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# Some important physicochemical and bioactive characteristics of the main apricot cultivars from Turkey

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**Abstract:** Turkey is one of the world's leading producers in both in fresh and dried apricots, and Malatya Province is the capital for apricots. In the present study, the fruit of 13 apricot cultivars (Adilcevaz, Alkaya, Aprikoz, Çataloğlu, Hacıhaliloğlu, Hasanbey, İsmailağa, Kabaaşı, Mahmuduneriği, Soğancı, Şam, Şekerpare, and Tokaloğlu-Erzincan), grown together at the Apricot Research Institute in Malatya Province, were harvested and evaluated for some important physicochemical and bioactive characteristics. The results showed statistically significant differences in most of the physicochemical and bioactive characteristics. Fresh apricot fruit peel color values, *L*, *a*, and *b*, were determined as between 48.66 and 64.70, 8.12and 22.82, and 16.50and 38.67, respectively. The fruit, the dry matter (DM), pH, titratable acidity, reducing sugar, sucrose, total sugar, total phenolic content, lycopene, β-carotene, vitamin A, vitamin E and vitamin C contents were between 13.05% and 23.12%, 3.68 and 5.04, 0.22% and 1.40%, 2.02 and 5.40 g/100 g, 1.83 and 3.97 g/100g, 4.96 and 8.04 g/100 g, 24.60 and 50.69 mg GAE/mg fresh weight, 3.84 and 17.89 mg/100g, 19.59 and 40.53 mg/100g, 0.13 and 0.67 µg/g, 15.67 and 22.12 µg/g, and 1.41 and 8.16 µg/g, respectively. Antioxidant activity was determined using 3 different methods, β-carotene bleaching, trolox equivalent antioxidant capacity (TEAC), and 2,2-Diphenyl-1-picrylhydrazyl hydrate (DPPH). The antioxidant capacity varied according to the methods used. The results showed that apricot fruit had high antioxidant activity and varied according to methods used, and was rich in carotenoids and phenolic substances, which have positive effects on human health and can be consumed as a functional food.

**Keywords:** Antioxidants, apricot, cultivar, content, diversity

## 1. Introduction

Turkey has the potential for growing manyfruit species, including apricots, due to its diverse soil and climate conditions (Altindag et al., 2006; Ozturk et al., 2009). The country dominates the world in fresh and dry apricot production, with approximately 810,000 tons of fresh and 145,000 tons of dried apricot production in 2017. Turkey alone meets nearly 24% of the world's fresh apricot production and 68% of the dried apricot production (FAO, 2018).

Apricot trees and cultivation are spread across most of the agricultural regions of Turkey, except for the Black Sea region and the high plateau of the eastern Anatolian region (Ercisli, 2009). The best environment conditions forapricot trees are in the central eastern Anatolian region, including Malatya Province, where nearly half of the apricot crops in Turkey are produced. The other important apricot growing areas in Turkey are Elazig Province, the Erzincan Plain, Aras Valley, Aegean region, and Mersin Province (Ercisli, 2009; Halasz et al., 2010). The ecological conditions in Malatya are perfect for dried apricots, which is the main economical source of the province. Almost the entire fresh apricot crop in Malatya is processed as dried fruit and nearly 90%–95% of the dried apricots produced are exported (Ercisli, 2009).

Apricot (*Prunus armeniaca L.*) fruit are consumed as a fresh, dried, and processed product,and have positive effects on human nutrition and health (Kan, 2005; Ozsahin and Yilmaz, 2010; Coban, 2018).

Different amounts of sugar, acids, certain vitamins, proteins, and antioxidants, such as carotenoids and polyphenols, play an important role in creating the nutritional value, color, and taste of apricots. The positive effects of apricots on health are due to the antioxidant effect of polyphenols and carotenoids, and their suppression of chronic diseases (Rice-Evans et al., 1997; Vinson et al., 1998; Gardneret al., 2000; Karatas and Kamisli, 2007; Leccesse et al.. 2007; Akin et al., 2008; Ali et al., 2011). Apricots havehigh antioxidant activity (Sakooei-Vayghan et al., 2020). Antioxidants play a protective role in the

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prevention of many diseases (cardiovascular diseases, cancer, type-2 diabetes, and inflammation). Many phenolic acids play an active role in eliminating free radicals because they have higher levels of antioxidant activity than β-carotene and vitamin C (Kan and Karaat, 2009). It has been reported that apricots are a functional food for strengthening the defense mechanism of the body against free radicals, delaying aging, and protecting the body from diseases, and could be recommended for consumption to improve health and quality life (Lichou et al., 2003; Akin et al., 2008; Ozsahin and Yilmaz, 2010; Ali et al., 2011; Sakooei-Vayghanet al., 2020).

Apricot is a fruit that is highly rich in carotenoids. β-carotene makes up more than 50% of the carotenoids in apricots (Radi et al., 1997; Sass-Kisset al., 2005; Dragovic-Uzelacet al., 2007; Akin et al., 2008). Apricots also contain α-carotene, γ-carotene, zeaxanthin, and lutein (Radi et al., 1997; Fraser and Bramley, 2004; Dragovic-Uzelacet al., 2007).

The aim of this study was to determine certain physicochemical and bioactive properties of 13 major apricot cultivars (Adilcevaz, Alkaya, Aprikoz, Çataloğlu, Hacıhaliloğlu, Hasanbey, İsmailağa, Kabaaşı, Mahmuduneriği, Soğancı, Şam, Şekerpare, and Tokaloğlu-Erzincan), grown together,at the Malatya Apricot Research Institute in Malatya Province, Turkey.

## 2. Materials and methods

The fruit were harvested in 2011from apricot varieties at the Malatya Apricot Research Institute. The meteorological data of 2011 for Malatya are given in Table 1.A total of 13 apricot cultivars (Adilcevaz, Alkaya, Aprikoz, Çataloğlu, Hacıhaliloğlu, Hasanbey, İsmailağa, Kabaaşı, Mahmuduneriği, Soğancı, Şam, Şekerpare, and Tokaloğlu-Erzincan) were used. The trees were 15 years old and grafted on wild apricot seedlings. Approximately 1 kg of fruit was harvested for each cultivar. The analysis was done with 4 replicates.

### 2.1. Physicochemical analysis

The apricots were placed on a white background and the color values of the skin were determined as *L*, *a*, and *b* using a Minolta CR-200 chromameter (Konica Minolta, Inc., Tokyo, Japan) based on 3-dimensional color measurement. The dry matter (DM), pH, and titratable acidity were determined according to the method of Cemeroğlu (2009), the pH was determined using a WTW inolab 720 pH meter (Xylem Analytics Germany Sales GmbH & Co. KG., Weilheim, Germany), titratable acidity, expressed as a percentage of the malic acid, was determined with 0.1 N NaOH up to a pH of 8.1.Total sugar, invert sugar, and sucrose contents were analyzed using the Lane-Eynon method (Cemeroğlu, 2009). The concentration of total phenolics extract of the apricots was determined using the Folin-Ciocalteau colorimetric method (Slinkard and Singleton, 1977). The antioxidant capacity of the apricots was determined using 3 different methods, comprising the β-carotene bleaching method, as described by Kaur and Kapoor (2002), with some modifications; the 2,2-Diphenyl-1-picrylhydrazyl hydrate (DPPH) method of Pokorny et al. (2001), and trolox equivalent antioxidant capacity (TEAC) method of Re et al. (1999).

### 2.2. Bioactive content

#### 2.2.1. β-carotene and lycopene analysis via high-performance liquid chromatography

β-carotene and lycopene contents of the apricots were determined via high-performance liquid chromatography (HPLC) (Sadler et al., 1990). The HPLC system, with a diode array detector (DAD) and HP-Agilent 1100 modular system gradient pump (Agilent Technologies, Inc., Santa Clara, CA, USA), was used in the analyses. First, 10 g of fresh apricots were weighed. They were then passed through a mincing machine twice. For extraction, 10 g of apricots were weighed and 30 mL of water was added and homogenized at 13,500 rpm for 2 min. Next, 2 g of homogenate was weighed and 0.2 g of $CaCO_3$ was

**Table 1.** Climatic data for Malatya Province in 2011.

| Climatic data | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly average temperature (°C) | 0.8 | 5.0 | 8.7 | 14.6 | 19.2 | 24.2 | 26.7 | 27.3 | 21.7 | 14.2 | 10.7 | 0.0 |
| Monthly maximum temperature (°C) | 12.1 | 16.2 | 20.7 | 28.8 | 30.7 | 37.9 | 37.5 | 37.0 | 34.4 | 28.3 | 20.8 | 10.7 |
| Monthly minimum temperature (°C) | –9.6 | –4.5 | –3.9 | 5.7 | 9.5 | 12.6 | 16.1 | 18.4 | 11.2 | 4.0 | 1.7 | –8.2 |
| Monthly total precipitation (mm) | 62.4 | 52.2 | 20.1 | 39.6 | 77.3 | 10.8 | 0.0 | 0.2 | 17.1 | 12.9 | 25.1 | 11.3 |

added. A mixture of methanol (MeOH) and tertiary-butylmethylether (TBME) (65:35 v/v) was used as the mobile phase solution. These solutions also contained 0.1% butylated hydroxytoluene (BHT). Prepared solutions were kept in an ultrasonic bath for 10 min and degassed. A mixture of hexane, acetone, and ethanol (50:25:25, v/v/v), containing 0.1% BHT, was prepared as the extraction solution. In the analysis, a reverse phase $C_{30}$ column (250 mm × 4.6 mm, 5 µm particle size) and an appropriate protection column (10 mm × 4.0mm, 5 µm particle size) were used. Chromatography conditions comprised an elution time of 30 min, wavelength of 471 nm, flow rate of 1 mL/min, column temperature of 30 °C, and injection volume of 100 µL. The lycopene and β-carotene peaks that formed in the chromatograms of the samples were defined by comparing the arrival time of the standard substances and UV spectrometry. Whether the carotenoid peaks in the samplecontained impurity was determined by comparing the spectrum obtained for the sample with the spectrum of the standard substance. The concentration of lycopene or β-carotene was calculated by determining their peak areas in the chromatograms obtained from the prepared standard solution and the sample extract injected into the HPLC device.

**2.2.2. Analysis of vitamins A and E by HPLC**

Vitamin A and E contents of the samples were determined using the HPLC method (Catignani, 1983; Miller et al., 1984). First, 10 g of fresh apricots were weighed. They were then passed through a mincing machine twice. Next, 1 g of homogenized apricot sample was weighed and 4 mL of ethanol was added and centrifuged at 4500 *g* for 5 min at 4 °C. It was then filtered through Whatman No.1 filter paper and 0.15 mL of n-hexane was added. Vitamins A and E were evaporated from the hexane phase with nitrogen flow and the extracts were collected. The dry extract was dissolved in 0.2 mL of methanol and injected into the HPLC device. A reverse phase $C_{18}$ column (250mm × 4.6mm, 5 µm particle size) and an appropriate protection column (10mm × 4.0mm, 5 µm particle size) were used for the analysis. The vitamin A reading was performed at 326 nm and the vitamin E reading was performed at 296 nm, with a flow rate of 1 mL/min. A mixture of methanol:aceto nitrile:chloroform (47:42:11) was used as the mobile phase. Vitamin A and E peaks in sample chromatograms were defined by comparing the arrival time of the standards and UV spectrometry.

**2.2.3. Ascorbic acid (vitamin C) analysis by HPLC**

Vitamin C analysis of the samples was performed by modifying the methods of Lee and Coates (1999), and Poyrazoglu et al. (2002). The HPLC system, with a DADandHP-Agilent 1100 modular system gradient pump, was used in the analyses. First, 10 g of fresh apricots were weighed, passed through a mincing machine twice, and homogenized. Next, 1 g of homogenized apricot sample was weighed and 5 mL of 2.5% metaphosphoric acid solution was added. The mixture was centrifuged at 6500 *g* for 10 min at 4°C, and then, 0.5 mL of supernatant was taken and topped up to 10 mL with 2.5% metaphosphoric acid solution. As a next step, 10 µL of sample was then injected into the HPLC device. In the analysis, a reverse phase $C_{18}$ column (250mm×4.6mm, 5µm particle size) and an appropriate protection column (10mm×4.0mm, 5µm particle size) were used. Chromatography conditions comprised an elution time of 15 min, wavelength of 245 nm, flow rate of 0.5 mL/min, column temperature of 35 °C, and injection volume of 10 µL. For the mobile phase, 2% $KH_2PO_4$ (pH 2.4) was used. Vitamin C peaks in the chromatograms of the samples were defined by comparing the time of arrival of standard ascorbic acid and UV spectrometry.

**2.3. Statistical analysis**

Results obtained with 4 replicates and were evaluated using SPSS Statistics for Windows 13.0 (SPSS Inc., Chicago, IL, USA) and subjected to ANOVA and the Duncan multiple range test, and the data were presented as the mean ± SD.

## 3. Results and discussion

**3.1. Physicochemical properties of the apricots**

ANOVA analysis results of the physicochemical and bioactive properties of the fresh apricots of 13 cultivars are given in Table 2 and the Duncan multiple range test results are given in Table 3. It was seen that the DM contents of the apricot cultivars were statistically significantly different at $P < 0.01$ (Table 2). According to the Duncan multiple range test results, the lowest DM content was found in the Şamcultivar at 13.05%,while the highest content was in the Soğancı cultivar at 23.12% (Table 3). Physicochemical properties of fruit differed depending on various factors, such as the cultivar, cultivation practices, and ecological conditions (Ercisli et al., 2008; Ersoy et al., 2018a; Ersoy et al., 2018b). Changes in the DM contents of the apricots were due to the cultivars, which grew together under the same ecological conditions. The DM content is an important criterion for determining whether the fruit should be dried or consumed fresh (Akin et al., 2008). According to the results of this study, the DM contents of the fresh apricots were between 13.05% and 23.41%. It was determined that this change in the DM contents was caused by the different apricot cultivars used in the study. Similar results were obtained in previous studies (Pala and Saygi, 1994; Yildiz 1994; Akin et al., 2008).The results indicated that the Alkaya, Hacıhaliloğlu, Çataloğlu, Hasanbey, Kabaaşı, Mahmuduneriği, and Soğancı cultivars had higher DM contents and were suitable for drying.

It was observed that the pH values of the apricots significantly differed among the cultivars ($P < 0.01$) (Table

**Table 2.** ANOVA analysis results of some physicochemical and bioactive properties of the fresh apricots.

| Variation sources | | Apricot cultivar (F) |
|---|---|---|
| DM (%) | | 19.125** |
| pH | | 0.487** |
| Titratable acidity fresh fruit (%) | | 0.358** |
| Reducing sugar (g/100 g) | | 2.751** |
| Sucrose (g/100 g) | | 0.985** |
| Total sugar (g/100 g) | | 3.077** |
| Phenolic compounds (µg GAE/mg of sample) | | 118.532** |
| Antioxidant activity | β-carotene bleaching (%) | 53,086** |
| | TEAC ($IC_{50}$, mg/mL) | 2670,794** |
| | DPPH ($IC_{50}$, mg/mL) | 3342,142** |
| Vitamins | Vitamin A (µg/g) | 0,051** |
| | Vitamin C (µg/g) | 6,227** |
| | Vitamin E (µg/g) | 9,621** |
| Carotenoids | β-carotene (mg/100g) | 89,780** |
| | Lycopene (mg/100g) | 28,403** |
| *L* value | | 71.045** |
| *a* value | | 39.312** |
| *b* value | | 156.479** |

Means within the same line followed by the same letter were not statistically significant ($P < 0.05$).

**Table 3.** Physicochemical properties of the apricots (mean ± SD).

| Cultivar | DM (%) | pH | Titratable acidity (%) | Reducing sugar (g/100 g) | Sucrose (g/100 g) | Total sugar (g/100 g) | *L* | *a* | *b* |
|---|---|---|---|---|---|---|---|---|---|
| Adilcevaz | 16.45 ± 0.12$^{i}$ | 3.97 ± 0.01$^{h}$ | 1.07 ± 0.01$^{c}$ | 2.02 ± 0.1$^{g}$ | 3.12 ± 0.01$^{abcde}$ | 5.14 ± 0.02ef | 64.70 ± 0.43$^{a}$ | 9.78 ± 0.70$^{de}$ | 36.78 ± 1.47$^{ab}$ |
| Alkaya | 20.32 ± 0.15$^{d}$ | 3.89 ± 0.01$^{i}$ | 0.34 ± 0.01$^{f}$ | 4.35 ± 0.13$^{c}$ | 2.74 ± 0.70$^{cdef}$ | 7.09 ± 0.06$^{bc}$ | 51.17 ± 0.71$^{f}$ | 22.82 ± 3.58$^{a}$ | 23.76 ± 4.67$^{de}$ |
| Aprikoz | 17.02 ± 0.90$^{h}$ | 4.12 ± 0.02$^{g}$ | 0.39 ± 0.00$^{d}$ | 2.42 ± 0.1$^{f}$ | 3.97 ± 0.40$^{a}$ | 6.39 ± 0.41$^{cde}$ | 55.28 ± 0.62$^{e}$ | 9.32 ± 3.42$^{e}$ | 25.11 ± 3.03$^{cde}$ |
| Çataloğlu | 22.91 ± 0.17$^{b}$ | 4.46 ± 0.09$^{e}$ | 0.36 ± 0.02$^{ef}$ | 4.34 ± 0.15$^{c}$ | 3.86 ± 0.04$^{ab}$ | 8.22 ± 0.19$^{ab}$ | 60.51 ± 0.24$^{c}$ | 8.12 ± 0.48$^{e}$ | 38.67 ± 0.06$^{ab}$ |
| Hacıhaliloğlu | 21.86 ± 0.24$^{d}$ | 4.03 ± 0.00$^{a}$ | 0.34 ± 0.01$^{h}$ | 5.40 ± 0.20$^{f}$ | 3.55 ± 0.24$^{abc}$ | 8.95 ± 0.70$^{cde}$ | 63.68 ± 0.77$^{f}$ | 8.84 ± 0.62$^{cd}$ | 42.45 ± 1.03$^{e}$ |
| Hasanbey | 20.70 ± 0.16$^{c}$ | 5.04 ± 0.03$^{h}$ | 0.22 ± 0.01$^{f}$ | 2.41 ± 0.08$^{a}$ | 3.75 ± 1.40$^{abcd}$ | 6.36 ± 1.29$^{a}$ | 50.49 ± 0.70$^{ab}$ | 14.37 ± 1.79$^{e}$ | 18.06 ± 0.40$^{a}$ |
| İsmailağa | 18.86 ± 0.22$^{f}$ | 4.98 ± 0.00$^{ab}$ | 0.25 ± 0.00$^{g}$ | 3.12 ± 0.23$^{e}$ | 1.83 ± 0.24$^{f}$ | 4.96 ± 0.48$^{f}$ | 57.09 ± 1.22$^{d}$ | 9.96 ± 0.04$^{de}$ | 31.59 ± 10.24$^{bcd}$ |
| Kabaaşı | 22.18 ± 0.16$^{c}$ | 4.87 ± 0.14$^{c}$ | 0.38 ± 0.00$^{de}$ | 5.38 ± 0.10$^{a}$ | 2.66 ± 0.14$^{def}$ | 8.04 ± 0.25$^{ab}$ | 60.82 ± 0.88$^{c}$ | 12.46 ± 1.76$^{cde}$ | 34.09 ± 3.01$^{abc}$ |
| Mahmuduneriği | 23.12 ± 0.15$^{ab}$ | 4.63 ± 0.01$^{d}$ | 0.40 ± 0.00$^{d}$ | 4.78 ± 0.13$^{b}$ | 2.82 ± 0.04$^{bcdef}$ | 7.64 ± 0.21$^{bc}$ | 48.84 ± 0.55$^{g}$ | 17.06 ± 1.74$^{bc}$ | 16.50 ± 2.67$^{e}$ |
| Soğancı | 23.41 ± 0.41$^{a}$ | 4.37 ± 0.02$^{f}$ | 0.27 ± 0.00$^{g}$ | 3.74 ± 0.21$^{d}$ | 3.34 ± 0.44$^{abcd}$ | 7.05 ± 0.62$^{bc}$ | 55.54 ± 0.26$^{de}$ | 11.91 ± 0.12$^{e}$ | 21.89 ± 0.65$^{e}$ |
| Şam | 13.05 ± 0.04$^{i}$ | 3.75 ± 0.01$^{i}$ | 1.30 ± 0.00$^{b}$ | 2.52 ± 0.06$^{f}$ | 2.23 ± 0.15$^{ef}$ | 5.24 ± 0.92$^{def}$ | 62.78 ± 0.57$^{b}$ | 14.45 ± 4.34$^{cd}$ | 36.61 ± 7.73$^{ab}$ |
| Şekerpare | 19.71 ± 0.42$^{e}$ | 4.96 ± 0.01$^{b}$ | 1.40 ± 0.02$^{a}$ | 3.45 ± 0.07$^{d}$ | 3.97 ± 0.05$^{a}$ | 7.42 ± 0.12$^{bc}$ | 48.66 ± 0.19$^{g}$ | 19.41 ± 0.36$^{ab}$ | 19.72 ± 0.20$^{e}$ |
| Tokaloğlu (Erzincan) | 17.67 ± 0.56$^{g}$ | 3.68 ± 0.02$^{j}$ | 0.22 ± 0.01$^{h}$ | 2.69 ± 0.12$^{f}$ | 3.81 ± 0.03$^{ab}$ | 6.51 ± 0.08$^{cd}$ | 63.70 ± 0.24$^{ab}$ | 11.48 ± 0.45$^{de}$ | 36.76 ± 0.33$^{ab}$ |

Different small letters in the same parameters represent statistically significant differences among the cultivars ($P < 0.05$).

2), and the pH values of the apricot cultivars varied between 3.68 and 5.04 (Table 3), with the lowest pH found in the Tokaloğlu (Erzincan) cultivar, while the highest was found in the Hasanbey cultivar (Table 3). In previous studies, the pH values of apricots were reported as 3.64–4.99 (Pala and Saygi, 1994), 3.83–6.61 (Akin et al., 2008), and 3.80–5.20 (Ali et al., 2011).

The taste of the fruit depends on the acid/sugar ratio and may change depending on the cultivar and type of fruit. It was found that the apricot cultivars significantly affected the titration acidity, at $P < 0.01$ (Table 2), which varied between 0.22 and 1.40%, expressed as malic acid (Table 3). The acid contents of apricots are high in early-ripening cultivars and low in late-ripening cultivars. The predominant acid in apricots is malic acid and in some cultivars, malic acid and citric acid can be in equal amounts (Akin et al., 2008). In studies conducted on different apricot cultivars, Kaska et al. (1989) found that the titration acidity of apricot cultivarswas between 0.7% and 1.2%, expressed as malic acid. Durgaç and Kaska (1995) found that the acid content of Bebeco apricot cultivar was 1.36%, expressed as malic acid. Pala and Saygi (1994) found that the titration acidity, expressed as malic acid, was 0.12%–1.38% among apricot cultivars. Akin et al. (2008) found that total acidity, expressed as malic acid, varied between 0.08% and 0.28% in apricot cultivars. The titration acidity values determined in the current study were generally similar to those of other studies.

Thereducing sugar content was lowest in the Adilcevaz cultivar,at 2.02 g/100 g, while the highest amount was obtained as 5.40 g/100 g in the Hacıhaliloğlu cultivar. The sucrose content was highest in the Aprikoz and Şekerpare cultivars (3.97 g/100 g), while the lowest was in the İsmailağa cultivar (1.83 g/100g) (Table 3). The total sugar content was highest in the Hacıhaliloğlu cultivar (8.95 g/100g), while the lowest was in the İsmailağa cultivar (4.96 g/100 g) (Table 3). It was observed that 70%–85% of the dry substance content of the apricots was composed of sugar, such as glucose, fructose, and sucrose, but the amount of sugar increased rapidly as the fruit ripened.

Fruit skin (peel) color was measured on fresh apricots and the peel color measurements revealed that the *L* value was between 48.66 and 64.70, and the Adilcevaz cultivar was lighter in color, while the Şekerpare cultivar had darker in color. It was determined that the *a* values of the apricots ranged from 8.12 to 22.82 and the *b* values ranged between 16.50 and 38.67 (Table 3). According to the determined *a* values, it can be said that the peel color of the Alkaya cultivar (22.82) was more reddish than those of the other cultivars. Considering the *b* values, it was clear that yellow was dominant in the apricots and this is caused by the carotenoids that they contained.

The total phenolic contents in the apricots were statistically significant at $P < 0.01$ (Table 2), and varied between 20.25 and 50.69 μg GAE/mg fresh weight (FW) (Table 4). The total phenolic contents reported by Çavuşoğlu et al. (2020) showed similarities to the values obtained as a result of the storage of the apricots in 2020, at the beginning of storage. In addition, when compared to other fruit, the apricots had higher total phenolic contentsthan mulberry and quince, and lower total phenolic contents than plums.

It was found that there were statistically significant ($P < 0.01$) differences between the antioxidant capacity of the apricots determined via the β-carotene bleaching method and apricot varieties that inhibited bleaching of β-carotene, by 70.14%–85.46% (Table 4). BHA was used as the standard substance and the antioxidant activity was determined as 92.23% at 100 mg/L.

The antioxidant capacity of the fresh apricot samples, determined via the TEAC method, was 5.24–20.23 μg/mL in terms of the trolox equivalent. According to the Duncan multiple range test results, the Aprikoz cultivar had the highest activity, while the Kabaaşı cultivar had the lowest (Table 4).

DPPH radical scavenging activity was determined as 5.75–21.51μg/mL in terms of the $IC_{50}$. The lowest activity was found in the Aprikoz cultivar, while the highest was found in the Kabaaşı cultivar (Table 4).

A negative correlation ($r = -0.512$) was found between the β-carotene bleaching method and the TEAC method ($P < 0.01$). The reason for this was that the TEAC method generally shows hydrophilic compounds in food, whereas the β-carotene bleaching method shows lipophilic compounds (Rufino et al., 2010).

The lycopene contents of the apricots were significantly different, at $P < 0.01$, among the cultivars (Table 1). The Adilcevaz cultivar had the lowest lycopene content, at 3.84 mg/100g, whereas the highest amount was in the Çataloğlu cultivar,at 17.89 mg/100g (Table 5). The carotenoid compound contents in the fruit varied according to various factors, such as the cultivar, species, growing conditions, and maturity stage (De Rigal, 2000).

The HPLC chromatogram of the standard β-carotene and lycopene contents is given in Figure 1, the HPLC chromatogram of the β-carotene and lycopene contents of the Çataloğlu cultivar is given in Figure 2, and the HPLC chromatogram of the β-carotene and lycopene contents of the Şekerpare cultivar is given in Figure 3.

The lycopene and β-carotene peaks formed in the chromatogram of the samples were defined by comparing the arrival time and UV spectra of the standard substances. Whether the carotenoid peaks in the sample contained impurities was determined by comparing the spectrum obtained for the sample with the spectrum of the standard substance.

**Table 4.** Phenolic contents and antioxidant activity of the apricots.

| Apricot cultivar | Total phenolic content (µg GAE/ mg of sample) | Antioxidant capacity | | |
|---|---|---|---|---|
| | | β-carotene bleaching (%) | TEAC ($IC_{50}$, mg/mL) | DPPH ($IC_{50}$, mg/mL) |
| Adilcevaz | 28.08 ± 0.31$^{i}$ | 84.16 ± 4.89$^{ab}$ | 11.00 ± 0.01$^{g}$ | 12.13 ± 0.00$^{de}$ |
| Alkaya | 35.47 ± 0.30$^{d}$ | 85.42 ± 3.69$^{a}$ | 7.35 ± 0.00$^{j}$ | 7.43 ± 0.02$^{f}$ |
| Aprikoz | 50.69 ± 0.31$^{a}$ | 85.46 ± 3.40$^{a}$ | 5.24 ± 0.01$^{k}$ | 5.75 ± 0.01$^{g}$ |
| Çataloğlu | 26.00 ± 0.43$^{i}$ | 82.72 ± 4.08$^{abc}$ | 10.80 ± 0.02$^{h}$ | 12.45 ± 0.01$^{de}$ |
| Hacıhaliloğlu | 36.78 ± 0.30$^{h}$ | 74.01 ± 0.04$^{de}$ | 9.58 ± 0.00$^{b}$ | 9.83 ± 0.02$^{e}$ |
| Hasanbey | 29.38 ± 0.31c | 72.07 ± 2.60$^{cde}$ | 15.65 ± 0.01$^{i}$ | 16.46 ± 0.04$^{b}$ |
| İsmailağa | 31.56 ± 0.31$^{e}$ | 79.38 ± 072$^{abcd}$ | 13.12 ± 0.01$^{d}$ | 14.58 ± 0.02$^{bc}$ |
| Kabaaşı | 24.60 ± 0.30$^{j}$ | 75.84 ± 6.17$^{bcde}$ | 20.23 ± 0.02$^{a}$ | 21.51 ± 0.12$^{a}$ |
| Mahmuduneriği | 28.08 ± 0.31$^{i}$ | 75.02 ± 1.95$^{cde}$ | 11.00 ± 0.21$^{f}$ | 12.82 ± 0.14$^{de}$ |
| Soğancı | 20.25 ± 0.30$^{k}$ | 70.14 ± 0.29$^{e}$ | 13.30 ± 0.00$^{c}$ | 16.70 ± 0.31$^{b}$ |
| Şam | 30.25 ± 0.30$^{g}$ | 78.93 ± 2.89$^{abcde}$ | 11.00 ± 0.01$^{f}$ | 12.53 ± 0.00$^{d}$ |
| Şekerpare | 30.91 ± 0.00$^{f}$ | 76.23 ± 4.87$^{bcde}$ | 9.86 ± 0.02$^{i}$ | 10.20 ± 0.00$^{e}$ |
| Tokaloğlu (Erzincan) | 39.60 ± 0.00$^{b}$ | 74.08 ± 4.87$^{cde}$ | 11.31 ± 0.01$^{e}$ | 12.71 ± 0.04$^{de}$ |
| BHA | - | 92.23 ± 4.17$^{a}$ | - | - |
| Trolox | - | - | 18.65 ± 0.01$^{m}$ | 29.90 ± 0.21$^{h}$ |

Different capital letters for the same cultivars represent statistically significant differences among the methods (β-carotene bleaching, TEAC, DPPH) ($P < 0.05$).

**Table 5.** Lycopene, β-carotene, and vitamin levels of the apricots.

| Apricot cultivar | Lycopene (mg/100g) | β-carotene (mg/100g) | Vitamin A (µg/g) | Vitamin E (µg/g) | Vitamin C (µg/g) |
|---|---|---|---|---|---|
| Adilcevaz | 3.84 ± 0.14$^{j}$ | 28.68 ± 0.00$^{e}$ | 0.17 ± 0.01$^{j}$ | 15.67 ± 0.02$^{l}$ | 2.27 ± 0.01$^{f}$ |
| Alkaya | 4.20 ± 0.01$^{i}$ | 19.59 ± 0.10$^{j}$ | 0.67 ± 0.01$^{a}$ | 16.89 ± 0.03$^{i}$ | 1.76 ± 0.02$^{i}$ |
| Aprikoz | 4.13 ± 0.01$^{i}$ | 30.34 ± 0.21$^{c}$ | 0.20 ± 0.02$^{i}$ | 17.43 ± 0.01$^{h}$ | 8.16 ± 0.01$^{a}$ |
| Çataloğlu | 17.89 ± 0.00$^{a}$ | 31.16 ± 0.45$^{b}$ | 0.20 ± 0.00$^{i}$ | 17.12 ± 0.00$^{i}$ | 1.43 ± 0.01$^{j}$ |
| Hacıhaliloğlu | 4.64 ± 0.24$^{i}$ | 29.23 ± 0.18$^{i}$ | 0.23 ± 0.00$^{i}$ | 21.78 ± 0.00$^{f}$ | 2.24 ± 0.00$^{h}$ |
| Hasanbey | 4.20 ± 0.10$^{f}$ | 20.12 ± 0.34$^{d}$ | 0.19 ± 0.01$^{g}$ | 18.54 ± 0.04$^{b}$ | 1.80 ± 0.00$^{g}$ |
| İsmailağa | 5.14 ± 0.12$^{e}$ | 20.69 ± 0.24$^{i}$ | 0.27 ± 0.03$^{c}$ | 21.31 ± 0.01$^{c}$ | 2.26 ± 0.41$^{f}$ |
| Kabaaşı | 4.32 ± 0.30$^{h}$ | 22.62 ± 0.15$^{g}$ | 0.25 ± 0.01$^{f}$ | 16.65 ± 0.11$^{j}$ | 1.41 ± 0.01$^{k}$ |
| Mahmuduneriği | 5.98 ± 0.03$^{d}$ | 40.53 ± 0.34$^{a}$ | 0.25 ± 0.01$^{e}$ | 19.65 ± 0.21$^{d}$ | 2.59 ± 0.02$^{d}$ |
| Soğancı | 4.43 ± 0.07$^{g}$ | 23.45 ± 0.00$^{f}$ | 0.20 ± 0.02$^{h}$ | 22.12 ± 0.15$^{a}$ | 1.58 ± 0.01$^{i}$ |
| Şam | 4.20 ± 0.00$^{i}$ | 30.34 ± 0.01$^{c}$ | 0.13 ± 0.01$^{k}$ | 18.89 ± 0.01$^{e}$ | 2.31 ± 0.02$^{e}$ |
| Şekerpare | 7.70 ± 0.02$^{b}$ | 37.50 ± 0.10$^{ab}$ | 0.58 ± 0.01$^{b}$ | 15.87 ± 0.20$^{k}$ | 3.42 ± 0.01$^{b}$ |
| Tokaloğlu (Erzincan) | 6.65 ± 0.25$^{c}$ | 21.89 ± 0.41$^{h}$ | 0.26 ± 0.00$^{d}$ | 17.78 ± 0.02$^{g}$ | 3.01 ± 0.07$^{c}$ |

Different small letters for the same parameters represent statistically significant differences among the cultivars($P < 0.05$).

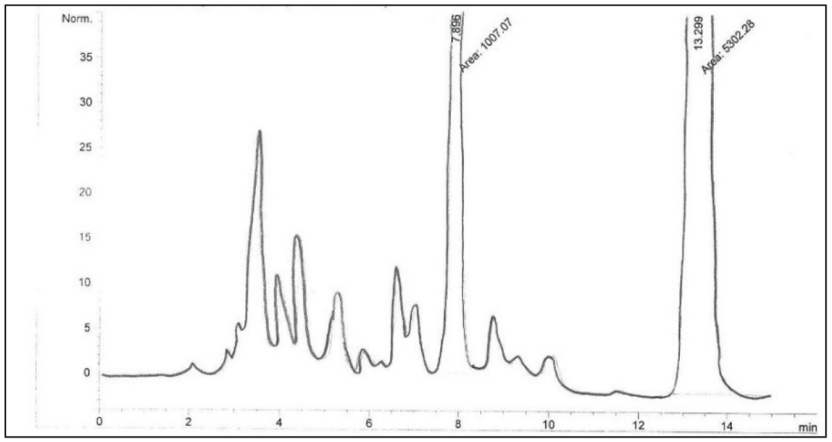


**Figure 1.** HPLC chromatogram of β-carotene and lycopene (Pik 1: lycopene, Pik 2: β-carotene).

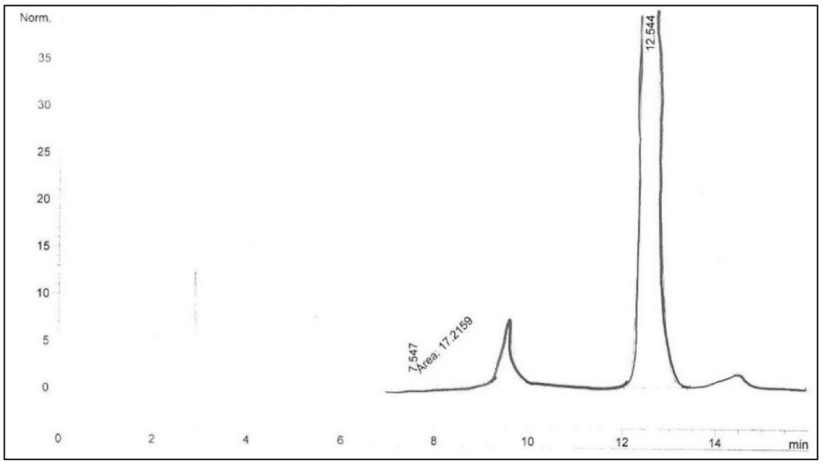


**Figure 2.** HPLC chromatogram of the β-carotene and lycopene contents of the Çataloğlu apricot cultivar (Pik 1: lycopene, Pik 2: β-carotene).

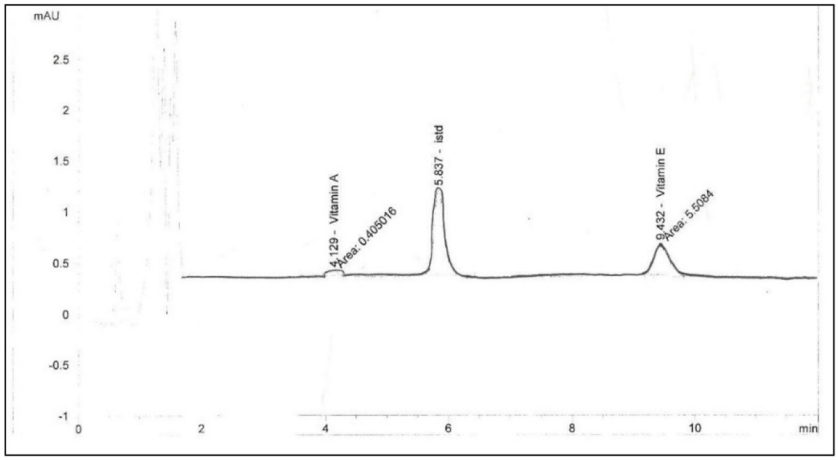


**Figure 3.** HPLC chromatogram of the β-carotene and lycopene contents of the Şekerpare apricot cultivar (Pik 1: lycopene, Pik 2: β-carotene).

It was determined that the β-carotene contents of the apricot varieties varied between 19.59 and 40.53 mg/100g ($P < 0.01$). The highest β-carotene content was in the Mahmuduneriği cultivar, whereas the lowest was in the Alkayacultivar (Table 5). The recommended daily intake (RDI) value for β-carotene recommended by the German Nutrition Agency is 2 mg, and the recommended amount by the American National Cancer Institute is 5–6 mg. Apricots are one of the most important sources of carotenoids with provitamin A activity. It has been reported that 250 g of fresh or 30 g of dried apricot meet all of the recommended daily amounts of provitamin A (De Rigal et al., 2000).

The vitamin A, C, and E contents in the apricots of the cultivars were significant, at $P < 0.01$ (Table 2). The vitamin Acontentwas highest (0.67 µg/g) in the Alkayacultivar,whileit was lowest (0.13 µg/g) in the Sam cultivar.On the other hand, the lowest vitamin E content was 15.67 µg/g in the Adilcevaz cultivar,while the highest was 22.12 µg/g in the Soğancı cultivar (Table 5).

The standard HPLC chromatogram of vitamins A and E is given in Figure 4, the HPLC chromatogram of vitamins A and E in the Çataloğlu cultivar is given in Figure 5, and the HPLC chromatogram of vitamins A and E in the Şekerpare cultivar is given in Figure 6.

The vitamin C content was lowest in the Kabaaşı cultivar and highest in the Aprikoz cultivar (Table 5). When the vitamin contents of the fresh apricots were examined, vitamin A was between 0.13 and 0.67 µg/g, vitamin E was between 15.67 and 22.12 µg/g, and vitamin C was between 1.41 and 8.16 µg/g.

Stone fruit apricot and peach generally have a high rate of ascorbic acid in the fleshy part of the fruit (Heinonen, 2002). In previous studies, the vitamin C contents in apricots were reported as 67.2 mg/100g FW (Bolin and

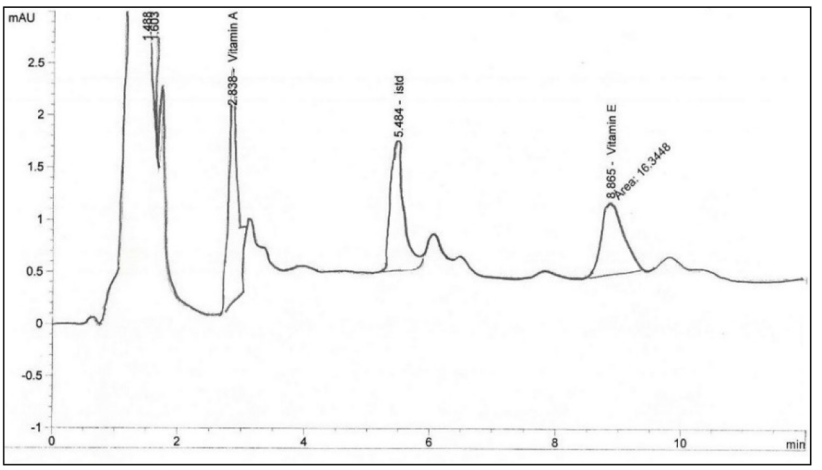


**Figure 4.** Standard HPLC chromatogram of vitamins A and E(Pik 1: vitamin A, Pik 2: vitamin E).

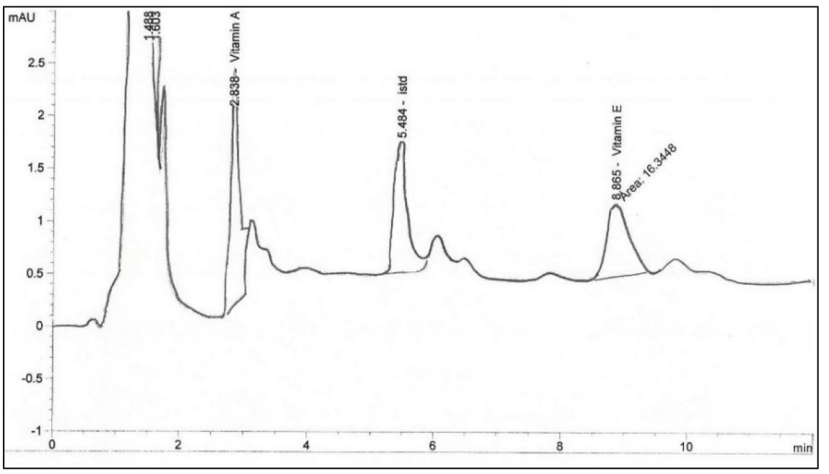


**Figure 5.** HPLC chromatogram of vitamins A and E in the Çataloğlu apricot cultivar (Pik 1: vitamin A, Pik 2: vitamin E).

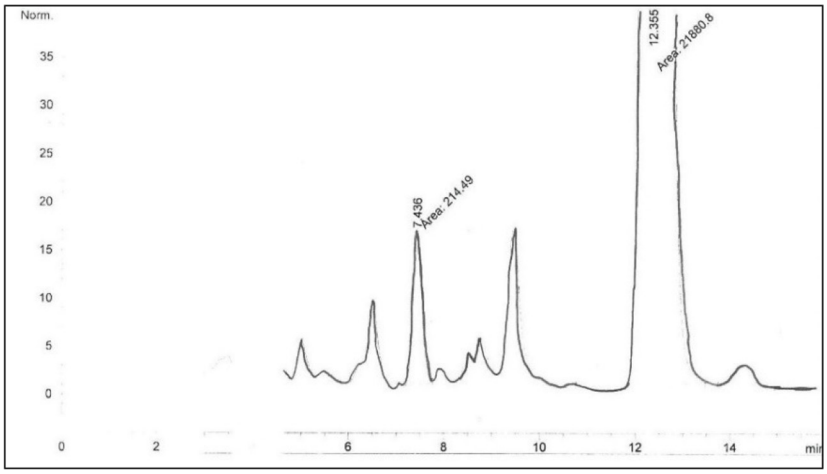


**Figure 6.** HPLC chromatogram of vitamins A and E in the Şekerpare apricot cultivar (Pik 1: vitamin A, Pik 2: vitamin E).

Stafford, 1974) and 1.8–2.7 µg/g (Munzuroglu et al., 2003). In a study conducted by Akin et al. (2008) on some apricot cultivars, vitamin C contents were 37.7 mg/100g dry weight (DW) in the Hacıhaliloğlu cultivar, 49.3 mg/100g in the Hasanbey cultivar, 28.5 mg/100g in the Soğancı cultivar, 41.6 mg/100g in the Kabaaşı cultivar, 20.6 mg/100g in the Çöloğlu cultivar, and 27.9 mg/100g in the Çataloğlu cultivar.

## 4. Conclusion

In the current study, it was found that the Alkaya, Hacıhaliloğlu, Çataloğlu, Hasanbey, Kabaaşı, Mahmuduneriği, and Soğancı apricot cultivars had high DM contents and were suitable for drying, while the other cultivars were more suitable for fresh consumption. In addition, it was observed that the apricots had high antioxidant capacity, and was rich in carotenoids and phenolic contents, which have positive effects on human health and can be consumed as a functional food.

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