RESEARCH ARTICLE

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The nutritional composition of key apricot varieties cultivated in Türkiye with a focus on health-related compounds

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Abstract
Türkiye's favorable geographical location and diverse climatic conditions provide it an ideal host for a wide range of fruit species. In this content, apricots have garnered significant global attention. In this study, local varieties such as Hasanbey, Hacıhaliloğlu, Kabaaşı, and Şalak were examined, alongside foreign varieties commonly cultivated in coastal regions, specifically Mikado and Mogador. It was found that domestic varieties are notably different from foreign varieties in terms of their health-related components. Fruits from various varieties sourced from significant apricot-producing provinces were investigated. The study revealed a range in total carotenoid content from 5.59 to 10.3 mg/kg, antioxidant activity spanning 478.5 to 1969 mgTE/kg, and total phenol content fluctuating between 122 and 771 mgTE/kg. The 'Şalak' distinguishes itself significantly from others due to its elevated phenolic content, leading to a correspondingly higher level of antioxidant activity. In conclusion, it has been observed that the antioxidant content in this variety is significantly higher (approximately 4 times higher). The study results unequivocally demonstrate that, beyond the significance of cultivation location, genotype plays a pivotal role as an essential determinant in relation to the evaluated quality features.
Keywords: Antioxidant activity, Apricot, Fruit quality, Phenolic content, Total carotenoid

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INTRODUCTION

Based on 2021 data, global apricot production amounted to 3,578,412 tons. Türkiye contributed significantly to this total, producing 800,000 tons, which accounts for nearly 22% of the world's apricot production (FAOSTAT, 2023).

Incorporating fruits into one's diet has been related to a decreased risk of cancer and cardiovascular, stroke disease (Ness and Powles, 1997; Block et al., 1992; Gazino et al., 2010). The myriad phenolic compounds present in apricot fruits are widely acknowledged for their advantageous impact on human health, attributed to their antioxidative, anti-inflammatory features, and immune system-enhancing capabilities (Madrau et al., 2009). Antioxidant capacity and concentrations of individual antioxidant components in fruits are influenced by various factors (Papp et al., 2010). Multiple researchers have documented these factors, encompassing geographical origin, ripening period, and the duration of the fruit development stage (Dragovic-Uzelac et al., 2007; Leccese et al., 2008; Drogoudi et al., 2008). In this highly diverse species, the genotypic structure plays a pivotal role in determining fruit quality parameters. In Türkiye, the selection of genotypes for apricot cultivation is influenced by climatic circumstances. High chilling-requiring genotypes are aptly suited for high-altitude regions, while low chilling-requiring genotypes flourish in the Mediterranean basin, characterized by lower altitudes. Concurrently, indigenous varieties have traditionally been the preference for producing dried apricots, whereas foreign cultivars have been favored for fresh consumption.

In this comprehensive study, a range of widely cultivated apricot varieties, namely Hasanbey, Hacıhaliloğlu, Kabaaşı, Şalak, Magador, and Mikado, were selected based on their prevalence in specific provinces, namely Mersin, Hatay, Elazığ, Malatya, and Iğdır. These provinces were selected due to Türkiye's global leadership in apricot production. The study focused on assessing health-related compounds, namely total carotenoid content, total phenolic content and antioxidant activity.

MATERIALS AND METHODS

Materials

In this study, the materials under investigation comprised apricot varieties that are extensively cultivated in various regions of Türkiye. These included the Hacihaliloğlu, Kabaaşı and Hasanbey varieties, which are commonly grown in Malatya and Elazığ. Additionally, fruits from the Mikado and Mogador varieties sourced from the Hatay and Mersin (Mut) provinces, as well as apricots from Şalak trees in the Iğdır province, were also included in the study (Fig 1).

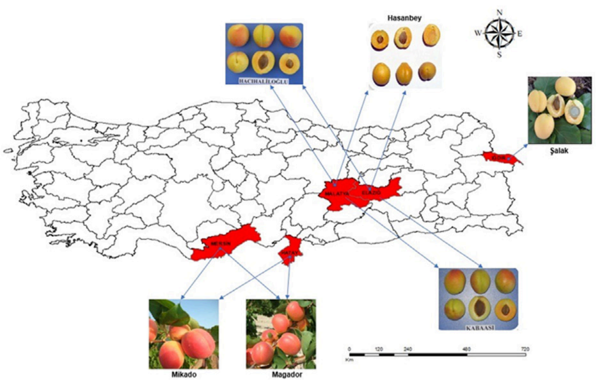

Figure 1. Information on varieties and provinces on the Türkiye map

Methods

In the study, apricot fruits harvested from different provinces during the 2020 growing season were utilized. Two kilograms of fruit from each variety were harvested from trees cultivated under typical farmer conditions and this collection was meticulously timed to align with the appropriate commercial harvest periods. These freshly harvested fruits were expedited to Çukurova University using a cold chain system to maintain their freshness. Upon arrival at the university, the fruit samples underwent biochemical analyses, which were conducted by the Food Engineering Departments. The fruit samples intended for biochemical analysis were stored at -80°C to preserve their integrity until testing.

Biochemical Analysis

Antioxidant Activity (AA) Analysis: In the analysis of AA, Klimczak et al. (2007) made some modifications to the spectrophotometric method proposed by the apricot extract. 5 mL of 80% methanol was added to 5 g of apricots and then centrifugation was performed (4 °C, 6000 rpm for 10 min). In this absorbance analysis, 100 µL of the extract was utilized, and 3000 µL of 1,1-diphenyl-2-picrylhydrazyl (DPPH*; 0.05 g/L in 80% methanol) was introduced. Subsequently, the samples were thoroughly mixed and allowed to incubate in the dark for one hour to achieve reaction equilibrium. Upon completion of this period, the absorbance of the samples was measured against an 80% methanol solution using a spectrophotometer (Perkin Elmer Lambda 25 UV/VIS, Massachusetts, USA, 2005) set to a wavelength of 515 nm. The AA values of the samples were expressed as % inhibition of DPPH* using the following equation.

$$AA\ (\%) = \frac{A_K - A_{\bar{O}}}{A_K} x100$$

AA (%)=(A_K- A_Ö)/A_K x100

AK: The absorbance value of the control

AÖ: The absorbance value of the sample

After determining the inhibition percentages of DPPH*, the DPPH* inhibition percentages of the samples were converted to equivalent gallic acid values using the gallic acid equivalent graph (50-1000 mg/L) created by the same method.

Total Phenolic Content Analysis

Following the crushing of the apricots in a high-speed shredder, 5 g of the resulting mixture was transferred to a 50 mL centrifuge tube, and 45 mL of an 80% MeOH solution was added. Subsequently, the centrifuge tube was vortex-mixed for 30 seconds before initiating centrifugation (6000 rpm, 4 °C, 10 minutes). Following this procedure, the main stock extract for the samples was obtained. Subsequently, 100 µL was drawn from the clear portion, and 200 µL of Folin-Ciocalteau reagent, along with 3000 µL of distilled water, were added, left to stand for 10 minutes. Upon completion of the designated period, 100 µL of 20% Na2CO3 was introduced into the solution, which was then placed in a dark environment for 2 hours. Subsequently, the solution was read against the blank at a wavelength of 765 nm using the Perkin Elmer Lambda 25 UV/VIS spectrophotometer (Massachusetts, USA, 2005). The quantity of phenolic compounds, corresponding to the measured absorbance value in gallic acid within the samples, was determined using the standard curve equation prepared with gallic acid. The total amount of phenolic substances in the samples was expressed as "mg gallic acid/kg." (Abdulkasim et al., 2007).

Total Carotenoid Analysis

The total carotenoid content of apricot samples was assessed using the method developed by Lee et al. (2001). Five grams of apricot pulp was transferred to a Teflon tube, and 10 mL of the extraction solution (hexane: acetone: methanol/50:25:25, with 0.1% BHT content) was added. Subsequent to this procedure, centrifugation (4000 rpm, 10 min, 4 °C) commenced immediately after the application of mixing. Following centrifugation, absorbance was promptly measured at 450 nm without delay. The total carotenoid content is expressed in terms of β-carotene, and the extinction coefficient (E1/2) was considered as 2505 in the calculation.

$$Total\ carotenoid\left(\frac{mg}{100\ g}\right) = \frac{Absorbans * DF}{E^{\frac{1}{2}}} * 1000$$

DF: Dilution Factor $E^{1/2}$= Extinction Coefficient (2505)

Statistical Analysis

Fruit quality parameters were analyzed with three replications, each comprising 30 fruits. The data obtained at the conclusion of the study underwent analysis of variance using the randomized plot design in the JMP statistical package program. Subsequently, averages were compared using the LSD test at significance thresholds of 5%, 1%, and 0.1%.

RESULTS AND DISCUSSION

In this study, the health-related compound contents of select apricot cultivars were investigated. The cultivars were sourced from the top five provinces, renowned for intensive and extensive apricot cultivation. (Fig 1).

Some important health components of apricot varieties harvested from different provinces

Today's consumers are interested not only in the eaten quality of fruits but also in their health composition and levels of these components. In this context, values for total carotenoid content, antioxidant activity and total phenol content are presented in Table 1. In varieties harvested from different provinces, statistically significant differences have been identified in terms of these compounds. In our investigation, the total carotenoid content exhibited a range from 5.59 to 10.3 mg/kg. Notably, the Magador, harvested in Mersin, demonstrated the highest carotenoid content at 10.3 mg/kg. Following this, within the same statistical group, the Hacıhaliloğlu fruit obtained from Malatya province exhibited a carotenoid content of 9.39 mg/kg, while the Hasanbey and Kabaaşı varieties grown in Elazığ province had carotenoid contents of 9.51 mg/kg. The Hasanbey, cultivated in Malatya, displayed the lowest carotenoid content at 5.59 mg/kg. It is evident that the carotenoid levels in varieties, excluding Mikado, are notably impacted by the prevailing cultivation conditions. In this regard, it is necessary to select an appropriate location based on the variety for high carotenoid content. It has been observed that during the ripening of apricots, there is a significant increase in all carotenoid compounds, with a notable surge in β-carotene levels. In commercially ripe fruits, β-carotene levels can escalate up to 10 times compared to their unripe counterparts (Dragovic-Uzelac et al., 2007). In the same study, it was determined that apricots generally cultivated in the Mediterranean region (Neretva Valley) have higher levels of all carotenoids compared to those grown in the continental region (Baranja). As observed in this study as well, it has been partially confirmed that cultivation conditions and the ripeness level of fruits are the key factors determining carotenoid content. In the Şalak variety, where inter-provincial comparison is not possible, the carotenoid content has been determined to be 7.16 mg/kg. In addition to this, it has been determined that apricots with orange-colored flesh have higher carotenoid content compared to apricots with white flesh (Ruiz et al., 2005). Researchers have found carotenoid levels ranging from 1512 to 16500 µg 100 g-1 in the edible parts of 37 apricot varieties in their studies. Rodriguez-Amay (2010), has been reported that these variations in carotenoid levels are associated with genetic, environmental and agronomic factors.

Fruits are rich sources of plant-based nutrients that contribute positively to our health, including phytonutrients, antioxidants, and various flavonoids such as anthocyanins, flavonols, and polyphenols, as well as proanthocyanidins (Reed, 2002; Sun et al., 2002). The antioxidant capacity of fruits, or the levels of individual antioxidants, is influenced by diverse factors such as variety, ripeness stage (Hegedüs et al., 2010), geographic region, fruit position on the tree (Dragovic-Uzelac et al., 2007), storage conditions, harvest year (Leccese et al., 2012; Hegedüs et al., 2010), and the fruit growing period (Leccese et al., 2008).

In the major apricot production centers of Türkiye, the antioxidant activity values in the cultivated varieties have shown differences of up to fourfold, ranging from 476.9 to 1969.7 mgTE/kg. In this sense, the Şalak stands out significantly with an antioxidant activity value of 1969.7 mgTE/kg, being notably different from others. The Hasanbey, harvested in the Elazığ province and belonging to a different statistical group, was observed to have an antioxidant activity value of 1042.3 mgTE/kg. When comparing local varieties within themselves, it has been found that the antioxidant value of apricots grown in Elazığ province is significantly higher than those grown in Malatya. On the other hand, in foreign-origin varieties, apricots harvested in Hatay province have a higher antioxidant content than others. The lowest antioxidant activity was found in the Hacıhaliloğlu, cultivated in Malatya as 476.9 mgTE/kg.

Similarly, Su et al. (2020), local apricot varieties showed significant differences in antioxidant activity, ranging

Table 1. The compound contents related to health in apricot varieties harvested from various provinces of Türkiye.

Province	Varieties	Total Carotenoid (mg/kg)	Antioxidant Activity (mgTE/kg)	Total Phenolic (mgTE/kg)
Elâzığ	Hasanbey	9.51 a[1]	1042.3 b	243.0 bc
	Kabaaşı	9.51 a	581.1 f	122.2 g
	Hacıhaliloğlu	7.44 b	612.9 ef	173.8 ef
Malatya	Hasanbey	5.59 b	705.1 d	222.5 cd
	Kabaaşı	7.44 b	478.5 g	159.8 fg
	Hacıhaliloğlu	9.39 a	476.9 g	188.3 def
Hatay	Mikado	6.19 b	981.8 b	280.7 b
	Magador	6.57 b	785.4 c	194.5 def
Mersin	Mikado	6.61 b	681.7 de	210.5 cde
	Magador	10.3 a	668.5 de	180.8 def
Iğdır	Şalak	7.16 b	1969.7 a	771.6 a
LSD		1.91***[2]	78.3***	45.9***

(1): Differences between means are shown by separate letters

(2): ***: p<0.001

from 61.72 to 135.52 mg TEs 100 g^{-1}. This genotypic variation in antioxidant activity has been reported in numerous previous studies (Alajil et al., 2021; Karatas et al., 2021; Karatas, 2022). Moreover, Leccese et al. (2008) identified substantial variations in total phenol content and antioxidant capacity parameters associated with ripening time. Additionally, Bartolini et al. (2014) conducted a study investigating the impact of grafting the 'Pisana' variety onto two commercial Prunus rootstocks ('Apricot Seedling' and 'Myrabolan 29/C') on fruit quality and formation. The research was carried out over a period of two years. In the study, plants grafted onto Myrabolan 29/C rootstock exhibited the highest levels of total antioxidants and total phenolic compounds. Additionally, similar to this study, they have determined that climatic factors play a significant role in the antioxidant content. It has been determined that regardless of the rootstock, fruits that experience a dry ripening period exhibit an enhancement in their antioxidant potential. Similarly, Hegedűs et al. (2010), observed differences in antioxidant activity of up to 21 times among 27 apricot varieties and hybrids originating from different sources. As seen in the previous studies, it has been determined that various factors, primarily the genetic structure, can have significant effects on the antioxidant content of apricot fruits. In this sense, the Şalak, with its considerably high antioxidant content, has been identified as a significant resource for important breeding studies and the food industry.

Phenolics are compounds with high antioxidant potential. They achieve these properties through different mechanisms, such as scavenging free radicals like ROS, suppressing ROS formation, chelating pro-oxidant metal ions, inhibiting enzymes and preserving or enhancing the antioxidant defense. In this study, it was determined that total phenol values ranged from 122.2 to 771.6 mgTE/kg. Similar to the total antioxidant content, the Şalak variety stood out once again with the highest total phenol value. When the cultivation locations were evaluated individually, it was found that in Elazığ province, the Hasanbey variety contained higher levels of phenolic compounds, while other local varieties performed better in terms of phenolic content in Malatya province. In foreign-origin varieties, it is observed that Hatay province is more suitable in terms of phenolic compounds. Among the varieties, differences of up to six times in total phenolic content have been identified. Similarly, Hegedűs et al. (2010) found significant differences of up to 35 times in total phenolic content among 27 apricot varieties and hybrids from different origins. In addition, Su et al. (2022), determined the total phenolic content in 18 apricot varieties ranging from 0.29 to 0.69 g GAE kg-1. Researchers reported that besides the genotypic structure, the variation in climate factors between years also contributed to such significant differences in total phenolic content. The study conducted by Tarantino et al. (2018) found that although the total phenolic amount was low in the first year of the experiment, the total antioxidant capacity was significantly higher in the year 2015 compared to 2016.

As it seen in the previous studies, the examined compounds in fruits are influenced not only by the genotypic structure but also by various factors such as ripeness level, harvest year, climatic conditions. According to obtained results, it is believed that in foreign-origin varieties, the partial decrease in carotenoid content is related to the ripeness level of the fruits, while the partial increase in antioxidant activity is also attributed to the ripeness level. Overall, it is concluded that the Şalak, with its significantly high antioxidant and phenolic content, not only serves as an important source of nutrients for consumers but also holds significant potential as a valuable material for apricot breeding. If the Şalak variety exists, its lacking characteristics should be improved and its cultivation should be promoted in Türkiye to the same extent as Hasanbey, Hacıhaliloğlu and Kabaaşı.

CONCLUSION

This study has generated valuable information about the quality parameters specific to significant apricot varieties and production regions in Türkiye, which is a key apricot producer. It has been determined that, in addition to the variety, the production location also has a significant impact on fruit quality parametersIn relation to essential quality components influencing health, the 'Şalak' variety notably distinguishes itself from others, displaying a significantly elevated phenolic content that contributes to heightened antioxidant activity. This variety with outstanding fruit qualities can be used as a significant genitor in hybridization studies.

COMPLIANCE WITH ETHICAL STANDARDS

This research article complies with research and publishing ethics.

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

Ethics committee approval

Ethics committee approval is not required.

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Data availability

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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