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# Evaluation of Pomological and Chemical Properties of Naturally Growing Hawthorn (*Crataegus* spp.) Genotypes

*Original Article*

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*Abstract:*

Hawthorn (*Crataegus* spp.), a wild fruit whose consumption has increased in recent years, is abundant in Turkey's ecology. This fruit is particularly important due to its aroma, color, partial taste formation, and antimicrobial effects. The aim of this study was to determine some pomological and chemical characteristics of hawthorn fruits collected from Ankara Province and the districts of Melikgazi, Hacılar, and Sarız in Kayseri Province during 2022-2023. The pomological characteristics of the selected hawthorn genotypes included fruit weight, fruit width, fruit length, and seed weight, while the chemical characteristics examined were pH, soluble solids content (SSC), titratable acidity (TA), vitamin C, phenolic compounds, flavonoids, antioxidant capacity (measured by DPPH), and anthocyanin content. The study found that the maximum fruit weight was 2.80 grams, with a fruit width of 18.80 mm and a fruit length of 16.01 mm. The seed weight was 0.99 grams. Regarding chemical characteristics, the pH was 3.91, titratable acidity was 2.5%, soluble solids content (SSC) was 14.3%, and the vitamin C content was 71.03 mg/100 g. The total phenolic content was 773.32 µg GAE/100 g, while the total flavonoid content was 23.87 mg CE/100 g. The antioxidant activity was determined to be 74.40%, and the anthocyanin content was found to be 1.11 µg cy-3-glu/g TA.

*Key words:*
chemical, hawthorn (*Crataegus* spp.), pomological

*Apstrakt:*

**Procena pomoloških i hemijskih karakteristika prirodno rastućih genotipova gloga (*Crataegus* spp.)**

Glog (*Crataegus* spp.), divlje voće čija je potrošnja poslednjih godina u porastu, zastupljen je u Turskoj. Ovo voće je posebno važno zbog svoje arome, boje, delimično formiranog ukusa i antimikrobnog dejstva. Cilj ovog istraživanja bio je da se utvrde neke pomološke i hemijske karakteristike plodova gloga prikupljenih iz provincije Ankara i okruga Melikgazi, Hacilar i Sarız u provinciji Kayseri tokom 2022-2023. Pomološke karakteristike odabranih genotipova gloga obuhvatale su masu ploda, širinu ploda, dužinu ploda i masu semena, dok su od hemijskih karakteristika ispitivane pH, sadržaj rastvorljivih čvrstih materija (SSC), titrabilna kiselost (TA), vitamin C, fenolna jedinjenja, flavonoidi, antioksidativni kapacitet (izražen kao DPPH) i sadržaj antocijana. Studijom je utvrđeno da maksimalna težina ploda iznosi 2,80 grama, širina ploda 18,80 mm, a dužina ploda 16,01 mm. Težina semena iznosila je 0,99 grama. Što se tiče hemijskih karakteristika, vrednost pH iznosila je 3,91, titraciona kiselost 2,5%, sadržaj rastvorljivih čvrstih materija (SSC) bio je 14,3%, a sadržaj vitamina C 71,03 mg/100 g. Ukupan sadržaj fenola bio je 773,32 µg GAE/100 g, dok je ukupan sadržaj flavonoida bio 23,87 mg CE/100 g. Utvrđeno je da antioksidativna aktivnost iznosi 74,40%, a sadržaj antocijanina 1,11 mg ci-3-glu/g TA.

*Ključne reči:*
hemijske karakteristike, glog (*Crataegus* spp.), pomološke karakteristike

## Introduction

Anatolia is an important gene center and natural distribution area for many fruit species. Turkey is a country rich in plant genetic resources due to its phytogeographic location (European Siberian, Irano-Turanian and Mediterranean phytogeographic regions). With approximately 12,000 plant species,

Turkey has a plant diversity equal to the European Continental Flora alone (Kutbay et al., 2014; Demir et al., 2017). In Turkey, most fruit species are cultivated, and only a few grow naturally. Hawthorn (*Crataegus* spp.) is one of these few species that Anatolian people have used for many years. In Turkey, it grows spontaneously in its natural ecological environment in bushes, river banks, rocky places, and mountainous regions (Anonymous, 2022). Hawthorn, which has local names such as May thorn, white thorn, quince hawthorn, bird nuts, edran in the popular language, is botanically a plant species belonging to the order *Rosales*, family *Rosaceae*, species *Crataegus*, generally in the form of thorny shrubs or trees, deciduous in winter (Davis et al., 1972; Kayacık, 1981; Seçmen et al., 1989), and its homeland is spread over a wide area such as Europe, Asia and North America. There are 50 species of hawthorn in the world and more than 20 species in Turkey. Geographically, *Crataegus orientalis*, *Crataegus monogyna, Crataegus oxyacanth* and *Crataegus aroniaen* are known as the most widespread species (Davis et al., 1972). In Turkey, hawthorn grows intensively in natural ecological environments in the Aegean, East Anatolian, and Mediterranean regions (Kıral, 2022). Hawthorn (*Crataegus* spp.) fruits are highly nutritious, containing a variety of minerals that promote human health, including potassium (K), calcium (Ca), phosphorus (P), iron (Fe), and magnesium (Mg). In addition to these minerals, hawthorn fruits are also rich in sugars, carbohydrates, and vitamin C (Özcan et al., 2005). Hawthorn, known for its ability to inhibit low-density lipoprotein (LDL) cholesterol and its antioxidant properties, offers several health benefits due to its richness in phenolic compounds. It plays a particularly significant role in medicine for supporting heart health, including the prevention of hypertension and cardiovascular diseases, and is also recognized for its anti-carcinogenic effects (Batu, 2012). Hawthorn fruit is consumed as molasses, jam, paste, concentrated juice, soft drinks, sauce, nectar, hawthorn yogurt, Turkish delight, and dried fruit. Hawthorn powder is also produced and marketed as cakes, biscuits, sweets, and ice cream (Batu, 2012).

This study was carried out to determine some pomological (fruit weight, fruit width, fruit length, and kernel weight) and chemical (soluble solids content (SSC), pH, titratable acidity (TA), phenolic content, flavonoid content, antioxidant capacity (DPPH), anthocyanin and vitamin C) properties of fruits of naturally growing hawthorn genotypes. Various genotypes of hawthorn were collected from Melikgazi (M), Hacılar (H), and Sarız (S) districts of Kayseri province and Ankara province during the years 2022/2023.

## Materials and Methods

### *Plant Material*

Fruit samples were collected from the Melikgazi, Hacılar, and Sarız districts of Kayseri and Ankara provinces and stored in a refrigerator at 4 °C. The pomological (average fruit weight, fruit width, fruit length, and kernel weight) and chemical (soluble solids content (SSC), pH, titratable acidity (TA), phenolic content, flavonoid content, antioxidant capacity (DPPH), anthocyanin and vitamin C) characteristics of selected hawthorn genotypes were analyzed.

### *Pomological Measurements and Chemical Analyses*

For each genotype, 20 fruits were weighed and the fruit samples were weighed on a digital balance with a sensitivity of 0.05 g. Pomological measurements and examinations of the sample fruits from the genotypes were conducted by measuring the widest part of the fruit, the length between the top and bottom of the fruit, as well as the width and length of the fruit in millimeters (mm) using a digital caliper. The soluble solids content of the fruit was determined using a Mettler-Toledo 30 P digital refractometer at 22 °C, and the acidity was determined using the titrimetric method according to Cemeroğlu (1992). Ten ml of juice was made up to 100 ml with distilled water and titrated with 0.1 N sodium hydroxide (NaOH) until the pH was 7.0. The resulting titration acidity was calculated as a percentage of malic acid. The pH values of the hawthorn genotypes were determined by measuring with a digital pH meter (Şen & Güneş, 1996). For the determination of vitamin C (ascorbic acid) content (mg/100 g), 5 g of fruit flesh was weighed and immediately made up to 50 ml by using 0.4% oxalic acid solution, and the samples were filtered with filter paper and read in a spectrophotometer at a wavelength of 520 nm (Kılıç et al., 1991). The spectrophotometric method was used to determine total phenolic content (TPC) (Spanos & Wrolstad, 1992). 100 µL of the sample was transferred into a tube, to which 900 µL of water, 5 mL of 0.2 N Folin-Ciocalteau reagent, and 4 mL of saturated sodium carbonate solution (75 g/L) were added. The tubes were then vortexed and kept in the dark for 2 hours. Calculation was then made by reading the values at a wavelength of 765 nm in the spectrophotometer and using the graph prepared with gallic acid. The spectrophotometric method described by Karadeniz et al. (2005) was used for the colorimetric determination of total flavonoid content (TFC) with aluminum chloride. One ml sample was placed in a 10 ml glass bottle, to which 4 ml of distilled water and 0.3 ml of 5% $NaNO_2$ were

added and mixed. After 5 min, 0.6 ml of 10% $AlCl_3$ x 6 $H_2O$ and 2 ml of 1 mol $l^{-1}$ NaOH were added and the total volume was made up to 10 ml with distilled water. After homogenization, readings were taken at a wavelength of 510 nm in a spectrophotometer, and calculations were made using the graph prepared with catechin. The antioxidant activity (AA) of the extracts was measured using 2,2-diphenyl-1-picrylhydrazyl (DPPH) according to the method modified by Lafka et al. (2007). To 0.1 ml of the sample solution prepared at different concentrations with methanol, 3.9 ml of DPPH solution prepared in methanol (25 mg $l^{-1}$) was added, stirred for 30 seconds with a vortex, and kept for 30 min in a dark room at room temperature. The absorbance of the samples was measured against methanol at 515 nm using a UV spectrophotometer. The % inhibition values obtained were plotted, and the effective concentration ($EC_{50}$) and the % effect that reduced the effect of DPPH by 50% were calculated for each sample. The total amount of anthocyanins in the fruits was determined by the pH difference method (Giusti & Wrolstad, 2005). The extracts were measured at 531 and 700 nm wavelength by preparing solutions at pH 1.0 and 4.5. Total anthocyanin content (molar extinction coefficient of 28000 cyanidin-3-glycoside) was calculated as absorbances [(A531-A700) pH 1.0- (A531-A700) pH 4.5] µg anthocyanin/g dry matter.

### *Statistical Analyses*

All analyses were repeated 3 times, and SPSS 16.0 statistical analysis package program was used to evaluate the data obtained after the experiment. Differences between groups were determined using the Duncan multiple comparison test at a significance level of $p<0.05$ (SPSS, 2007).

## Results and discussion

Results of fruit weights (g), fruit width and length (mm) and kernel weights (g) of the genotypes are given in **Tab. 1**; soluble solids content (%), titratable acidity (%), pH, phenolic content (µg GAE/100 g), flavonoid content (mg CE/100 g), antioxidant capacity (%), anthocyanin content (µg cy-3-glu/g TA) and vitamin C (mg/100 g) are given in **Tab. 2**. As shown in **Tab. 1**, the highest values of fruit weight 2.80 g, fruit width 18.80 mm, fruit length 16.01 mm, and kernel weight 0.99 g were recorded in the S genotype.

In a study conducted in 2021, it was found that the fruit weights of the hawthorn genotypes were between 0.89-1.80 g, fruit length was 11.48-13.62 mm, fruit width was 10.92-15.68 mm, and the fruit width/length ratio was between 0.95-1.15 mm (İkinci et al., 2022). In some studies carried out in different regions of Turkey, the mean fruit weight of the investigated genotypes of hawthorn (*Crataegus* spp.) was between 0.29-7.67 g, the mean fruit width was 6.56-28.10 mm, and the mean fruit length was 5.86-24. 23 mm (Karadeniz & Kalkışım 1996; Gazioğlu, 2000; Asma & Birhanlı, 2003; Özcan et al., 2005; Balta et al., 2006; Yanar et al., 2011; Balta et al., 2015; Gürsoy, 2016; Yavıç et al., 2016; Bektaş et al., 2017; Okatan et al., 2017; Bağran, 2018; Gürlen, 2018; Keles, 2018). Caliskan et al. (2018) determined the average fruit weight of yellow hawthorn genotypes as 15.03 g, fruit width as 32.03 mm and fruit length as 26.88 mm. Okatan et al. (2017) found that the fruit width and length of the genotypes were between 12.53-19.94 and 10.48-17.43 mm, respectively. Özgen & Sorgun (2010) found the mean fruit width between 14.28-20.87 mm and mean fruit length between 14.38-17.43 mm among the genotypes. In a study conducted in the Van region, Türkoğlu et al. (2005) reported that the average fruit height was between 12.45-12.89 mm, and the average fruit width was between 13.44-14.48 mm among the genotypes. Okatan et al. (2017) found the average fruit weight to be between 0.96 and 4.03 g in genotypes in their research. Balta et al. (2015) reported the average fruit weight between 1.54-4.72 g, and Karadeniz and Kalkamış (1996) reported it between 0.81-2.14 g in genotypes they investigated in their research. Okatan et al. (2017) found that the mean kernel weight of the genotypes they examined was between 0.23-0.98 g, Yavıç et al. (2016) 0.39-0.86 g, and Özgen & Sorgun (2010) found that the mean kernel weight among the genotypes was between 0.31-0.83 g for each fruit. Öztürk et al. (2023) determined the highest fruit weight as 5.75 ± 0.14 g and the lowest fruit weight as 2.12 ± 0.10 g from some pomological characteristics of hawthorn fruits. Ercişli et al. (2015) reported that the fruit weight of

**Table 1.** Some pomological characteristics of hawthorn genotypes

| Genotype | Fruit weight (g) | Fruit width (mm) | Fruit length (mm) | Kernel weight (g) |
|---|---|---|---|---|
| **M** | 2.31$^{b}$ | 17.02$^{b}$ | 15.08$^{b}$ | 0.87$^{bc}$ |
| **H** | 2.11$^{b}$ | 17.75$^{b}$ | 15.46$^{b}$ | 0.85$^{c}$ |
| **S** | 2.80$^{a}$ | 18.80$^{a}$ | 16.01$^{a}$ | 0.99$^{a}$ |
| **A** | 1.92$^{c}$ | 16.84$^{c}$ | 13.56$^{c}$ | 0.90$^{b}$ |

* differences between means marked with different letters in the same column are significant at the $p\leq0.05$ level

**Table 2.** Some chemical properties of hawthorn genotypes

| Genotype | SSC (%) | TA (%) | pH (%) | Vitamin-C (mg/100 g) | Total phenolic content (µg GAE/100 g) | Total flavonoid content (mg CE/100 g) | Total antioxidant capacity (%) | Total anthocyanin (µg cy-3-glu/g TA) |
|---|---|---|---|---|---|---|---|---|
| **M** | 12.5$^{c}$ | 2.4$^{ab}$ | 3.89$^{ab}$ | 65.03$^{c}$ | 705.06$^{c}$ | 18.78$^{c}$ | 70.75$^{b}$ | 0.73$^{d}$ |
| **H** | 13.2$^{b}$ | 2.3$^{b}$ | 3.84$^{b}$ | 67.84$^{b}$ | 742.191$^{b}$ | 20.05$^{b}$ | 70.9$^{b}$ | 0.93$^{b}$ |
| **S** | 14.3$^{a}$ | 2.5$^{a}$ | 3.91$^{a}$ | 71.03$^{a}$ | 773.32$^{a}$ | 23.87$^{a}$ | 67.76$^{c}$ | 1.11$^{a}$ |
| **A** | 10.3$^{d}$ | 2.4$^{ab}$ | 3.82$^{b}$ | 62.59$^{d}$ | 670.43$^{d}$ | 13.69$^{d}$ | 74.40$^{a}$ | 0.89$^{c}$ |

* differences between means marked with different letters in the same column are significant at the $p \leq 0.05$ level

hawthorn species varied from 0.76 to 4.27 g. Gürlen et al. (2020) found that the fruit length and width of hawthorn genotypes grown in Turkey varied from 8.43 ± 0.12 to 17.58 ± 0.23 mm and from 6.56 ± 0.93 to 20.71 ± 1.22 mm, respectively. According to five-year average data, Caliskan et al. (2018) determined the average fruit weight to be 15.03 g, fruit width to be 32.03 mm, and fruit length to be 26.88 mm in yellow hawthorn genotypes. They also reported that there were 2.4 seeds in each fruit and the average weight of these seeds was 0.7 g. Karadeniz & Kalkışım (1996) reported that the fruit weights of hawthorn varieties naturally distributed in the Edremit and Gevaş districts of Van province were between 0.81-2.14 g, and the seed weights were between 0.17-0.55 g. Guo & Jiao (1995) reported that the fruit weights of hawthorn varieties grown in China varied between 10-16 g. Gündoğdu et al. (2014) found fruit weight between 0.58-3.48 g, seed number between 1.0-5.0, seed weight between 0.13-0.68 g, and water-soluble dry matter (brix) content between 2.35-20.0% in hawthorn species selected from Erzincan province. In other studies, Balta et al. (2015) found fruit weight between 1.54-4.72 g and seed weight between 0.32-0.90 g, Ercişli et al. (2015) found fruit weight between 0.76-4.27 g, and Özderin and Fakir (2015) found average fruit weight between 0.45-3.88 g. The values obtained in our study and those of other studies were found to be close to each other.

The water-soluble solids (SSC) value of the hawthorn genotypes was 14.3%, the titratable acid (TA) ratio was 2.5%, the pH value was 3.91, the vitamin C content was 71.03 mg/100 g, the TPC 773.32 µg GAE/100 g, the TFC 23.87 mg CE/100 g, the anthocyanin 1.11 µg cy-3-glu/g TA, and the highest values were obtained in the S genotype (**Tab. 2**).

Rüzgar & Yazıcı (2022), as a result of their measurements on the production of hawthorn puree suitable for industry from hawthorn fruit, measured the soluble solids content amounts of hawthorn fruit samples obtained from Erzincan and Sivas Su city district as 8.47±0.02 and 6.79±0.02°Bx, pH values of 3.45±0.03 and 3.44±0.01, total acidity (malic acid equivalent) of 0.690±0.03 and 0.345±0.02 g/100 g, whereas for puree they found soluble solids content values of 7.37±0.01°Bx, pH values of 3.66±0.01 and total acidity (malic acid equivalent) of 0.517±0.01 g/100 g. In another study, soluble solids content of hawthorn samples was reported to be in the range of 12.6-17.7°Bx, pH and total acidity (malic acid equivalent) values were 3.6-4.0 and 0.9-1.7 g/100 g, respectively (Güzel, 2021). In Tunisia, Bahri-Sahloul et al. (2009) conducted a study with 14 hawthorn genotypes collected from three locations. They determined the soluble solids content of hawthorn samples in the range of 16.3-21.8°Bx, pH in the range of 3.2-4.2, and acidity (malic acid equivalent) in the range of 0.9-1.9. Caliskan et al. (2018) reported pH values between 3.0-3.6 and titratable acid content (in terms of malic acid) between 1.3-1.6 g/100 g; Gündoğdu et al. (2014) reported these values between 4.22-5.99 and 0.22-2.40% and soluble solids content between 2.35-20.0%, respectively. Öztürk et al. (2023) reported that the highest soluble solids content of hawthorn samples in their study was 16.99°Bx. In some studies conducted in different regions of Turkey, Yanar et al. (2011) determined the total soluble solids content and pH of hawthorn genotypes to be 11.66% and 24.00% and 3.12 and 4.09, respectively. Alireza et al. (2020) found pH 3.03-4.35, titration acidity 0.75-1.17%, and soluble solids content 14.99-23.43% for 15 species of the genus *Crataegus*. Radi et al. (2023) found pH values of 5.12±0.00 and 4.51±0.00 and titration acidity in terms of citric acid of 0.202±0.00 and 0.1±0.02, respectively. In other studies conducted in previous years, Karadeniz and Kalkışım (1996) reported that the soluble solids content of hawthorn cultivars grown in the Edremit and Gevaş districts of Van province ranged between

12.20 and 27.20%. Guo & Jiao (1995) reported that hawthorn cultivars grown in China had dark red bark and their soluble solids content ranged from 4.9% to 13.8%. Similarly, Ercişli et al. (2015) found that the soluble solids content of hawthorn cultivars ranged from 6.71% to 14.85%.

Murathan et al. (2022), after comparing the bioactive constituents, antioxidant and mutagenic properties of different *Crataegus* species growing in Elazig, found that the bioactive constituent content and antioxidant activity of *C. sinaica* species were high and determined that the TPC in the samples was between 670.43 and 773.32 mg/100 g, the TFC was between 345.52 and 452.46 mg/100 g, and the total ascorbic acid content was between 17.7 and 60.3 mg/100 g. This value was reported by Ercişli et al. (2015) as 660 to 3460 mg/100 g wet weight, by Çalışkan et al. (2012) as 26.6 to 57.1 mg/g dry weight, and by Mraihi et al. (2013) as 60.89 to 122.26 mg/100 g dry weight in different hawthorn species. Güzel (2021) determined the total flavonoid content of hawthorn samples from Çorum province in the 78.2 to 272.6 mg/100 g range. Ebrahizadeh and Bahramian (2009) reported total flavonoid content between 10.56 and 23.98 mg/g, and Edwards et al. (2012) between 4.46 and 147.3 mg/g.

Previous studies on the antioxidant capacity of hawthorn samples showed that Keser et al. (2012) measured 50.76% in the aqueous extract and 52.50% in the ethanolic extract. Additionally, the DPPH radical scavenging activity was 27.63% in the aqueous extract and 33.24% in the ethanolic extract. Okatan et al. (2017) reported that the DPPH radical scavenging activity of hawthorn samples grown in Uşak province ranged from 19.24% to 59.24%. Caliskan et al. (2012) found that the DPPH radical scavenging rate of hawthorn genotypes grown in the Eastern Mediterranean region ranged between 21.4-33.2%. Keser (2012) found that the DPPH radical scavenging activity of *C. monogyna* fruit ethanol extract was 88.22%, 87.22% in water extract; ABTS radical scavenging activity was 52.50% in ethanol extract and 50.76% in water extract. Kiselova et al. (2006) observed that the ABTS radical scavenging capacity of water extracts of *C. monogyna* fruits was 50.76%. Çınar et al. (2020), in their study to determine the amount of phenolic/flavonoid substances, antioxidant and antimicrobial activity values in *Crataegus* spp. taxa from the Western Mediterranean region, found the highest antioxidant activity value to be 20% in fruit samples. In a study on *Crataegus oxyacantha* species, which has an important medicinal use in Europe, the antioxidant activity (DPPH) was determined to be 78.9%, and the total phenolic content was determined to be 244.3 mg $g^{-1}$ (Mraihi et al., 2013). Çoklar & Akbulut (2016) found the total phenolic content of 1245.3 mg GAE 100 $g^{-1}$ (12.45 mg GAE $g^{-1}$), 12.89-16.54 mg GAE $g^{-1}$ and 2.56-63.02 mg 100 $g^{-1}$ in Konya-Beyşehir region, respectively.

Demir (2021), in his study on the determination of antioxidant contents of some *Crataegus taxa* naturally distributed in Afyonkarahisar, found the gallic acid value to be 30.32 mg $g^{-1}$, 1,2-dihydroxybenzene value to be 178.63 mg $g^{-1}$ and catechin amount to be 163.08 mg $g^{-1}$. The antioxidant activity ranged from 0.255 mg $g^{-1}$ to 0.082 mg $g^{-1}$, and the TPC ranged from 0.75 mg $g^{-1}$ to 0.621 mg $g^{-1}$. In addition, the highest phenolic compound detected was 3,4-dihydroxybenzoic acid and the lowest was the naringenin compound. Bahorun et al. (2003), in a study on hawthorn genotypes, determined the amount of total phenolics in the samples as 47.40 mg/g and total anthocyanin as 2.38-6.12 µg siy-3-glk/g, while Kostić et al. (2012) determined the amount of total phenolics as 2.12-30.63 mg GAE $g^{-1}$ and total anthocyanin as 0.3207-3.168 mg.

Öztürk et al. (2023) determined the total phenolic content in their samples to be 13.81±0.93, 2.86±0.24 and 13.43±0.89 mg GAE/g DW, respectively. According to the different results obtained in the studies investigating the antioxidant activity and total phenolic content of fruits of different hawthorn species, Čopra-Janićijević et al. (2018) reported that the total phenolic content in the extract for *C. microphylla* fruits varied between 2.47 and 8.63 mg GAE/g DW, Çoklar et al. (2018) reported that the total phenolic content in the extract for *C. orientalis* species was 13.36 mg GAE/g DW, and Tahirović and Bašić (2014) determined that the total phenolic content of the fruit varied between 2.02 and 4.60 mg GAE/g DW in their extraction for *C. monogyna* L. using different proportions of water and different solvents.

Radi et al. (2023) investigated the amount of polyphenols and flavonoids present in the aqueous extracts of *C. monogyna* and *C. laciniata* fruits. They reported that the aqueous extract of *C. monogyna* fruits contained the most abundant phenolic compounds, 1.04 ± 2.4 EAG/g, while the aqueous extract of *C. laciniata* fruits contained only 0.9 5 ± 0.21 EAG/mg extract. Total flavonoids were 0.19 ± 0.02 EQ/g and 0.13 ± 0.04 EQ/g for *C. laciniata* and *C. monogyna*, respectively. They also determined the antioxidant values of aqueous extracts of *C. monogyna* and *C. laciniata* as 0.34 ± 0.03 mg/mL and 0.47 ± 0.04 mg/mL and the ascorbic acid values as 0.13 ± 0.03 mg/mL and 0.05 ± 0.03 mg/mL, respectively. Çoklar and Akbulut (2016) conducted a study to determine the changes in antioxidant activity, total phenolic content, and phenolic profile of naturally grown hawthorn

(*Crataegus orientalis*) fruits in Konya-Beyşehir. As a result, they determined the total phenolic content as 818.3, 974.2, and 1957.4 mg GAE 100 $g^{-1}$ and the antioxidant activity as 52.85±1.81, 31.74±1.09 and 22.75±2.26 mmol trolox equivalent dry weight, respectively, according to the 2,2-diphenyl-1-picrylhydrazyl (DPPH) antioxidant activity method.

According to the results of vitamin C content in previous years, Gürsoy (2016) reported 17.91-35.17 mg/100 g, Koşar (2017) reported 17.00 mg 100 $g^{-1}$ to 64.00 mg 100 $g^{-1}$, Keles (2018) reported 19.57-67.19 mg/100 g, Yanar (2021) reported 19.1 mg/100 g-0.9 mg/100 g and Guo & Jiao (1995) reported that vitamin C content of hawthorn cultivars grown in China varied between 52-74 mg/100 g in fresh fruit flesh.

## Conclusion

There are many hawthorn populations in different regions of Turkey. Each region has hawthorn genotypes with their own characteristics. These areas should be studied and hawthorn genotypes with superior characteristics should be protected. In order to popularise the consumption of hawthorn fruit, it is very important to produce products suitable for the industry. In this way, products with high added value will be developed, and the attention of the producers will be attracted. The nutritional value of hawthorn is impressive, and its vinegar, in particular, has become a highly valuable product. Hawthorn fruit is very convenient for fresh consumption due to its rich content of bioactive components. For this reason, hawthorn, which is consumed in the form of various products, especially vinegar, is also valued as a nutrient with its rich content of many minerals and vitamins. Due to the phytochemical content of hawthorn and its ease of industrial processing, it is necessary to work with genotypes with the highest phytochemical content in future studies, which have been preserved by appropriate methods and whose content characteristics can be preserved.

In this context, the study to determine some pomological and chemical properties of hawthorn genotypes grown in Kayseri and Ankara ecology was carried out in 2022-2023. Soluble solids content, pH, titratable acidity, total phenolics, total flavonoids, vitamin C, antioxidants, and anthocyanins analyses were carried out on the samples of all genotypes, and the highest values were obtained from genotype S. The genotype that was found to be promising in our research can be valuable as gene source material for future breeding studies.

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