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Evaluation of Nutritional Content in Wild Apricot Fruits for Sustainable Apricot Production

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Abstract: Apricot (*Prunus armeniaca* L.) trees are common from Asia to North America and have been used for delicious and nutritious fruits for centuries. Wild apricot trees show great environment plasticity and are free of pest and disease traits, both of which are important for sustainable apricot production. However, wild apricots are more common in Asia and North African countries. Wild apricot trees and fruits show great variability due to seed propagation characteristics. Seeds of wild apricots are used as rootstocks for apricot cultivars, in particular in main apricot producer countries such as Turkey, Uzbekistan, and Iran. Fruits of wild apricots are also an important food in wild apricot growing countries and add value as a sustainable nutrition source. In the present study, a total of 14 wild apricots widely grown in inner Anatolia were characterized by morphological (fruit weight, flesh/seed ratio, fruit firmness, and color index), nutritional (individual sugars and organic acids) and nutraceutical (total phenolic, total flavonoids, total carotenoid, and antioxidant activity) features. The obtained results showed that wild apricot genotypes differed from each other for most of the morphological, nutritional, and nutraceutical characteristics. The genotypes were found pest- and disease-free and had fruit weight, flesh/seed ratio, and fruit firmness of between 18.24 and 27.54 g; 8.96 and 12.44; and 4.05 and 6.03 kg/cm^2, respectively. Citric acid was the dominant organic acid for fruits of all wild apricot genotypes, and ranged from 923 to 1224 mg/100 g. Sucrose was the highest soluble sugar in fruits for all wild apricots, and ranged from between 6.80 and 8.33 g/100 g. Moreover, the level of nutraceutical parameters also varied among genotypes and high amounts of total phenol and antioxidant activity were obtained in fruit extracts of IA8 genotype as 81.4 mg gallic acid equivalent per 100 g and 2.44 µmoL trolox equivalent per g, respectively. Different wild apricot genotypes are rich in certain nutritional and nutraceutical compounds, with significant variations in their levels being observed. The aim of the study was to evaluate fruits of wild apricot genotypes in terms of their total phenolics, antioxidants, and other bioactive compounds for use in future breeding programs and sustainable food and pharma industries.

Keywords: wild apricot; diversity; content; nutrition

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1. Introduction

Fruits have long been consumed due to the benefits they provide to human survival and well-being. They possess a high content of non-nutritive, nutritive, and bioactive compounds such as flavonoids, phenolics, anthocyanins, phenolic acids, and as well as nutritive compounds such as sugars, essential oils, carotenoids, vitamins, and minerals. Different fruit groups have distinct flavors and taste, excellent medicinal value and health care functions as well [1–4].

Prunus is one of the large genera in the plant kingdom and includes about 250 species with important fruit crop representatives such as apricots, almonds, sweet and sour cherries, peaches, and plums [5,6]. They possess long natural propagation periods; mutations have occurred during this long growing period and artificial cultivation leads to a great genetic diversity among cultivars, accessions, and genotypes within *Prunus* [7–9].

The genus representatives can be found in almost every country and continent. They have been recognized not only for their delicious fruits and nuts, but also because of their beneficial properties. To date, numerous cultivars have been phytochemically studied, which has led to the identification of various compounds including flavonoids, phenolic acids, carotenoids, fatty acids, and so on [10–12]. Pharmacological studies on *Prunus* species have also revealed a variety of bioactive potentials including antioxidant, anti-inflammatory, hypolipidemic, antidiabetic, brain protecting, and other evidence-based uses [13–15].

Apricot trees representatives are largely distributed in many countries and their fruits have been highly cherished for their delicious flavors. Apricot fruits not only have a delicious taste, alluring smell, and vivid colors, but also numerous nutritional properties due to their rich content of vitamin C, β-carotene, thiamine, riboflavin, niacin, and pantothenic acid, as well as phenols, carotenoids, and tocopherols [16]. The apricot fruit (*Prunus armeniaca* L.) is considered a good source of total phenolics, flavonoids, and bioactive compounds that have health applications [9,16].

Apricot fruits show a presence of magnesium, calcium, iron, zinc, and copper in larger quantities [17]. The fruits are rich for five different phenolic compounds (chlorogenic acid, syringic acid, quercetin 3-rutinoside, catechin, and epicatechin) [18]. The apricot is known to be a rich source of carotenoids, especially β-carotene, which represents 50% of the total carotenoids in the fruit [19,20]. Sucrose was the predominant sugar in the apricot fruits at harvest. Quercetin-3-rutinoside may be substantially responsible for the antioxidant capacities of the fruits [21].

The growing of apricots has increased steadily and has reached 3.8 million tons world production, however, the production area remains stable [22]. Among the apricot producers, Turkey dominates world apricot production and has had a yearly average of 600–800 thousand tons production for a long time, supplying 20% of world production. The other important producers are Uzbekistan, who supply 13% of world production, and Iran, who supply 9% of world production [22].

Wild apricot trees, called Zerdali in Turkey, have diverse fruit and tree characteristics, and are common in most of the apricot growing areas in Turkey [10]. All wild apricot trees are obtained from seeds, namely from an ungrafted situation [23]. There have been no commercial wild apricot orchards in the country from past to date and all wild apricot trees in general grow as solitary trees at the field borders [23,24]. In Turkey, the majority of wild apricot trees are found in middle and eastern Anatolia, including Nigde, Nevsehir, Kayseri, Sivas, Malatya, and Elazig in the country. In particular, wild apricots are abundant in the Aras valley and the Erzincan plain, etc., ranging between 500 and 1650 m above sea level [25].

The fruits of wild apricot trees are quite variable compared to apricot cultivars and have different fruit shapes, maturation times, fruit colors, tastes, and aroma characteristics. They have sweet-sour taste in general and are very suitable for industrial processing due to a better sugar/acid ratio [10]. Local people prefer wild apricot fruits in Turkey, and seek to obtain very special apricot products such as ‘pestil’, or ‘kome’, etc. The people also use it after drying and, due to better rheological and aroma characteristics, process it into jam, fruit juice, and marmalade [23,26,27].

In Turkey, each apricot growing region has its own apricot cultivars, and interregional cultivar transfer generally results in negative adaptation. Because apricot cultivars show low environmental adaptability, the introduction of foreign germplasm may also result in fluctuating or limited yield. However wild apricots have a high environmental plasticity. Thus, wild apricots are very important for sustaining apricot product demand in Turkey [23,27].

Wild apricots are a very important source of adapted plant material, especially when unfavorable climatic and soil conditions are present [10,23]. Once established, they are adapted to local dry conditions and their care is easier than their cultivated relatives. There is some indication that new markets for specialty native fruits may be expanding.

Wild apricot fruits have remarkable roles in and contributions to Turkish diets and food security [10,23,27]. The utilization and knowledge of wild apricots as a nutritional source is confined to local people. A detailed literature review into the morphological, nutritional, and nutraceutical content of the wild apricots consumed in the Turkey has not currently been detailed. Thus, this study appears to be the first to validate the detailed morphological, nutritional, and nutraceutical content of selected wild apricot genotypes from Turkey.

2. Materials and Methods

2.1. Plant Samples

A total 80 fruits per tree were sampled from different parts of wild-grown apricot trees in inner Anatolia in 2018's fruiting season. The examined 10 genotypes were pre-selected according to higher yield, pest- and disease-free trees, and more attractive, larger fruit characteristics. Special attention was given that harvest and fruits were harvested in the same period with the same degree of maturity. Harvested fruits were sorted and cleaned. Mature and healthy fruits were transported to the laboratory and divided into two equal parts for morphological measurements and nutritional and nutraceutical analysis. Figure 1 shows some varieties with different genotypes.

Figure 1. Wild apricot samples (Figures are original).

2.2. Morphological Parameters

For morphological measurements (weight, flesh/seed ratio, fruit firmness, and fruit color coordinates), a total of 40 fruits selected among 80 fruits per genotype were used for color coordinates (L, a and b values). Fruit weight (g) was measured with a digital scale sensitive to 0.01 g (Scaltec SPB31). Fruit firmness was determined with non-destructive Acoustic Firmness Sensor (Aweta B.V., The Netherlands) expressed as kg/cm^2. Color coordinates (L^*, a^* and b^*) of fruit skin were determined by a Konica Minolta, CR-400 Plus fruit colorimeter (Konica Minolta, Inc., Chiyoda City, Tokyo, Japan) at four different positions around the equator of the fruits [28].

2.3. Nutritional and Nutraceutical Composition

2.3.1. Sample Preparation and Extraction

The fruits were introduced to a High-Speed Pulp Ejection Juicer (Omega Products International, Corona, CA, USA), allowing the separation of pomace and juice. The juice was stored at −80 °C until its use for nutritional and nutraceutical content. During the analysis, the frozen fruits were taken and thawed to 24–25 °C. A laboratory blender was used to homogenize the fruit samples (100 g lots of fruits per genotype) and a single extraction procedure (taking 3 g aliquots transferred inside tubes and extracted for 1 h with 20 mL buffer including acetone, water (deionized), and acetic acid (70:29.5:0.5 *v*/*v*) was used [29].

2.3.2. Organic Acids

Organic acid composition in fruits of Sekerpare apricot clones was determined by [30]. Organic acid readings were performed by HPLC using the Aminex column (HPX-87 H, 300 mm × 7.8 mm, Bio-Rad Laboratories, Richmond, CA, USA) at 214 and 280 nm wavelengths in the Agilent package program (Agilent, Santa Clara, CA, USA). Results expressed as mg/100 g.

2.3.3. Determination of Soluble Sugars

For soluble sugars (fructose, glucose, and saccharose) analyses, the method of Melgarejo et al. [31] was used. The HPLC analysis was conducted using a PerkinElmer HPLC system with Amino NH_2 column (Waters), and 85% acetonitrile/15% H_2O (*v*/*v*) as a mobile phase. Refractive index detector (RID) was used. Samples were identified and quantified by standards. Results were expressed as g/100 g fw. To specify the sweetness perception of 40 fruits per clones, their sweetness indices (*SI*) were calculated due to Roussos et al. [32]. The *SI* index considers the relative sweetness as a factor of each of the three sugars measured. It is described in the following Equation (1): where *Glu* stands for glucose concentration, *Fru* for fructose concentration, and *Sacch* stands for saccharose concentration.

$$SI = 1.00 \times Glu + 2.3 \times Fru + 1.35 \times Sacch \quad (1)$$

2.3.4. Total Phenol Content

The total phenolic content (TPC) of the samples was evaluated using the Folin–Ciocalteu method according to [33]. The total phenolic content was calculated against the reference standard calibration curve of gallic acid. The TPC was expressed as mg of gallic acid equivalents (GAE) per 100 g of fresh sample.

2.3.5. Total Carotenoid Content

The total carotenoid content was determined by Lichtenthaler [34]. For total carotenoid content, 1 g of fruit sample was homogenized with 5 mL of acetone in a cold porcelain mortar in an ice bath. Then 1 g of anhydrous sodium sulfate (Na_2SO_4) was added to the homogenate, which was elutriated using a paper filter. The filtered solution was made up to 10 mL with acetone and centrifuged at 2600× *g* for 10 min. The upper phase was collected and the absorbance of the solution at 662, 645, and 470 nm was measured. Acetone was used as control. Total carotenoid content was expressed as mg per 100 g fresh fruit sample.

2.3.6. Antioxidant Capacity

TEAC (Trolox Equivalent Antioxidant Capacity) value of each sample was detected according to the method described by Rice-Evans et al. [35]. A total of 7 mM ABTS reagent solutions were prepared and diluted with sodium acetate ($C_2H_3NaO_2$) until 0.700 ± 0.01 spectrophotometrical absorbance level at 734 nm. Following this, 2.97 mL buffered solution was mixed with 30 µmoL fruit extract and kept in the dark at room temperature for 10 min, and measured for their absorbance levels at 734 nm using spectrophotometer. Obtained results were calculated according to TEAC standard calibration curve and expressed as µmoL of trolox equivalent/g fresh fruit weight (µmoL TE/g FW).

2.4. Statistical Analysis

All the experiments were repeated in four replications and the data recorded for different morphological, nutritional, and nutraceutical parameters were analyzed in order to discover which of the genotypes showed a statistically significant difference at 5% level using one-way analysis of variance (ANOVA) and LSD test at $p \leq 0.05$ level of probability with SPSS Software (Release 15.0; SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

3.1. Morphological Features

Fruit weight, flesh/seed ratio, fruit firmness (Figures 2–4), and color coordinates (L, a, b) were used as morphological features of 10 wild apricot genotypes (Table 1).

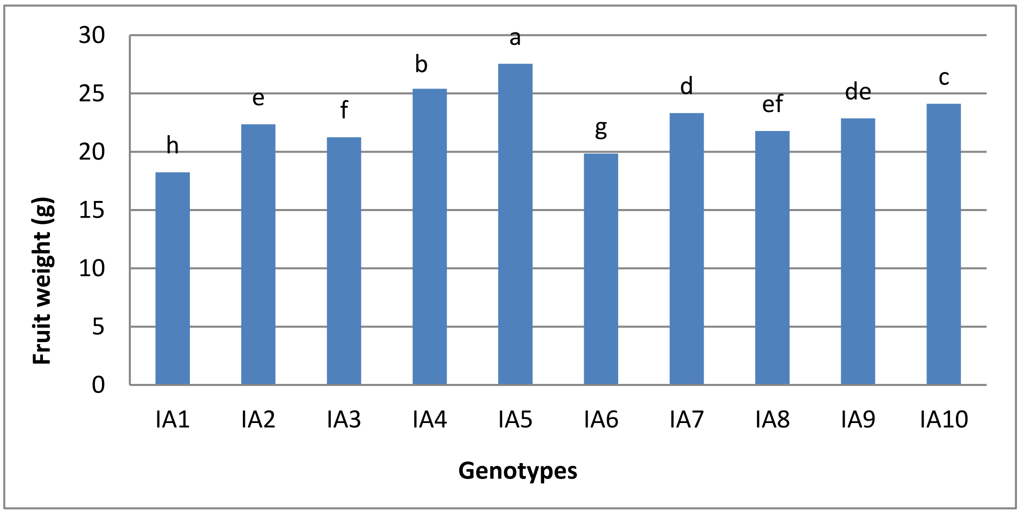

Figure 2. Fruit weight of 10 wild apricot genotypes.

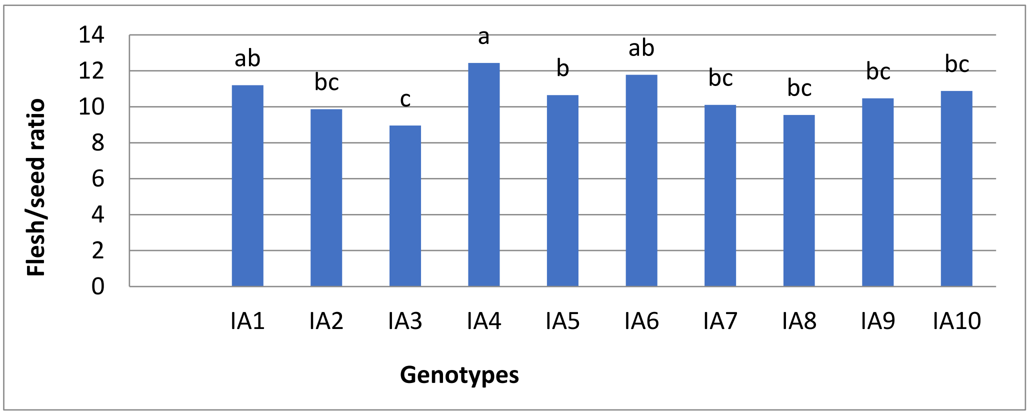

Figure 3. Flesh/seed ratio of 10 wild apricot genotypes.

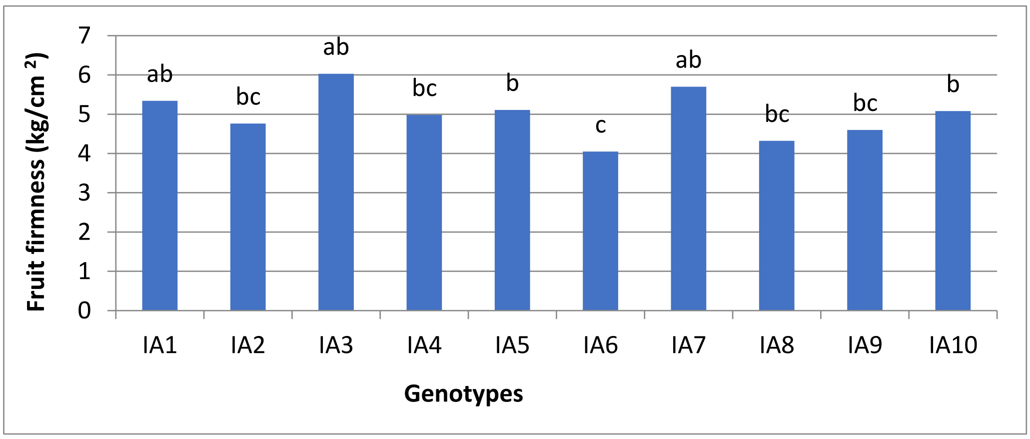

Figure 4. Fruit firmness of 10 wild apricot genotypes.

Table 1. Fruit skin color parameters of 10 wild apricot genotypes.

Genotypes	*L**	*a**	*b**	Ground Color	Red Blushed Skin
IA1	52.72 cd	11.37 cd	46.11 ab	Orange	Exist
IA2	56.24 bc	10.44 d	39.11 c	Dark yellow	Absent
IA3	58.11 b	12.24 c	44.22 b	Dark yellow	Exist
IA4	53.44 cd	9.44 de	46.89 ab	Orange	Exist
IA5	49.14 e	11.15 cd	48.56 a	Dark yellow	Absent
IA6	60.14 ab	13.23 bc	41.23 bc	Yellow	Exist
IA7	51.27 d	9.89 de	47.55 ab	Orange	Exist
IA8	54.32 cd	15.33 ab	42.12 bc	Light orange	Exist
IA9	61.07 a	14.12 b	40.33 bc	Yellow	Exist
IA10	55.31 c	16.32 a	44.78 b	Dark orange	Exist

Different letters in the same column indicate significant differences ($p < 0.05$) among genotypes.

There were statistically significant differences ($p < 0.05$) among genotypes for fruit weight, flesh/seed ratio, and fruit firmness (Figures 2–4).

The highest fruit weight was observed in genotype IA5 as 27.54 g, followed by IA4 as 25.40 g and IA10 as 24.12 g, while the lowest fruit weight was evident in IA1 genotype as 18.24 g (Figure 2). The obtained fruit weight results were comparable to a previous study conducted in Turkey, because all Turkish apricot cultivars have a relatively small-to-medium fruit weight changing from 25 g to 40 g [36–39]. Turkish national apricot cultivars have a relatively small fruit size and previous studies indicated this fact. In the main apricot growing region, namely, Malatya in Turkey, fruit weights were found in the range of 21.16–38.24 g [40]. In another study conducted on 12 wild apricots in the northeastern part of Turkey, fruit weight was reported between 18.56 and 34.28 g [41]. In another study conducted, Turkish national apricot cultivar Cagataybey and Sekerpare cultivars and fruit weight were found as 25.12 g and 25.65 g, respectively [42], which is in agreement with the present fruit weight results. Fruit weight is one of the most important properties in markets of fresh apricots and determines consumer acceptance.

Fruit flesh/seed ratio of the 10 wild apricot genotypes were found between 8.96 (IA3) and 12.44 (IA4), respectively (Figure 3). The higher flesh/seed ratio are preferred by both producers and consumers of apricot. In Turkey, the flesh/seed ratio of apricot was reported as 12:02 [10]. Yaman [43] reported the flesh/seed ratio among apricot cultivars between 9.98–16.16, which is in accordance with the present results. Ilhan et al. [41] used 12 wild apricots in northeastern part of Turkey and reported flesh/seed ratio between 8.96–13.30. Akca and Asma [44] found flesh/seed ratio between 12.38 and 16.64 among several clones of cv. Kabaasi in Turkey. In addition, flesh/seed ratios of the foreign apricot cultivars introduced to Turkey and grown in Mediterranean region varied between 8.9 and 21.8 [45,46]. Consumers prefer apricots with a high ratio of flesh and a very small number of seeds.

The fruit firmness values of wild apricot genotypes are in descending order 6.03 kg/cm^2 (IA3) > 5.70 kg/cm^2 (IA7) > 5.34 kg/cm^2 (IA1) > 5.11 kg/cm^2 (IA5) > 5.08 kg/cm^2 (IA10) > 4.98 kg/cm^2 (IA4) > 4.76 kg/cm^2 (IA2) > 4.60 kg/cm^2 (IA9) > 4.32 kg/cm^2(IA8) > 4.05 kg/cm^2 (IA6); respectively (Figure 4). Caliskan et al. [47] found the fruit firmness values between 1–4.3 kg/cm^2 for early apricot cultivars in Mediterranean areas in Turkey and present results indicated that wild apricots are suitable for fresh consumption [48].

All wild apricot genotypes were found to be pest- and disease-free. This is very important for sustainable apricot production. Consumers primarily choose unsprayed apricots because of the perceived health benefits, including reduced exposure to pesticide residue as compared to conventionally produced apricots. These genotypes could be important to use in organic apricot production because reduced pesticide exposure for growers and consumers of organic produce can be attributed to prohibition of the use of synthetic pesticides on organic farms, as well the as use of safer alternatives such as biopesticides and biologically derived substances, when needed.

Table 2 presents L^*, a^* and b^* peel (skin) color coordinates of 10 wild apricots. The all-peel color results indicated statistically significantly differences among genotypes at $p < 0.05$ for L^*, a^* and b^* values.

Table 2. Organic acids in fruits of 10 wild apricot genotypes (mg/100 g).

Genotypes	Citric Acid	Malic Acid	Ascorbic Acid	Tartaric Acid
IA1	1224 ab	441 ab	18.4 b	4.2 ^{NS}
IA2	1167 ab	502 ab	21.5 ab	4.7
IA3	1114 ab	380 c	20.6 ab	5.4
IA4	1268 a	397 bc	20.2 ab	3.1
IA5	1087 b	567 a	18.8 b	6.1
IA6	965 bc	515 ab	22.2 ab	5.0
IA7	982 bc	470 b	19.6 ab	6.8
IA8	923 c	495 abc	23.6 a	6.2
IA9	1035 bc	544 ab	19.4 ab	4.4
IA10	996 bc	450 ab	21.0 ab	5.3

Different letters in the same column indicate significant differences ($p < 0.05$) among genotypes; NS: Nonsignificant.

The 10 wild apricot fruits showed quite variable L^*, a^*, and b^* values. The L^*, a^*, and b^* values were observed between 49.14 (IA5)–61.07 (IA9); 9.44 (IA4)–16.32 (IA10) and 39.11 (IA2)–48.56 (IA5), respectively (Table 1). Previously Karaat [16] indicated L^*, a^*, and b^* values in apricot fruit as 64.17, 14.07, and 42.27, respectively, which is in accordance with our results. Karatas and Sengul [49] found L^*, a^*, and b^* values of 13 main apricot cultivars grown in Turkey between 48.66–64.70; 8.12–19.41 and 18.06–42.45, respectively. In India L^*, a^*, and b^* values of six international apricot cultivars were between 52.10–71.51; 1.03–39.85; and 40.56–62.94, respectively [50]. These results reveal that growing conditions and genetic background strongly affect peel color coordinates of apricots.

The most important attribute of any food's appearance is its color, especially when it is directly associated with other food-quality attributes, for example the changes that take place during the ripening of fruit or the loss in color quality as food spoils or becomes stale.

Considering 10 wild apricots, 3 genotypes had dark yellow, 3 genotypes had orange, 2 genotypes had yellow, 1 genotype had light orange, and 1 genotype had dark orange peel color (Table 1). Results implied that yellow and orange was dominant in the apricots, and this is caused by the carotenoids that they contained.

Most of the genotypes (eight) had red blushed skin (Table 1). Because of light penetration, apricot cultivars produce red blushed skin, which is preferred by consumers. Anthocyanins are responsible for the blushed skin of apricots [51]. Apricots with a blush on orange or yellow skin are becoming more and more popular in the market due to their colorful appearance and excellent nutritional value [52].

3.2. Nutritional Contents

3.2.1. Organic Acids

The literature about the nutritional composition of wild apricots is scarce, particularly regarding organic acids. Table 2 shows the results obtained for the organic acid composition in all of the wild apricot samples, and differentiates the wild apricot samples according to the genotypes considered. Significant differences were observed for all these parameters, except tartaric acid in the mean concentrations or values among the wild apricot genotypes. The wild apricot fruits were slightly acidic compared to cultivated apricots [23].

Wild apricot fruits dominantly included citric acid between 923–1268 mg/100 g, followed by malic acid (380–567 mg/100 g), ascorbic acid (18.4–23.6 mg/100 g), and tartaric acid (3.1–6.8 mg/100 g) (Table 2). Previously, Alajil et al. [50] revealed that citric acid was dominant in apricot fruits and comprised 55% of the organic acids in apricot fruits and ranged from 550 to 1170 mg/100 g, followed by malic acid, which comprised approximately 25% of the organic acids and ranged from 400 to 1430 mg/100 g; these results indicate similarities with this study. In another study, Fan et al. [49] presented that malic acid was mainly responsible for sourness of apricots, although malic acid was not the prominent organic acid in all apricot cultivars. Previous studies also indicated the cultivar- and genotype-dependent organic acid content of apricot fruits [50,53–55].

Apricot (*Prunus armeniaca* L.) is an important temperate fruit crop widely appreciated by consumers for its nutritional and organoleptic properties. The improvement of fruit quality is one of the major breeding objectives for matching a highly competitive market. Among the quality attributes, flavor plays a pivotal role in consumers' degree of liking, which results from a combination of taste and aroma. Apricots' taste primarily depends on sugars and, particularly, organic acids, which affect overall sweetness other than aroma perception. Organic acids' content and profile widely differ between cultivars and the quantitative nature of their inheritance complicates the breeding and selection procedures [56].

3.2.2. Soluble Sugars and Sweetness Indices

Table 3 shows soluble sugars of 10 wild-grown apricots. In accordance with the findings of this study, the major sugar was sucrose, followed by glucose and fructose in fruits of the 10 investigated wild apricot genotypes, which varied between 6.80 g/100 g and 8.33 g/100 g; 1.85 g/100 g and 3.04 g/100 g; and 0.58 g/100 g and 1.11 g/100 g, respectively. With respect to the outcomes of the analysis of variance (ANOVA), a significant impact of genotype ($p < 0.05$) has been noted in the sucrose and glucose (Table 3).

Table 3. Soluble sugars (g/100 g) and sweetness indices (SI) in fruits of 10 wild apricot fruits.

Genotypes	Sucrose	Glucose	Fructose	Sweetness Indices (SI)
IA1	7.03 de	2.09 ab	0.95 ^{NS}	13.77 ab
IA2	6.80 e	2.56 ab	0.77	13.51 ab
IA3	7.44 cd	1.85 b	0.63	13.34 b
IA4	8.33 a	2.44 ab	0.58	15.02 ab
IA5	6.97 de	2.95 ab	1.04	14.75 ab
IA6	7.77 bc	3.04 a	0.85	15.49 a
IA7	7.55 cd	2.80 ab	1.11	15.54 a
IA8	7.23 d	2.78 ab	0.67	14.08 ab
IA9	8.02 b	2.40 ab	0.80	15.07 ab
IA10	7.64 c	2.21 ab	0.60	13.90 ab

Different letters in the same column indicate significant differences ($p < 0.05$) among genotypes; NS: Non-Significant.

The results revealed that the genotypes IA4, IA9, and IA10 with 8.33 g/100 g, 8.02 g/100 g, and 7.64 g/100 g, respectively, contained the highest percentage of sucrose (Table 3). On the other hand, the genotypes IA5 and IA2 with 6.97 g/100 g and 6.80 g/100 g indicated the lowest sucrose. Kargi et al. [57] used 21 apricot genotypes grown in Malatya province in Turkey and found that sugar composition of apricot genotypes was different from one genotype to another, and sucrose was the major sugar in apricot fruits, followed by glucose and fructose. In India, Alajil et al. [50] used a number of apricot cultivars and reported sucrose as a major sugar, which accounted for more than 63% of total sugars and ranged from 4.15 to 10.13 g/100 g; glucose contributed about 22% of total sugars and ranged from 2.28 to 4.31 g/100 g; and fructose contributed about 15% of total sugars and ranged from 1.22 to 4.19 g/100 g, which is in accordance with our results. Saridas and Agcam [58] reported sucrose, glucose, and fructose content between 5.33 and 8.57; 1.90 and 2.95; and 0.60 and 0.88 g/100 g, respectively, in apricot cultivars in Eastern Turkey. Imrak et al. [59] found that the dominant sugar in apricot cultivars grown in Mediterranean area was sucrose. Karatas and Sengul [49] reported sucrose as the main sugar in apricot cultivars in Turkey. Su et al. [60] reported that in apricot fruits, sucrose was the main sugar, followed by glucose and fructose. Genard et al. [61] reported the order of individual sugars in apricot fruits depending on their content was in descending order sucrose > glucose > fructose for all cultivars.

Carbohydrates as one of the main sources of energy as well as their amount of sugar is important in the controlled diet of the diabetic patients [62]; providing information on the sugar composition and content in horticultural plants has gained increasing attention over the years. Furthermore, due to the significant influence of processing practices on different soluble sugars, a need for information on the amount of sugar has gained increasing interest for the food processing industry in order to optimize the processing conditions [63].

The sweetness indices (SI) in fruits of 10 wild-grown apricots were found to be between 13.34 and 15.54 (Table 4). Previously, the sweetness index (SI) ranged from 13.58 to 22.30 in apricot fruits grown in India [50]. In another study conducted in Greece, the sweetness index of early maturated apricot cultivars ranged from 8.16 to 11.25 [32] and in Spain it was found to be between 8.5 and 15.9 in a number of apricot cultivars [64]. Our findings are consistent with the above published studies. The sweetness is important not only to apricot consumers but also for breeders, and it also leads to market acceptance of the apricot fruits [47,65].

Table 4. Nutraceuticals in fruits of 10 wild apricot genotypes (fresh weight basis).

Genotypes	Total Phenolic Content (mg GAE/100 g)	Total Flavonoids (mg CE/100 g)	Total Carotenoid (mg/100 g)	TEAC (μmoL TE/g)
IA1	72.4 bc	11.2 e	8.42 bc	1.95 bc
IA2	70.1 bc	9.2 g	7.89 bc	1.85 bc
IA3	80.8 ab	14.6 b	7.13 c	2.35 ab
IA4	74.4 b	10.3	8.64 b	1.90 bc
IA5	68.3 c	9.7 f	7.02 cd	1.80 c
IA6	79.6 ab	13.7 c	6.41 cd	2.29 ab
IA7	77.2 ab	12.3 d	9.12 ab	2.11 b
IA8	81.4 a	15.1 a	6.67 cd	2.44 a
IA9	69.3 bc	9.2 g	6.15 d	1.76 bcd
IA10	76.0 ab	11.6 e	9.93 a	2.03 bc

Different letters in the same column indicate significant differences ($p < 0.05$) among genotypes.

3.3. Nutraceutical Compositions

Total Phenolic Content, Total Flavonoids, Total Carotenoids, and Antioxidant Activity

As shown in Table 4, wild apricot fruits statistically differed each other at $p < 0.05$ level for total phenolic, total flavonoid, total carotenoid content, and antioxidant activity.

The total phenolic content in fruits of wild apricot genotypes ranged from 68.3 to 81.4 mg GAE/100 g fresh weight base, representing variation. IA8, IA3, and IA6 had the greatest total phenolic content (81.4, 80.8 and 79.6 mg GAE/100 g FW, respectively), while the lower amounts of total phenolic were found in IA2, IA9, and IA5 genotype (70.1, 69.3, and 68.3 mg GAE/100 g FW, respectively) (Table 4).

In Pakistan, higher and quite variable total phenolic contents (50–220 mg GAE/100 g FW) were reported in eight apricot cultivars grown in stress condition [66]. However, in Turkey, the total phenolic content in wild apricots was found to be between 34.2 and 52.8 mg GAE/100 g [10]. The total phenolic content in a large number of apricot cultivars grown in Hungary ranged from 12.0 to 89.0 mg GAE/100 g [7]. In India, Alajil et al. [50] found cultivar-dependent total phenolic content between 25.31 and 89.95 mg GAE/100 g FW. Phenolic compounds are important plant constituents with redox properties responsible for antioxidant activity [67]. The hydroxyl groups in plant extracts are responsible for facilitating free radical scavenging.

Antiradical activity against $ABTS^+$ expressed as TEAC is presented in Table 4. As presented in Table 4, fruit extracts of IA8, IA3, and IA6 genotypes showed the highest activity with values of 2.44, 2.35, and 2.29 μmoL TE/g, which did not differ statistically from each other ($p < 0.05$), while the lowest $ABTS^+$ scavenging activity was exhibited by IA5 and IA9 fruit extract (1.80 and 1.76 μmoL TE/g). In general, a similar trend was observed for total phenolic content and antiradical activity among genotypes (Table 4). Previously, similar antiradical activity was reported between 1.36 and 4.55 μmoL TE/g in a number of apricot cultivars grown in Italy [68]. Horticultural crops rich in antioxidant components and antiradical activity were found to be cultivar-, genotype- and clone-dependent [68,69].

Fruits of ten wild apricot genotypes had a total flavonoid content between 9.2–15.1 mg CE/100 g (Table 4), indicating approximately 1.5 differences between genotypes that have the highest and lowest flavonoid content. Previous studies also indicated quite variable genotype-dependent total flavonoid content. For example, Saeed et al. [66] found a total flavonoid content between 48–382 mg QE/100 g in apricots. In India, Alajil et al. [50] reported it as being between 5–15 mg CE/100 g, which indicated good agreement with our study. In Italy, Carbone et al. [70] presented total flavonoid content (TFC) in apricot cultivars between 1.9 and 12.0 mg CE/100 g. Wani et al. [71] found TFC values ranging from 12.2 to 36.2 mg/100 g in apricot genotypes grown in India. The fruits of wild apricots revealed the presence of considerable amounts of flavonoids, which supports the antioxidant and nutritional potential of this plant species. In our study, the content of flavonoids differs from one genotype to another.

Total carotenoid content of 10 wild apricot fruits was in the range of 6.15–9.93 mg/100 g, and genotypes exhibited statistically significant differences to each other at $p < 0.05$ level (Table 4). IA10 and IA9 genotypes characterized the highest (9.93 mg/100 g) and lowest (6.15 mg/100 g) total carotenoid values, respectively. The other genotypes' total carotenoid content decreased in the order: IA7 > IA4 > IA1 > IA2 > IA3 > IA5 > IA8. There was discovered a 1.5-fold difference in TEAC obtained from wild apricot fruit extracts (Table 4). In Spain, Ruiz et al. [19] reported a total carotenoid content between 1.5 and 16.5 mg/100 g among diverse apricot cultivars. In Israel, Shemesh et al. [20] reported it between 0.5 and 9.5 mg/100 g among apricot cultivars. In Turkey, Gecer et al. [10] reported total carotenoid content between 1.1 and 12.5 mg/100 g in wild apricots. The above studies are in agreement with present results. Apricots are high in carotenoids, which influence the color and visual appearance of the fruit; the color of the fruit can vary from yellow to orange depending on the carotenoids content [21,67].

Previous studies conducted on different horticultural plants indicate a great biochemical difference among genotypes [72–79].

4. Conclusions

As a conclusion, the present study provides one of the first detailed data describing the morphological, nutritional, and nutraceutical characteristics of a large number of diverse wild apricot genotypes sampled from inner Anatolia. The results indicated considerable variation in most of the phytochemical and fruit quality characters in wild apricot genotypes. The genotypes IA5 and IA4 had the highest fruit weight and IA8 and IA5 had the highest total phenolic content and antiradical activity. Results also indicated the importance of wild apricots in more sustainable apricot production due to their pest- and disease-free characteristics. Therefore, this work represents a valuable source of genotypes to be used in apricot breeding programs. The findings contribute to the improvement of an integrated, effective, and sustainable strategy for apricots.

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