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Review

WILD EDIBLE SMALL FRUITS IN TURKEY AND THEIR FRUIT CHARACTERISTICS

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Wild fruits are essential genetic resources for fruit breeding and have either been domesticated or used to introgress disease resistance and tolerance to abiotic and biotic stress. Numerous studies have previously described the health benefits of wild berry fruits and reported their antioxidant, anti-inflammatory, antimicrobial, and anticancer activity. Turkey has a rich plant biodiversity thanks to its geographic location and encirclement by three seas, leading to a wide variety of climates. The great ecological diversity of the wild berry species in Turkey is a significant bio-gene pool that is vital to human life and can serve as a source of agricultural development in the future. This review aims to introduce some of the wild edible berry species naturally occurring in Turkey such as Morus *spp.,* Hippophae rhamnoides *L.,* Viburnum opulus *L.,* Rubus idaeus *L.,* Rubus fruticosus *L.,* Sambucus nigra *L.,* Vaccinium *spp.,* Arbutus unedo *L.,* Ribes *spp., and* Fragaria vesca *L., and describe their distribution, uses, and fruit characteristics. Conservation of these wild fruit genetic resources is necessary for use in breeding for novel traits.*

Keywords: *biochemical composition, genetic resources, plant biodiversity, wild berries.*

INTRODUCTION

Wild fruits have built extraordinary survival mechanisms, by which they have been able to endure against extreme environments such as severe temperatures, drought, flooding, saline soils, low or high pH, as well as various pests, and diseases without human intervention. They also show significant morphological and biochemical diversity and are considerably rich in organic acids, fibres, sugars, minerals, phenolics, and anthocyanins (Nile and Park, 2014; Skrovankova *et al*., 2015; Bakar *et al*., 2016). Berries are one of the richest fruit groups and contain powerful antioxidants due to their great variety of anthocyanins and high phenolic content (Ozkan *et al*., 2019). Several studies have shown that berry fruits have many positive impacts on human health thanks to their high non-nutritive antioxidant content, which can prevent chronic diseases such as diabetes, obesity, cancer, and cardiovascular diseases (Paredes-López *et al*., 2010; Harris *et al*., 2014; Nile and Park, 2014). Therefore, berries are considered an important part of a healthy diet.

Wild berry plants have been used in various plant breeding programmes not only for their adaptation to challenging climatic and soil conditions but also for their high phytochemical contents (Darrow, 1952; Hancock *et al*., 2002; Vijayan *et al*., 2006; Capocasa *et al*., 2008; Diamanti *et al*., 2014; Ikase, 2015; Lebedev *et al*., 2020). The increasing adverse effects of climate change, loss of fertile soil, pollution, and water deficit have been leading to reduced plant biodiversity all over the world (Rao and Hodgkin, 2002). Therefore, the conservation of wild fruit genetic resources is essential to sustainable agricultural production. Turkey has seven geographical regions and a noticeable variety of climates between the regions because of the different exposure of slopes and coasts, as well as a variety of soil, and water types (Kahraman *et al*., 2012). These climate differences, geological and geomorphologic diversity, sea, stream, and

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lake mediums, and variation in elevation lead to a high amount of plant diversity (Kahraman *et al*., 2012). Turkey is well-known for its abundant genetic resources as far as wild edible fruits, which have constituted an important part of the source of income of rural people for centuries (Ilhan *et al*., 2021). Along with other wild plant species, there is also a significantly wide range of berry species occurring in the wild throughout the country. This paper aims to present some of the wild edible berry species naturally growing in Turkey, namely *Morus* spp., *Hippophae rhamnoides* L., *Viburnum opulus* L., *Rubus idaeus* L., *Rubus fruticosus* L., *Sambucus nigra* L., *Vaccinium* spp., *Arbutus unedo* L., *Ribes* spp., *Fragaria vesca* L., and define their distribution, uses and some fruit characteristics.

WILD SMALL FRUIT SPECIES, THEIR DISTRIBUTION, AND USAGE IN TURKEY

Mulberries (*Morus* spp.). *Morus* species belong to the *Moraceae* and are long-lived deciduous trees (Ercisli and Orhan, 2007). Mulberries can grow in an extensive range of climatic and soil conditions and are found from temperate to subtropical regions of the Northern Hemisphere and in the tropics of the Southern Hemisphere from sea level to altitudes up to 4000 m (Tutin *et al*., 1996; Machii *et al*., 2000; Ercisli and Orhan, 2007).

Morus alba L., *Morus rubra* L., and *Morus nigra* L. are the most popular mulberry species with edible fruits grown in Turkey (Ercisli, 2004). While 95% of mulberry trees in Turkey belong to *M. alba*, 3% and 2% are *M. rubra* and *M. nigra*, respectively (Ercisli, 2004). Mulberry cultivation in Turkey dates back to 400–500 years ago (Eyduran *et al*., 2015). Mulberries have been processed into juice, molasses, jam, vinegar, and some traditional products such as 'pestil' and 'kome' (Eyduran *et al*., 2015), which are made by mixing mulberry honey, walnut, hazelnut and flour (Yildiz, 2013).

White mulberry, *M. alba*, is native to Northern China (Kadam *et al*., 2019). The fruits are white and have a very sweet taste and low acidity, and can assist with digestion, high cholesterol, obesity, blood circulation issues, and weak immune system (Kadam *et al*., 2019). The leaves provide food for silkworms (*Bombyx mori* L.) for silk production in Turkey (Ercisli, 2004), and the wood and bark are used for tannery and paper fabrication (Baytop, 1963).

Red mulberry, *M. rubra*, is native to eastern and central North America (Kadam *et al*., 2019). The fruits are red, rich in anthocyanins and phenolics, and high in dry matter (Ercisli and Orhan, 2007). They have a sweet taste, and low acidity (Ercisli and Orhan, 2007). Wild forms of *M. alba* and *M. rubra* are found in temperate regions like Central and Northeastern Anatolia in Turkey (Ercisli, 2004).

Black mulberry, *M. nigra*, is native to Southwestern Asia (Lim and Choi, 2019). It can adapt easily to different soil and climatic conditions, and are very tolerant of atmospheric pollution (Gundogdu *et al*., 2017). *M. nigra* is commonly found as wild old trees in warmer regions such as the Mediterranean, the Aegean, Marmara, and the Black Sea regions in Turkey (Ercisli, 2004). The fruits are juicy, dark, and have a slightly acidic flavour (Okatan, 2018). Due to its dark fruits, black mulberry is significantly rich in phytochemicals and phenolic compounds (Ozgen *et al*., 2009; Okatan, 2018). They are very rich in anthocyanins, sugars, organic acids such as malic and citric acid, tannin, cyanine, pectin, and vitamin C.

Sea buckthorn (*H. rhamnoides*). The genus *Hippophae* belongs to the *Elaeagnaceae* (Wang *et al*., 2011) and was divided into three species by Rousi (1971) with nine subspecies in the species *H. rhamnoides*. Sea buckthorn is found in temperate regions of the Himalayas, China, central Asia, and Europe (Singh, 2005). The plant is 2 to 4 m tall, fast-growing, deciduous, a spiny shrub with yellow or orange berries, and alternate, narrow-lanceolate and silver-coloured leaves (Pop *et al*., 2014). Its morphological structure mainly depends on the species and microclimate variation (Pop *et al*., 2014). Frankia, the nitrogen-fixing bacteria in its roots aids sea buckthorn to easily adapt to dry conditions and dry and infertile soil easily (Singh, 2003). It is distributed from 60 to 5300 m above sea level and can grow on slopes with well-drained soil with silt, along riversides, and in wastelands (Singh, 2003). It can prevent soil erosion and help with land reclamation thanks to its rapidly developing root system and ability to survive temperatures from –43 to 40 °C (Rongsen, 1992).

The only species growing in Turkey is *H. rhamnoides* ssp. *caucasica* Rousi (Rousi, 1971), and it is found in Central Anatolia, Eastern Anatolia, and the Black Sea regions (Ercisli *et al*., 2007). Sea buckthorn berries have been used for centuries in Europe and Asia (Ercisli *et al*., 2007) as food, nutraceuticals, pet food, in cosmetics for improvement of the appearance of the skin (Li, 2002), and for treatment of some chronic diseases like cancer and high blood pressure (Zeb, 2004). Sea buckthorn is accepted as a "superfood" due to its high amounts of fibres, antioxidants, vitamins, minerals, flavonoids, amino acids, organic and fatty acids, saponin, ether oil, and sugar (Ilhan *et al*., 2021).

European cranberrybush (*V. opulus*). European cranberrybush (*V. opulus*) belongs to the *Caprifoliaceae* and is native to Europe, Northern Africa, and Central Asia (Cesoniene *et al*., 2008). The plant naturally occurs in the central, western, and northern provinces of Turkey, and shows a rich plant diversity (Ersoy *et al*., 2017). The plant carries 30–50 red-coloured berries, which bear resemblance to grapes (Ersoy *et al*., 2017). The juice has antimicrobial, antioxidant, antimutagenic, and pharmacological effects (Sagdic *et al*., 2006). It is used as herbal medicine for its nerve sedative and antispasmodic effects in asthma and hysteria, and for high blood pressure treatment (Akbulut *et al*., 2008).

Wild raspberry (*R. idaeus*). The origin of wild raspberry, or red raspberry, was reported to be the Ida Mountains of

Turkey (Jennings, 1988). Wild raspberry belongs to the *Rosaceae* and is native to Europe, Northern Asia, and Northern America (Ercisli *et al*., 2008).

Wild raspberry grows best in moist and rich soils (Cekic *et al*., 2018). Raspberry fruit has antimicrobial, anticancer, and antioxidant effects and is an important source of phenolic compounds and vitamin C (Perova *et al*., 2014). It is found at high elevations in forests, riverbanks, edges of meadows, and rocky slopes in the Southern and Easten Marmara region, Black Sea region, and Northeastern Turkey (Ercisli, 2004). The northeastern part of the country has a large population of wild *Rubus* accessions, and Turkey is an important natural habitat centre of the *Rubus* genus (Ercisli *et al*., 2008).

Wild blackberry (*R. fruticosus*). Wild blackberry, *R. fruticosus* belongs to the *Rosaceae* (Zia-Ul-Haq *et al*., 2014). It is extensively found in northern countries of the world (Koczka *et al*., 2018). In Turkey, it is distributed through Central Anatolia, the Mediterranean, and the Black Sea regions. It contains a wide variety of bioactive compounds such as phenolic acids, flavonoids, and vitamin C (Tavares *et al*., 2013), and is a valuable source of minerals and vitamins. The fruits are consumed either fresh or processed as jam, syrup, wine, tea, ice cream, and bakery products (Koczka *et al*., 2018).

Elderberry (*S. nigra*). European elderberry (*S. nigra*) belongs to the *Caprifoliaceae*, and is a large deciduous shrub or a small tree that is native to the northern hemisphere (Ritter and McKee, 1964). It grows better in sunlight-exposed locations in most parts of Europe, Asia, North Africa, and the USA (Christensen *et al*., 2008), and occurs in Northwest Anatolia in Turkey. Generally, its fruits are not consumed fresh because of the bitter flavour. Instead, it is processed into juices, jams, preserves, and pies (Kan, 2019). Its fruits are very dark purple, and often preferred by birds; thus, it rapidly grows in moist areas next to railways, roadways, and forest edges (Lee and Finn, 2007). The fruits have many nutritional benefits and are believed to have antibacterial, anti-allergic, antiviral and immunity-stimulating effects that help prevent certain diseases such as cancer, cardiovascular diseases, and diabetes (Dawidowicz *et al*., 2006).

***Vaccinium* spp.: Caucasian whortleberry (*Vaccinium arctostaphylos* L.) and bilberry (*Vaccinium myrtillus* L.).** *Vaccinium* spp. belong to the *Ericaceae*. Caucasian whortleberry, *V. arctostaphylos* is native to Western Asia, the Caucasus, and Southeastern Europe (Ayaz *et al*., 2001). Caucasian whortleberry is a perennial, deciduous shrub that grows wild in acidic soils of forests of the Northeastern Black Sea region of Turkey (Ozgen *et al*., 2014). It is a medicinal plant that is used for its high phenolic and anthocyanin content, and its fruits are harvested by rural peoples for direct consumption and/or to sell on the roads (Ozkan *et al*., 2019). Its shrub can be used as an ornamental due to the attractive appearance of its leaf and dark berries (Celik and Koca 2013). Young and fresh shoots and leaves of Caucasian whortleberry are used in soup and as dried black tea by local people living in the Giresun province of Turkey (Celik and Koca, 2013).

Bilberry, *V. myrtillus* is native to northern Europe (Ayaz *et al*., 2001). It is a deciduous shrub that can grow up to 50 cm in height (Elkiran and Avsar, 2020). It is smaller than its congener, the Caucasian Whortleberry, which can reach up to 3 m in height. It has globular, bluish black, and sour berries, elliptical leaves and flowers that are single on short stems (Elkiran and Avsar, 2020). Bilberry is commonly found in moist coniferous forests. It thrives under moderate shade and high humidity. Like the Caucasian whortleberry, bilberry is commonly found in the Black Sea, Marmara, and Thrace regions of Turkey (Saral *et al*., 2015).

Strawberry tree (*A. unedo*). The strawberry tree (*A. unedo*) belongs to the *Ericaceae*. It is native to the Mediterranean region (Males *et al*., 2006) with hot summer and rainy winters (Pallauf *et al*., 2008). It is a typical Mediterranean-climate plant, and can be found in a shrub or a tree form that reaches up to 12 m in height. It grows under a range of altitudes between 700 to 1000 m (Celikel *et al*., 2008). The strawberry tree is valued as an ornamental plant due to its red fruits in the fall and winter, pink-white flowers in the fall, and silvery leaves (Celikel *et al*., 2008). It is naturally found in the maquis areas of the Mediterranean, the Aegean and Marmara regions, and the Black Sea coasts in Turkey. It is used as a traditional medicine to treat arterial hypertension (Pallauf *et al*., 2008). Its fruits are consumed fresh when fully ripe but are more often used in processed products such as cider, jam, marmalade, and jelly (Pallauf *et al*., 2008).

Currants (*Ribes* spp.). *Ribes* spp. belong to the *Grossulariaceae*. Currants and gooseberries are deciduous evergreen shrubs (Kendir and Koroglu, 2015) which are found in the cold and temperate regions of North America, Europe, Asia, and South America (Pfister and Sloan, 2008). Red currant (*Ribes rubrum* L.), black currant (*Ribes nigrum* L.), rock currant (*Ribes petraeum* L.), mountain currant (*Ribes alpinum* L.), and oriental gooseberry (*Ribes orientale* L.) are all found in the flora of Turkey (Ercisli, 2004). Red currant is native to Western Europe. Its fruits are consumed fresh, or processed for juices, jam, and jellies (Eminagaoglu, 2014). It naturally occurs in Central Anatolia in Turkey (Ercisli, 2004). Black currant is native to northern and eastern Europe. Its fruits are rich in vitamins, but are rarely consumed fresh because of their special strong taste. Instead, they are processed as juices, jam, jellies, wine, and liqueur (Eminagaoglu, 2014). It is found in eastern Anatolia in Turkey (Ercisli, 2004). While rock currant and mountain currant naturally occur in North and Northeastern Anatolia, respectively, oriental gooseberry commonly grows on cliffs of Southeastern and Northeasten Anatolia in Turkey (Ercisli, 2004).

Wild strawberry (*F. vesca*). Wild strawberry (*F. vesca*) belongs to the *Rosaceae* and is found in temperate climate zones of Europe and Asia (Jurgiel-Malecka *et al*., 2017). It

is naturally found in sunny and dry areas, in forest clearings and edges (Jurgiel-Malecka *et al*., 2017). It naturally occurs in the highlands of the Northwest, in East Anatolia, and the Black Sea region of Turkey (Ercisli, 2004). Its fruits are ovate, bright red and soft, and are consumed fresh or used for preserves (Ercisli, 2004; Yildiz *et al*., 2014).

FRUIT CHARACTERISTICS OF THE WILD SMALL FRUIT SPECIES IN TURKEY

Wild berry species are considerably rich in phenolic compounds, antioxidant capacity, anthocyanins, organic acids, and vitamin C.

Total anthocyanin and phenolic contents and anthocyanin activity have been reported for most of these fruit crops and are listed in Table 1. All species have significant total phenolic content with European cranberrybush having the highest value, ranging from 690 to 830 mg GAE per 100 g, followed by the strawberry tree, with 570 to 820 mg GAE per 100 g (Table 1). White mulberry has the lowest total phenolic content, at 110 to 190 mg GAE per 100 g (Table 1).

The highest antioxidant capacity was reported in European cranberrybush (28 to 36 μmol·g^{-1} of TE) and bilberry (24 to 35 μmol·g^{-1} of TE).

Black mulberry has the highest anthocyanin content (230 to 830 mg per 100 g), followed by sea buckthorn (90–390 mg per 100 g) and bilberry (300 to 340 mg per 100 g).

The vitamin C content, major organic acid and major phenolic compound and their content are available for most of these wild fruit crops and are listed in Table 2.

The major organic acid in black mulberry, white mulberry, and the strawberry tree is malic acid while citric acid is dominant in wild raspberry and Caucasian whortleberry. Both tartaric and malic acid are prevalent in European cranberrybush.

Rutin is the major phenolic compound of black and white mulberry, while gallic acid is the dominant phenolic acid of sea buckthorn and strawberry tree. In European cranberrybush and strawberry, chlorogenic acid and ellagic acid are the most abundant phenolic acids, respectively (Table 2).

Of these wild fruit crops, the strawberry tree contains the highest amount of vitamin C (60 to 90 mg per 100 g), followed by wild strawberry and sea buckthorn (40 to 60 mg per 100 g). Bilberry has the lowest amount of vitamin C at between 4–8 mg per 100 g.

CONCLUSION

Turkey has a remarkable diversity of wild small fruits. Wild raspberry and *Vaccinium* species are only found in the Black Sea, and Marmara region; the strawberry tree only occurs along coasts; while the other wild berries occur in nature in almost every region of Turkey.

Wild berry fruits have very rich bioactive compounds. The strawberry tree, sea buckthorn, and wild strawberry have very high vitamin C content. The European cranberrybush and bilberry are very rich in antioxidants. The black mulberry has extremely high anthocyanin levels and it plays a significant role in the prevention of many diseases due to its natural phytochemical content. Wild berry fruits provide a significant genetic diversity for plant breeding programmes thanks to their high phytochemical contents and adaptability to unfavourable climatic and soil conditions. Conservation of wild fruit genetic resources is essential for sustainable agricultural production. As in many other parts of the world, there have been an increasing number of efforts by institutes

Table 1. Average total phenolic content (mg GAE (Gallic acid equivalents) 100 g^{-1}), antioxidant capacity TEAC (Trolox equivalent antioxidant capacity) (μmol TE (Trolox equivalent) g^{-1}) and anthocyanin (mg·100 g^{-1}) content for some wild berry fruits found and analysed in Turkey and Moscow

Species/fruit characteristics	Total phenolics (mg GAE·100 g^{-1})	Antioxidant capacity TEAC (μmol TE g^{-1})	Anthocyanin (mg·100 g^{-1})	References
Black mulberry *M. nigra*	140–350	6–26	230–830	Gundogdu *et al*., 2017; 2018; Okatan, 2018
White mulberry *M. alba*	110–190	9–21	N/A	Gundogdu *et al*., 2017; 2018
Sea buckthorn *H. rhamnoides*	400–600	17–30	90–390	Yildiz *et al*., 2012; Ilhan *et al*., 2021
European cranberrybush *V. opulus*	690–830	28–36	200–320	Ersoy *et al*., 2017; Ozrenk *et al*., 2020
Wild raspberry *R. idaeus*	150–350	9–22	65–295	Cekic and Ozgen, 2010; Perova *et al*., 2014
Caucasian whortleberry *V. arctostaphylos*	375–555	16–22	90–170	Celik and Koca, 2013; Ozkan *et al*., 2019
Bilberry *V. myrtillus*	490–565	24–35	300–340	Saral *et al*., 2015; Celik *et al*., 2018; Guder *et al*., 2015
Strawberry tree *A. unedo*	570–820	15–30	N/A	Gundogdu *et al*., 2018; Sagbas *et al*., 2020
Wild strawberry *F. vesca*	170–230	8–19	25–55	Yildiz *et al*., 2014; Akbulut *et al*., 2006

Table 2. Content of major organic acids (mg·100 g^{-1}), major phenolic compounds (mg·100 g^{-1}), and vitamin C (mg·100g^{-1}) for some wild berry fruits found and analysed in Turkey and Moscow

Species/fruit characteristics	Major organic acid and range (mg·100 g^{-1})	Major phenolic compound and range (mg·100 g^{-1})	Vitamin C (mg·100 g^{-1})	References
Black mulberry *M. nigra*	Malic acid (0.2–14)	Rutin (6–134)	11–31	Gundogdu *et al*., 2017; 2018; Okatan, 2018
White mulberry *M. alba*	Malic acid (3–13.5)	Rutin (11–73)	12–30	Gundogdu *et al*., 2017; 2018
Sea buckthorn *H. rhamnoides*	N/A	Gallic acid (5–17)	40–63	Yildiz *et al*., 2012; Ilhan *et al*., 2021
European cranberrybush *V. opulus*	Tartaric acid (120–144), Malic acid (110–135)	Chlorogenic acid (250–580)	28–44	Ersoy *et al*., 2017; Ozrenk *et al*., 2020
Wild raspberry *R. idaeus*	Citric acid (11–18)	N/A	21–36	Cekic and Ozgen, 2010; Perova *et al*., 2014
Caucasian whortleberry *V. arctostaphylos*	Citric acid (9–11)	N/A	7–50	Celik and Koca, 2013; Ozkan *et al*., 2019
Bilberry *V. myrtillus*	N/A	N/A	4–8	Saral *et al*., 2015; Celik *et al*., 2018; Guder *et al*., 2015
Strawberry tree *A. unedo*	Malic acid (1–3)	Gallic acid (3-9)	60–90	Gundogdu *et al*., 2018; Sagbas *et al*., 2020
Wild strawberry *F. vesca*	N/A	Ellagic acid (15–26)	40–60	Yildiz *et al*., 2014; Akbulut *et al*., 2006

in the Ministry of Agriculture in the Republic of Turkey to conserve and utilise native wild germplasm of Turkey.

REFERENCES

Akbulut, M., Calisir, S., Marakoglu, T., Coklar, H. (2008). Chemical and technological properties of European cranberrybush (*Viburnum opulus* L.) fruits. *Asian J. Chem*., **20** (3), 1875.

Akbulut, M., Cekic, C., Unver, A. (2006). Determination of phytochemical characteristics, antioxidant capacity and mineral contents of some of the octoploid and diploid strawberries. In: *Proceedings of the II International Small Fruits Symposium, 14–16 September 2006, Tokat, Turkey*, pp. 299–303 (in Turkish).

Ayaz, F. A., Kadioglu, A. S. I. M., Bertoft, E., Acar, C., Turna, I. (2001). Effect of fruit maturation on sugar and organic acid composition in two blueberries. (*Vaccinium arctostaphylos* and *V. myrtillus*) native to Turkey. *New Zealand J. Crop Horticult. Sci.,* **29** (2), 137–141.

Bakar, M. F. A., Ismail, N. A., Isha, A., Ling, A. L. M. (2016). Phytochemical composition and biological activities of selected wild berries (*Rubus moluccanus* L., *R. fraxinifolius* Poir., and *R. alpestris* Blume). *Evid. Based Complement. Alternat. Med.,* 2016, 2482930.

Baytop, T. (1963). *Medicinal and Poisonous Plants of Turkey*. İsmail Akgun Press, İstanbul. 268 pp.

Capocasa, F., Scalzo, J., Mezzetti, B., Battino, M. (2008). Combining quality and antioxidant attributes in the strawberry: The role of genotype. *Food Chem.,* **111** (4), 872–878.

Cekic, C., Calis, O., Ozturk Erdem, S. (2018). Genetic diversity of wild raspberry genotypes (*Rubus idaeus* L.) in North Anatolia based on ISSR markers. *Appl. Ecol. Environ. Res*., **16** (5), 6835–6843.

Cekic, C., Ozgen, M. (2010). Comparison of antioxidant capacity and phytochemical properties of wild and cultivated red raspberries (*Rubus idaeus* L.). *J. Food Compos. Anal.,* **23** (6), 540–544.

Celik, F., Bozhuyuk, M. R., Ercisli, S., Gundogdu, M. (2018). Physicochemical and bioactive characteristics of wild grown bilberry (*Vaccinium myrtillus* L.) genotypes from northeastern Turkey. *Notulae botanicae horti agrobotanici cluj-napoca*, **46** (1), 128–133.

Celik, H., Koca, I. (2013). Pomological and chemical properties of some Caucasian whortleberry (*Vaccinium arctostaphylos* L.) grown in Guneyse-Rize, Turkey. In: *Proceedings of International Caucasian Forestry Symposium*, 24–26 October 2013, Artvin, Turkey, pp. 464–471.

Celikel, G., Demirsoy, L., Demirsoy, H. (2008). The strawberry tree (*Arbutus unedo* L.) selection in Turkey. *Scientia Horticulturae*, **118** (2), 115–119.

Cesoniene, L., Daubaras, R., Viskelis, P. (2008). Evaluation of productivity and biochemical components in fruit of different *Viburnum* accessions. *Biologija*, **54** (2), 93–96.

Christensen, L. P., Kaack, K., Frette, X. C. (2008). Selection of elderberry (*Sambucus nigra* L.) genotypes best suited for the preparation of elderflower extracts rich in flavonoids and phenolic acids. *Eur. Food Res. Technol.,* **227** (1), 293–305.

Darrow, G. M. (1952). Breeding of small fruits in the United States. *Sci. Monthly*, **75** (5), 288–297.

Dawidowicz, A. L., Wianowska, D., Baraniak, B. (2006). The antioxidant properties of alcoholic extracts from *Sambucus nigra* L. (antioxidant properties of extracts). *LWT-Food Sci. Technol.,* **39** (3), 308–315.

Diamanti, J., Mazzoni, L., Balducci, F., Cappelletti, R., Capocasa, F., Battino, M., Dobson G., Stewart D., Mezzetti, B. (2014). Use of wild genotypes in breeding program increases strawberry fruit sensorial and nutritional quality. *J. Agricult. Food Chem.,* **62** (18), 3944–3953.

Elkiran, O., Avsar, C. (2020). Chemical composition and biological activities of the essential oil from the leaves of *Vaccinium myrtillus* L. *Bangladesh J. Bot.,* **49** (1), 91–96.

Eminagaoglu, O. (2014). *Ribes* L. (Currants). In: Akkemik, U. (Ed.). *Natural-Exotic Trees and Shrubs of Turkey.* TC Orman ve Su Żžleri Bakanlžšž Orman Genel Müdürlüšü, pp. 707–715 (in Turkish).

Ercisli, S., Orhan, E. (2007). Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. *Food Chem.,***103**, 1380–1384.

Ercisli, S. (2004). A short review of the fruit germplasm resources of Turkey. *Gen. Res. Crop Evol.,* **51** (4), 419–435.

Ercisli, S., Badjakov, I., Kondakova, V., Atanassov, A., Todorovska, E. (2008). AFLP-based genetic relationships in wild and cultivated red raspberry genotypes (*Rubus idaeus* L.). *Biotechnol. Biotechnol. Equip.*, **22** (4), 907–910.

Ercisli, S., Orhan, E. (2005). Natural mulberry (*Morus* spp.) production in Erzurum Region in Turkey. In: *Proceedings of the International Scientific*

Conference: Environmentally Friendly Fruit Growing, Polli, Estonia, 7–9 September 2005. Tartu University Press, pp. 129–135.

Ercisli, S., Orhan, E., Ozdemir, O., Sengul, M. (2007). The genotypic effects on the chemical composition and antioxidant activity of sea buckthorn (*Hippophae rhamnoides* L.) berries grown in Turkey. *Scientia Horticulturae*, **115** (1), 27–33.

Ersoy, N., Ercisli, S., Gundogdu, M. (2017). Evaluation of European cranberrybush (*Viburnum opulus* L.) genotypes for agro-morphological, biochemical and bioactive characteristics in Turkey. *Folia Horticulturae*, **29** (2), 181–188.

Eyduran, S. P., Ercisli, S., Akin, M., Beyhan, O., Gecer, M. K., Eyduran, E., Erturk, Y. E. (2015). Organic acids, sugars, vitamin C, antioxidant capacity, and phenolic compounds in fruits of white (*Morus alba* L.) and black (*Morus nigra* L.) mulberry genotypes. *J. Appl. Bot. Food Qual.,* **88**, 134–138.

Guder, A., Gur, M., Engin, M. S. (2015). Antidiabetic and antioxidant properties of bilberry (*Vaccinium myrtillus* Linn.) fruit and their chemical composition. *J. Agricult. Sci. Technol.,* **17** (2), 401–414.

Gundogdu, M., Canan, I., Gecer, M. K., Kan, T., Ercisli, S. (2017). Phenolic compounds, bioactive content and antioxidant capacity of the fruits of mulberry (*Morus* spp.) germplasm in Turkey. *Folia Horticulturae*, **29** (2), 251–262.

Gundogdu, M., Ercisli, S., Canan, I., Orman, E., Sameeullah, M., Naeem, M., Ayed, R. B. (2018). Diversity in phenolic compounds, biochemical and pomological characteristics of *Arbutus unedo* fruits. *Folia Horticulturae*, **30** (1), 139.

Gundogdu, M., Tuncturk, M., Berk, S., Sekeroglu, N., Gezici, S. (2018). Antioxidant capacity and bioactive contents of mulberry species from Eastern Anatolia region of Turkey. *Indian J. Pharm. Educ. Res*, **52** (4), 96–101.

Hancock, J. F., Luby, J. J., Dale, A., Callow, P. W., Serce, S., El-Shiek, A. (2002). Utilizing wild *Fragaria virginiana* in strawberry cultivar development: Inheritance of photoperiod sensitivity, fruit size, gender, female fertility, and disease resistance. *Euphytica*, **126** (2), 177–184.

Harris, C. S., Cuerrier, A., Lamont, E., Haddad, P. S., Arnason, J. T., Bennett, S. A., Johns, T. (2014). Investigating wild berries as a dietary approach to reducing the formation of advanced glycation end products: Chemical correlates of *in vitro* antiglycation activity. *Plant Foods Hum. Nutr.,* **69** (1), 71–77.

Ikase, L. (2015). Results of fruit breeding in Baltic and Nordic states. In: *Proceedings of the 25th Congress of the Nordic Association of Agricultural Scientists (NJF). Nordic View to Sustainable Rural Development, 16-18 June, Riga,* pp. 16–18.

Ilhan, G., Gundogdu, M., Karlovic, K., Zidovec, V., Vokurka, A., Ercisli, S. (2021). Main agro-morphological and biochemical berry characteristics of wild-grown sea buckthorn (*Hippophae rhamnoides* L. ssp. *caucasica* Rousi) genotypes in Turkey. *Sustainability*, **13** (3), 1198.

Jennings, D. L. (1988). *Raspberries and Blackberries: Their Breeding, Diseases and Growth.* Academic Press, London. 230 pp.

Jurgiel-Małecka, G., Gibczyńska, M., Siwek, H., Buchwał, A. (2017). Comparison of fruits chemical composition of selected cultivars wild strawberry (*Fragaria vesca* L.). *Eur. J. Hortic. Sci.*, **82** (4), 204–210.

Kadam, R. A., Dhumal, N. D., Khyade, V. B. (2019). The Mulberry, *Morus alba* (L.): The medicinal herbal source for human health. *Int. J. Curr. Microbiol. Appl. Sci.,* **8** (4), 2941–2964.

Kahraman, A., Onder, M., Ceyhan, E. (2012). The importance of bioconservation and biodiversity in Turkey. *Int. J. Biosci. Biochem. Bioinform.,* **2** (2), 95.

Kan, T. (2019). Some biochemical characteristics of fruit samples of *Sambucus nigra* genotypes from Northeastern Turkey. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **47** (3), 553–557.

Kendir, G., Koroglu, A. (2015). *In vitro* antioxidant effect of the leaf and branch extracts of *Ribes* L. species in Turkey. *Int. J. Pharm. Sci. Res.,* **2**, 2:IJPSR-108

Koczka, N., Stefanovits-Banyai, E., Prokaj, E. (2018). Element composition, total phenolics and antioxidant activity of wild and cultivated blackberry (*Rubus fruticosus* L.) fruits and leaves during the harvest time. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **46** (2), 563–569.

Lebedev, V. G., Subbotina, N. M., Maluchenko, O. P., Lebedeva, T. N., Krutovsky, K. V., Shestibratov, K. A. (2020). Transferability and polymorphism of SSR markers located in flavonoid pathway genes in *Fragaria* and *Rubus* species. *Genes*, **11** (1), 11.

Lee, J., Finn, C. E. (2007). Anthocyanins and other polyphenolics in American elderberry (*Sambucus canadensis*) and European elderberry (*S. nigra*) cultivars. *J. Sci. Food Agricult.,* **87** (14), 2665–2675.

Li, T. S. (2002). Product development of sea buckthorn. In: Janick, J., Whipkey, A. (eds.). *Trends in New Crops and New Uses*. ASHS Press, Alexandria, VA, 393–398.

Lim, S. H., Choi, C. I. (2019). Pharmacological properties of *Morus nigra* L. (black mulberry) as a promising nutraceutical resource. *Nutrients*, **11** (2), 437.

Machii, H., Koyama, A., Yamanouchi, H. (2002). Mulberry breeding, cultivation and utilization in Japan. In: M. D. Sánchez (Ed.). *Mulberry for Animal Production. FAO Animal Production and Health Paper*, pp. 63–72. https://www.fao.org/3/x9895E/x9895e00.htm

Maleš, Z., Plazibat, M., Bilusic Vundac, V., Zuntar, I. (2006). Qualitative and quantitative analysis of flavonoids of the strawberry tree-*Arbutus unedo* L. (*Ericaceae*). *Acta Pharmaceutica*, **56** (2), 245–250.

Nile, S. H., Park, S. W. (2014). Edible berries: Bioactive components and their effect on human health. *Nutrition*, **30** (2), 134–144.

Okatan, V. (2018). Phenolic compounds and phytochemicals in fruits of black mulberry (*Morus nigra* L.) genotypes from the Aegean region in Turkey. *Folia Horticulturae*, **30** (1), 93.

Ozgen, M., Celik, H., Saracoglu, O. (2014). Less known *Vaccinium*: Antioxidant and chemical properties of selected Caucasian whortleberry *(Vaccinium arctostaphylos*) fruits native to Black Sea region of Turkey. *Acta Scientiarum Polonorum-Hortorum Cultus*, **13** (2), 59–68.

Ozkan, G., Ercisli, S., Alam, Z. E. B., Guleray, A. G. A. R., Sagbas, H. I., Ilhan, G. (2019). Some morphological and biochemical characteristics of wild grown Caucasian Whortleberry (*Vaccinium arctostaphylos* L.) genotypes from Northeastern Turkey. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **47** (2), 378–383.

Ozrenk, K., Ilhan, G., Sagbas, H. I., Karatas, N., Ercisli, S., Colak, A. M. (2020). Characterization of European cranberrybush (*Viburnum opulus* L.) genetic resources in Turkey. *Scientia Horticulturae*, **273**, 109611.

Pallauf, K., Rivas-Gonzalo, J. C., Del Castillo, M. D., Cano, M. P., de Pascual-Teresa, S. (2008). Characterization of the antioxidant composition of strawberry tree (*Arbutus unedo* L.) fruits. *J. Food Compos. Anal.,* **21** (4), 273–281.

Paredes-López, O., Cervantes-Ceja, M. L., Vigna-Pérez, M., Hernández-Pérez, T. (2010). Berries: Improving human health and healthy aging, and promoting quality life: A review. *Plant Foods Human Nutr.,* **65** (3), 299–308.

Perova, I. B., Zhogova, A. A., Cherkashin, A. V., Eller, K. I., Ramenskaya, G. V., Samylina, I. A. (2014). Biologically active substances from European guelder berry fruits. *Pharmaceut. Chem. J.,* **48** (5), 332–339.

Pfister, R. D., Sloan, J. P. (2008). *Ribes* L.: Currant, gooseberry. In: Bonner, F. T., Karrfalt, R. P. (eds.). *The Woody Plant Seed Manual.* Agriculture Handbook No. 727. US Department of Agriculture, Forest Service, Washington, DC, pp. 961–968.

Pop, R. M., Weesepoel, Y., Socaciu, C., Pintea, A., Vincken, J. P., Gruppen, H. (2014). Carotenoid composition of berries and leaves from six Romanian sea buckthorn (*Hippophae rhamnoides* L.) varieties. *Food Chem.,* **147**, 1–9.

Rao, V. R., Hodgkin, T. (2002). Genetic diversity and conservation and utilization of plant genetic resources. *Plant Cell Tiss. Org. Cult.,* **68** (1), 1–19.

Ritter, C. M., McKee, G. W. (1964). *The Elderberry: History, Classification and Culture*. Pennsylvania State University, College of Agriculture, Agricultural Experiment Station. 22 pp.

Rongsen, L. (1992). *Seabuckthorn: A Multipurpose Plant Species for Fragile Mountains*. International Centre for Integrated Mountain Development, Kathmandu, Nepal. 73 pp.

Rousi, A. (1971). The genus *Hippophae* L. A taxonomic study. *Ann. Bot. Fenn.,* **8**, 177–227.

Sagbas, H. I., Ilhan, G., Zitouni, H., Anjum, M. A., Hanine, H., Necas, T., Ondrasek, I. Ercisli, S. (2020). Morphological and biochemical characterization of diverse strawberry tree (*Arbutus unedo* L.) genotypes from Northern Turkey. *Agronomy*, **10** (10), 1581.

Sagdic, O., Aksoy, A., Ozkan, G. (2006). Evaluation of the antibacterial and antioxidant potentials of cranberry (*Viburnum opulus* L.) fruit extract. *Acta Alimentaria*, **35** (4), 487–492.

Saral, O., Olmez, Z., Sahin, H. (2015). Comparison of antioxidant properties of wild blueberries (*Vaccinium arctostaphylos* L. and *Vaccinium myrtillus* L.) with cultivated blueberry varieties (*Vaccinium corymbosum* L.) in Artvin region of Turkey. *Turkish J. Agricult. Food Sci. Technol.,* **3** (1), 40–44.

Singh, V. (2003). Geographical adaptation and distribution of seabuckthorn (*Hippophae* L.) resources. In: Singh, V. (Ed.). *Seabuckthorn* (*Hippophae* L.): A multipurpose wonder plant. Vol. 1. Indus Publishing Company, New Delhi, pp. 21–34.

Singh, V. (2005). Free radicals, diseases, anti-oxidants and anti-oxidant properties of seabuckthorn (*Hippophae rhamnoides* L.). *Seabuckthorn*, 3–69.

Skrovankova, S., Sumczynski, D., Mlcek, J., Jurikova, T., Sochor, J. (2015). Bioactive compounds and antioxidant activity in different types of berries. *Int. J. Mol. Sci.,* **16** (10), 24673–24706.

Tavares, L., Figueira, I., McDougall, G. J., Vieira, H. L., Stewart, D., Alves, P. M., Ferreira R. B., Santos, C. N. (2013). Neuroprotective effects of digested polyphenols from wild blackberry species. *Eur. J. Nutr.,* **52** (1), 225–236.

Tutin, G. T., Burges, N. A., Chater, A. O., Edmondson, J. R., Heywood, V. H., Moore, D. M., Valentine, D. H., Walters S. M., Webb, D. A. (1996). *Morus* L. *Flora Europa*. Cambridge University Press, Vol. 1.

Vijayan, K., Tikader, A., Kar, P. K., Srivastava, P. P., Awasthi, A. K., Thangavelu, K., Saratchandra, B. (2006). Assessment of genetic relationships between wild and cultivated mulberry (*Morus*) species using PCR based markers. *Gen. Res. Crop Evol.,* **53** (5), 873–882.

Wang, Y., Jiang, H., Peng, S., Korpelainen, H. (2011). Genetic structure in fragmented populations of *Hippophae rhamnoides* ssp. *sinensis* in China investigated by ISSR and cpSSR markers. *Plant Syst. Evol.,* **295** (1), 97–107.

Yildiz, O. (2013). Physicochemical and sensory properties of mulberry products: Gumushane pestil and kome. *Turkish J. Agricult. Forestry*, **37** (6), 762–771.

Yildiz, H., Ercisli, S., Hegedus, A., Akbulut, M. Topdas, E. F., Aliman, J. (2014). Bioactive content and antioxidant characteristics of wild (*Fragaria vesca* L.) and cultivated strawberry (*Fragaria*× *ananassa* Duch.) fruits from Turkey. *J. Appl. Bot. Food Qual.,* 87, 274–278.

Yildiz, H., Sengul, M., Celik, F., Ercisli, S., Duralija, B. (2012). Bioactive content of sea buckthorn (*Hippophae rhamnoides* L.) berries from Turkey. *Agriculturae Conspectus Scientificus*, **77** (1), 53–55.

Zeb, A. (2004). Important therapeutic uses of sea buckthorn (*Hippophae*): A review. *J. Biol. Sci.,* **4** (5), 687–693.

Zia-Ul-Haq, M., Riaz, M., De Feo, V., Jaafar, H. Z., Moga, M. (2014). *Rubus fruticosus* L.: Constituents, biological activities, and health related uses. *Molecules*, **19** (8), 10998–11029.

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SAVVAĻAS ĒDAMIE OGULĀJI TURCIJĀ UN TO AUGĻU ĪPAŠĪBAS

Savvaļas augļaugi ir selekcijai būtiski ģenētiskie resursi, tāpēc tie tiek domestificēti vai arī izmantoti kā slimību izturības un tolerances pret abiotisko un biotisko stresu avoti selekcijā. Daudzos iepriekšējos pētījumos aprakstīts savvaļas ogulāju devums veselībai un ziņots par to antioksidatīvo, pretiekaisuma, pretmikrobu un pretvēža aktivitāti. Turcijā raksturīga augu bioloģiskā daudzveidība, pateicoties valsts ģeogrāfiskajai atrašanās vietai un trim jūrām, kas nodrošina ļoti dažādus klimatiskos apstākļus. Turcijas savvaļas ogulāju sugu lielā ekoloģiskā daudzveidība ir nozīmīgs genofonds, kas ir būtisks cilvēka patēriņam un var kalpot lauksaimniecības attīstībai nākotnē. Šī apskata mērķis ir iepazīstināt ar dažām Turcijā dabiski sastopamām savvaļas ēdamo ogulāju sugām, piemēram, *Morus* spp., *Hippophae rhamnoides* L., *Viburnum opulus* L., *Rubus idaeus* L., *Rubus fruticosus* L., *Sambucus nigra* L., *Vaccinium* spp., *Arbutus unedo* L., *Ribes* spp. un *Fragaria vesca* L., aprakstīt to izplatību, pielietojumu un augļu īpašības. Šo savvaļas augļaugu ģenētisko resursu saglabāšana ir nepieciešama, lai tos varētu izmantot jaunu īpašību selekcijā.