), except in the 5<sup>th</sup> week, and then decreased until the 8<sup>th</sup> week (14.71). This finding indicates that the color saturation of the 0900 Ziraat cultivar increased during ripening and decreased after full ripening.

In many plants, the change in fruit color is due to the degradation of chlorophyll and the synthesis of new pigments (Ferrer et al., 2005). As the fruit ripens, different pigments take precedence, shaping its visual characteristics. In addition, biochemical transformations during growth contribute to variations in physical properties (Ochmian et. al., 2016). The skin color of cherries varies depending on the variety and is an important criterion for harvest and quality. As the fruit ripens, its color changes, which is influenced by the anthocyanin content (Göksel and Aksoy, 2014).

As the cherry ripens, the chlorophyll is broken down, the anthocyanins increase, and the sugar accumulates. This result leads to a color change from green to dark red, which is influenced by light, temperature, and nutrients (Gonçalves et al., 2007).

Tab. 2: Color parameters ( $L^*$ ,  $a^*$ ,  $b^*$ ,  $C^*$ , and  $h^\circ$ ) of 0900 Ziraat sweet cherry cultivar

No.	Harvest Date	$L^*$	$a^*$	$b^*$	$h^\circ$	$C^*$
1	02.05.2017	39.96±0.71 <sup>b</sup>	-4.39±0.33 <sup>c</sup>	5.65±0.54 <sup>c</sup>	128.01±0.65	7.16±0.63 <sup>e</sup>
2	09.05.2017	33.40±0.38 <sup>d</sup>	-7.91±1.01 <sup>cd</sup>	14.89±1.65 <sup>b</sup>	117.87±1.03 <sup>a</sup>	16.87±1.91 <sup>cd</sup>
3	16.05.2017	34.91±0.07 <sup>cd</sup>	-7.92±0.30 <sup>cd</sup>	15.13±0.24 <sup>b</sup>	117.60±0.58 <sup>a</sup>	17.08±0.35 <sup>cd</sup>
4	23.05.2017	40.30±1.15 <sup>b</sup>	-8.57±0.19 <sup>d</sup>	22.67±0.64 <sup>a</sup>	110.71±0.34 <sup>b</sup>	24.24±0.65 <sup>b</sup>
5	30.05.2017	43.91±1.09 <sup>a</sup>	12.83±1.69 <sup>b</sup>	16.60±1.25 <sup>b</sup>	52.77±1.63 <sup>c</sup>	21.00±2.01 <sup>bc</sup>
6	06.06.2017	36.78±1.81 <sup>c</sup>	29.82±2.16 <sup>a</sup>	15.07±2.48 <sup>b</sup>	26.29±2.77 <sup>d</sup>	33.53±2.87 <sup>a</sup>
7	13.06.2017	29.72±1.22 <sup>e</sup>	28.56±1.55 <sup>a</sup>	8.61±1.74 <sup>c</sup>	16.31±2.35 <sup>e</sup>	29.90±1.98 <sup>a</sup>
8	20.06.2017	25.59±0.08 <sup>f</sup>	14.67±0.45 <sup>b</sup>	1.06±0.20 <sup>d</sup>	4.08±0.66 <sup>f</sup>	14.71±0.47 <sup>d</sup>
Significance <sup>++</sup>		0.000	0.000	0.000	0.000	0.000

Color values represent the mean of two independent experiments, with three samples per replicate (n = 6).

Different letters in the same column indicate statistically significant differences according to Duncan's test (P < 0.001)

## Firmness and Elasticity

Firmness and elasticity are important quality characteristics that affect consumer preference and post-harvest performance. They help maintain fruit integrity, reduce mechanical damage, and extend shelf life, directly impacting marketability and overall quality (Crisosto et al., 2003; Ballistreri et al., 2013). In the 0900 Ziraat cultivar, firmness was found at its high level (1969.55- 1988.36 g) between the 1<sup>st</sup> and 3<sup>rd</sup> week, but it decreased rapidly from the 4<sup>th</sup> week onward and reached its lowest value (232.55g) in the 8<sup>th</sup> week (Fig. 2). This change indicates that the texture of the fruit became softer during the ripening phase and the firmness decreased over time. On the other hand, the lowest elasticity

value (1.47 mm) was recorded in the 4<sup>th</sup> week, while the highest value (2.93 mm) was measured in the 2<sup>nd</sup> week. The elasticity values showed slight fluctuations from the 5<sup>th</sup> week onwards and reached 2.10 mm in the 8<sup>th</sup> week. The elasticity of the fruit reflects its freshness and degree of ripeness. A higher elasticity indicates a firmer and more desirable fruit. As ripeness increases, the elasticity decreases, which affects the texture, shelf life, and market value (Li et al., 2010). Fruit softening plays a key role in ripening, which is caused by protopectin degradation, polymer shortening, and chemical changes that weaken the cell wall and alter texture (Zhou et al., 2021).

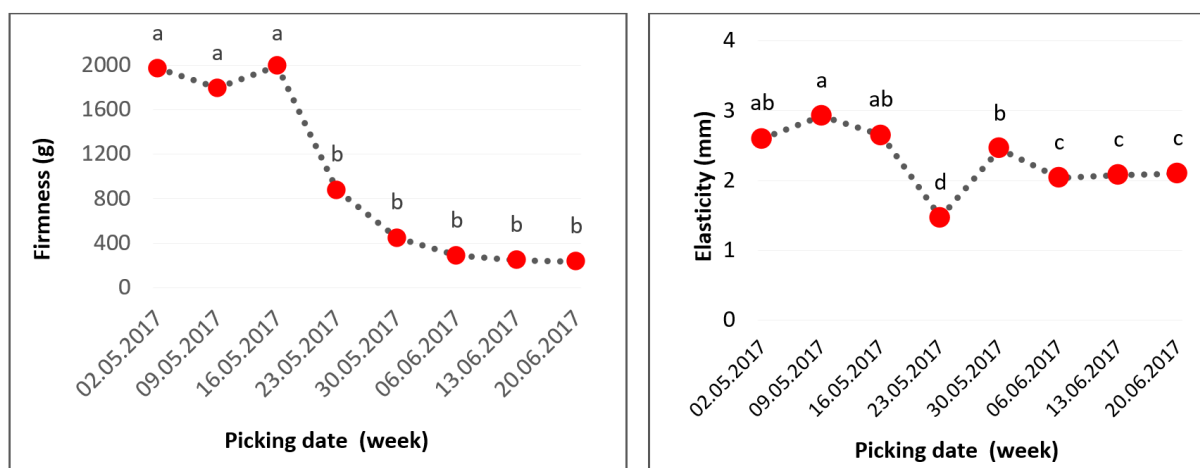


Fig. 2: Changes in firmness (g) and elasticity (mm) of cv. 0900 Ziraat of sweet cherry during the ripening period. ANOVA results indicated these changes were statistically significant ( $P < 0.001$ ).

### pH and Total Soluble Solids (TSS)

pH is an important factor influencing cherry quality linked to color, anthocyanin levels, and phenols. While a pH range of 3-5 promotes anthocyanin formation, higher pH levels lead to color loss (Serradilla et al., 2012; Ballistreri et al., 2013). During the ripening period, the pH value of the 0900 Ziraat cultivar varied between 3.43 and 4.53 (Fig. 3). The pH value increased up to the 3<sup>rd</sup> week, reached its highest value of 4.53 and declined from the 4<sup>th</sup> week onwards and reached 3.43 in the 5<sup>th</sup> week. In the following weeks, it showed slight fluctuations and was recorded at 3.57 in the 8<sup>th</sup> week. Previous studies have reported similar results, with pH values ranging from 3.4 to 4.8 (Ballistreri et al., 2013; Chockchaisawasdee et al., 2016; Gonçalves et al., 2004; Hayaloğlu & Demir, 2016). Similar pH values for the 0900 Ziraat variety were reported by Bolcu & Akça, 2011 (4.27), İkinci & Bolat, 2015 (3.59), and Üstün & Bostan, 2022 (4.15).

TSS is another important quality factor for sweet cherries. The balance of sugar and acidity improves the flavor of the cherry and increases consumer preference and acceptance (Ballistreri et al., 2013; Chockchaisawasdee et al., 2016). The TSS value showed slight changes in the first four weeks (8.10%-8.90%), then exhibited a significant increase from the 5<sup>th</sup> week onwards and reached its peak in the 8<sup>th</sup> week (16.00%) (Fig. 3). During the ripening process, the TSS/TA ratio increases due to a more significant increase in TSS compared to TA (Crisosto et al., 2003). The balance between TSS and TA is crucial in determining fruit flavor and is an important indicator of fruit quality (Serradilla et al., 2012). Çalhan et al. (2014) collected fruit samples of Lapin's cherry cultivar at ten different stages and reported a continuous increase in TSS from the first to the last week. Mineata et al. (2024) recorded TSS values between 9.40 and 10.50 in three different cherry cultivars at two stages (pre-ripening and full ripening) and reported an increase in TSS from pre-ripening to full ripening. This result shows that the 0900 Ziraat cultivar shows the highest sugar content compared with other cultivars reported in the literature, indicating that the sweet taste of this cultivar makes it favorable to consumers.



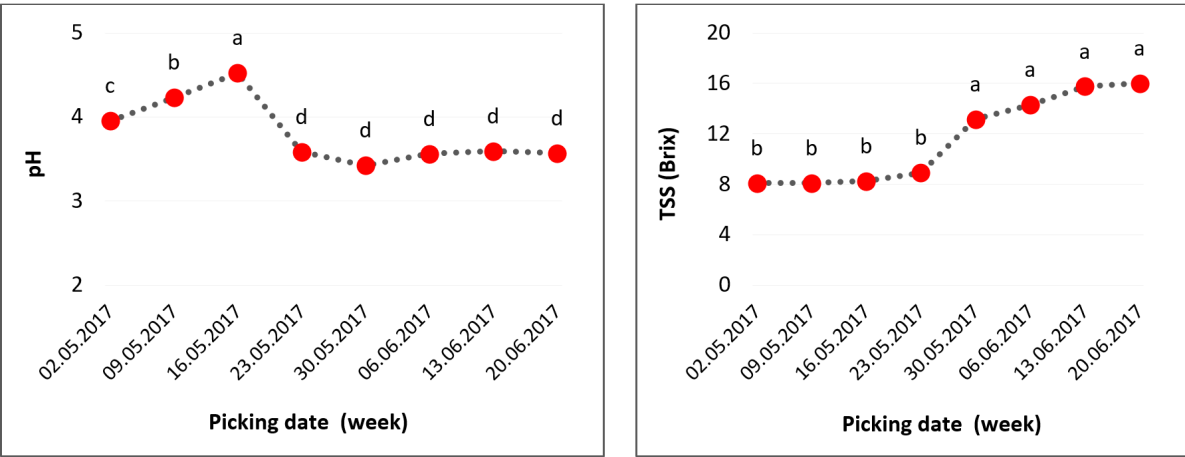


Fig. 3: Changes in pH and total soluble solids measurement (TSS) of 0900 Ziraat sweet cherry cultivar during ripening. ANOVA results showed that changes in SSC were statistically significant ( $P < 0.001$ ).

Organic Acids

The changes in ascorbic acid and citric acid contents during the ripening phase of the 0900 Ziraat cultivar are shown in Fig. 4. Citric acid content decreased significantly during the 8 weeks, reaching its peak ( $455.99 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ ) in the 2<sup>nd</sup> week and its lowest ( $55.76 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ ) in the 7<sup>th</sup> week. In general, citric acid continuously decreased from the 3<sup>rd</sup> to the last week. Ascorbic acid content fluctuated during the 8 weeks. The lowest value ( $106.72 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ ) was shown in the 1<sup>st</sup> week, while the highest values were shown in the 6<sup>th</sup> ( $214.52 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ ) and 8<sup>th</sup> week ( $255.67 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ ).

Ascorbic acid extends shelf life through its antioxidant properties, preserves color and flavor, and supports the immune system (He et al., 2024),

while citric acid balances acidity, shapes the characteristic flavor profile, acts as a natural preservative and supports energy metabolism (Carr & Maggini, 2017). Usenik et al. (2008) found that the citric acid content in the fruit of 13 sweet cherry cultivars varied between 11 and  $54 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ . Hayaloglu and Demir (2016) reported that the citric acid content of 12 cherry cultivars ranged between 59 and  $617 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$ . Mineata et al. (2024) reported an ascorbic acid content of 5.3 to  $9.8 \text{ mg } 100 \text{ g}^{-1} \text{ fw}$  in three cherry cultivars and found an increase in its value from pre-ripeness to full ripeness. In this study, the ascorbic acid content was higher than that reported by Mineata et al. (2024), while the citric acid content was consistent with the results of Usenik et al. (2008) and Hayaloglu & Demir (2016).

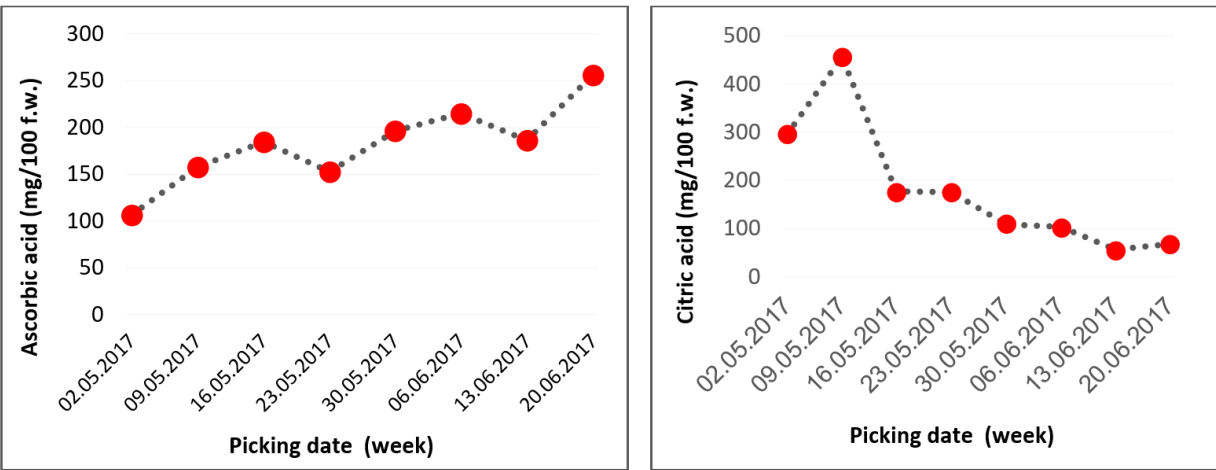


Fig. 4: Changes in ascorbic acid and citric acid of 0900 Ziraat sweet cherry cultivar during the ripening period.

## Phenolic Compounds

The changes in gallic acid and catechin during the ripening process of the 0900 Ziraat cultivar are shown in Fig. 5. Gallic acid generally decreased during the 8 weeks. The highest value was recorded in the 1<sup>st</sup> week (2670.14 mg 100 g<sup>-1</sup> fw) and the lowest in the 7<sup>th</sup> week (293.24 mg 100 g<sup>-1</sup> fw). A significant decrease in its value was observed from week 3 onwards, but a slight increase was detected in week 8 (592.93 mg 100 g<sup>-1</sup> fw).

Catechin soared in the 3<sup>rd</sup> week (72.78 mg 100 g<sup>-1</sup> fw), followed by a sharp decrease in the 4<sup>th</sup> week, and reached its lowest values in the 5<sup>th</sup> and 6<sup>th</sup> weeks (6.43 mg 100 g<sup>-1</sup> fw). A slight increase was observed in the 7<sup>th</sup> week (10.18 mg 100 g<sup>-1</sup> fw), but in the 8<sup>th</sup> week the value dropped again to 7.54 mg 100 g<sup>-1</sup> fw.

Gündoğdu and Bilge (2012) reported that 1.76–5.02 mg 100 g<sup>-1</sup> of catechin was identified in sweet cherry cultivars, including the cv. 0900 Ziraat from Mardin, Türkiye. Canan et al. (2019) reported that the catechin content in 8 sweet cherry varieties, including cv. 0900 Ziraat, was between 1.00 and 8.03 mg 100 g<sup>-1</sup>. Kaya et al. (2024) found that the catechin content of the 0900 Ziraat cultivar was between 3.99 and 5.82 mg kg<sup>-1</sup> fw at harvest time and after a (30-day) post-harvest period. The catechin and gallic acid concentrations observed in this study were within the ranges reported in previous studies. The content of these compounds may vary depending on factors such as genotype, degree of ripeness, climate, and storage conditions. (Serradilla et al., 2012; Chockchaisawasdee et al., 2016; Kaya et al., 2024).

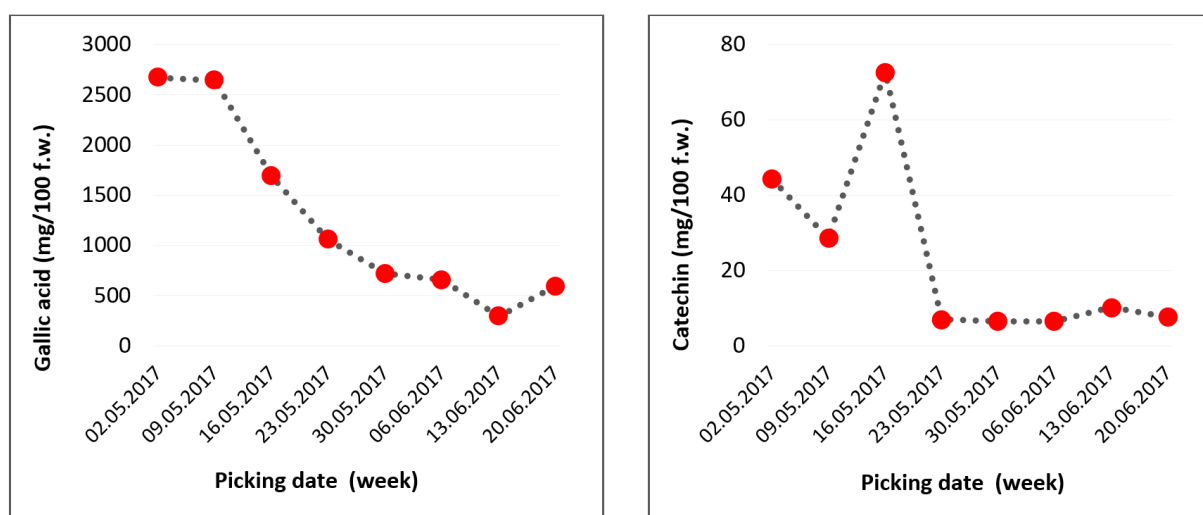


Fig. 5: Changes in gallic acid and catechin of 0900 Ziraat sweet cherry cultivar during the ripening period.

## Conclusions

In this study, the physical, chemical, morphological, and mechanical changes during the 8-week-ripening period of Ziraat 0900 cherry cultivar was investigated. Significant variations in the investigated parameters were observed during the ripening processing. The color changed from green to deep red as the  $a^*$  and chroma values

increased while the hue angle decreased, indicating an accumulation of anthocyanins. The color change intensified in the 5<sup>th</sup> week, peaked in the redness and saturation notes in the 6<sup>th</sup> week, and by the 8<sup>th</sup> week, the measured color values reflected the stage of full ripeness. Firmness was more pronounced in the first weeks but decreased

rapidly from the 4<sup>th</sup> week and reached its lowest values in the 8<sup>th</sup> week, while elasticity fluctuated, reaching its lowest level in the 4<sup>th</sup> week and showing slight fluctuations after the 6<sup>th</sup> week. The TSS values continuously increased, while the pH values fluctuated during the ripening period. Organic acids, especially citric acid, decreased during ripening, while ascorbic acid fluctuated and peaked in the later stages. Phenolic compounds such as gallic acid and catechin also reduced over time, with a slight increase in the last few weeks. These results show that the optimum harvest time for the 0900 Ziraat sweet cherry cultivar is between the 7<sup>th</sup> and 8<sup>th</sup> week after full bloom.

During this period, the fruit has reached its highest weight (9.80 g) and soluble solids content (16.00%), while firmness has declined to 232.55 g and the hue angle has dropped to 4.08°, indicating full ripeness. The concurrent changes in physical and biochemical traits confirm that this is the most suitable stage for harvest, when the fruit exhibits optimal size, sweetness, texture, and visual appeal. The outcomes of the present study can help producers and retailers collect 0900 ziraat sweet cherry cultivar at optimal harvest time when it possesses the highest sensory and nutritional quality parameters.

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