SİDAS MEDYA
Akademik Gıda®
ISSN Online: 2148-015X
https://dergipark.org.tr/tr/pub/akademik-gida

Akademik Gıda 20(4) (2022) 329-335, DOI: 10.24323/akademik-gida.1224295

Research Paper / Araştırma Makalesi

Antioxidant Activity, Physico-Chemical and Fatty Acid Composition of Oleaster (*Elaeagnus angustifolia* L.) Varieties Naturally Grown in Western Mediterranean Region of Turkey

Rabia Fakı[1], Hale Seçilmiş Canbay[2], Oguz Gursoy[3], Yusuf Yilmaz[3]

[1]Graduate School of Natural and Applied Sciences, Division of Food Engineering, Burdur Mehmet Akif Ersoy University, Turkey
[2]Department of Chemistry, Faculty of Science and Literature, Burdur Mehmet Akif Ersoy University, Turkey
[3]Department of Food Engineering, Faculty of Engineering and Architecture, Burdur Mehmet Akif Ersoy University, Turkey

Received (Geliş Tarihi): 12.09.2022, Accepted (Kabul Tarihi): 15.11.2022
Corresponding author (Yazışmalardan Sorumlu Yazar): yusufyilmaz@mehmetakif.edu.tr (Y. Yilmaz)
+90 248 213 2722 +90 248 213 2704

ABSTRACT

Elaeagnus angustifolia L. belongs to the family of Elaeagnaceae, and its fruits are consumed as an appetizer. Mesocarp tissue of Elaeagnus fruits contains mainly carbohydrates while endocarp part (kernel) is rich in lipids. In this study, fatty acid profiles and nitrogen contents of the endocarp tissues of four different *Elaeagnus angustifolia* varieties naturally grown in the Western Mediterranean Region of Turkey were determined as well as the total phenolic and flavonoid contents and antioxidant activity of their mesocarp and exocarp tissues. The crude fat content of endocarp tissues of Elaeagnus fruits ranged from 24.45 to 30.13%, and the highest nitrogen content (0.205%) was in the Native variety. The dominant fatty acid in endocarp tissue lipids was linoleic acid (ca. 48%), and the content of mono- and polyunsaturated fatty acids in this tissue was about 90%. Varietal differences were found in the total phenolic and flavonoid contents and antioxidant activities of mesocarp and exocarp tissues. The mesocarp tissues of Sugar variety had the highest total phenolic content (161.9 mg GAE 100/g dry matter (dm)) and antioxidant activity (118.3 µmol Trolox® equivalent (TE) g dm) while the highest total flavonoid content (216.5 mg catechin equivalent (CE) 100 g dm) was in the exocarp tissue of Native variety. Results indicated that endocarp tissue lipids can be a good source of polyunsaturated fatty acids for human consumption in food, feed and cosmetics industries.

Keywords: Antioxidant activity, *Elaeagnus angustifolia* L., Fatty acid composition, Flavonoid

Batı Akdeniz Bölgesi'nde Doğal Olarak Yetişen İğde (*Elaeagnus angustifolia* L.) Çeşitlerinin Antioksidan Aktivitesi, Fiziko-Kimyasal Özellikleri ve Yağ Asidi Kompozisyonu

ÖZ

Elaeagnus angustifolia L., Elaeagnaceae (İğdegiller) familyasından meyveleri iştah açıcı olarak tüketilen bir bitkidir. Elaeagnus meyvesinin mezokarp dokusu ağırlıklı olarak karbonhidrat içerirken, endokarp (çekirdek) kısmı lipidler bakımından zengindir. Bu çalışmada, Batı Akdeniz Bölgesi'nde doğal olarak yetişen dört farklı *Elaeagnus angustifolia* çeşidinin endokarp dokularının yağ asidi kompozisyonu ve nitrojen içeriği ile bunların mezokarp ve ekzokarp dokularının toplam fenolik ve flavonoid içerikleri ile antioksidan aktiviteleri belirlenmiştir. Elaeagnus meyvelerinin endokarp dokularının ham yağ içeriği %24.45 ile 30.13 arasında değişmiş ve en yüksek azot içeriği (%0.205) Yerli çeşidinde bulunmuştur. Endokarp doku lipidlerindeki baskın yağ asidi linoleik asit olarak belirlenmiş (yaklaşık %48) ve bu dokudaki tekli ve çoklu doymamış yağ asitlerinin içeriğinin yaklaşık %90 olduğu tespit edilmiştir. Mezokarp ve ekzokarp dokularının toplam fenolik ve flavonoid içeriklerinde ve antioksidan aktivitelerinde çeşit farklılıklar belirlenmiştir. Şeker çeşidinin mezokarp dokuları en yüksek toplam fenolik içerik (161.9 mg GAE/100 g kuru madde

(km)) ve antioksidan aktiviteye (118.3 µmol Trolox® eşdeğeri (TE) g km) sahipken, en yüksek toplam flavonoid içeriği (216.5 mg kateşin eşdeğeri (CE)/100 g km) Yerli çeşidi ekzokarp dokusunda tespit edilmiştir. Sonuçlar, endokarp doku lipitlerinin gıda, yem ve kozmetik endüstrisinde iyi bir çoklu doymamış yağ asitleri kaynağı olabileceğini göstermiştir.

Anahtar Kelimeler: Antioksidan aktivite, *Elaeagnus angustifolia* L., Yağ asidi bileşimi, Flavonoid

INTRODUCTION

Elaeagnus angustifolia L., known as Russian olive, is a shrub or tree, which can grow up to 7 m in height. It has been widely cultivated for its edible fruits in Central and Eastern Anatolia, and its fruits are elliptic-oblong, 10-20 x 6-12 mm in diameter and reddish-brown in color [1, 2] and consumed as an appetizer [3]. *E. angustifolia* L. can grow under different climatic conditions [4]. It can withstand temperatures between 45–46°C and requires a minimum of 20 cm of precipitation during the year [5]. It is a plant that likes the sunlight, and growth requirements include a shallow-dry, very poor or even salty in terms of soil and moderate in terms of water demands [6]. The leaves of *E. angustifolia* L. are 4-8 cm long, narrow and lance-shaped, with flat edges, sharp edges and sharp edges. It blooms in June. The flowers are very sharp and beautiful fragrance. Fruits are olive berry-sized and yellowish-brown, consumed fresh or dried [7].

Fruits of *E. angustifolia* L. have many nutritive constituents such as carbohydrates, proteins, organic substances, amino acids and vitamins [8]. In recent years, conscious of consumers has increased for eating more healthy foods. The fruits of Elaeagnus are low in calorie content, but contain a variety of nutrients like dietary fiber and minerals, especially Na, P, Ca and Mg [9]. The composition of *E. angustifolia* L. fruits varies according to their variety, cultivation, soil and geographical location [10]. Dry flowers of this plant are rich in folic acid and vitamin B12 [11]. The leaves and flowers of *E. angustifolia* L. contain phenolic and flavonoid compounds, and these compounds have antioxidant properties that protect the cells from oxidative damage [12].

Valuable extractable compounds found in the flowers and leaves of Elaeagnus species have been used in pharmacology. Elaeagnus plant has been used as a drought resistant species in Turkey to completely stop dune movements in arid regions. Exocarp tissues of Elaeagnus can be used in chemistry, textile, cosmetics and pharmacology industries, making it as an important crop in Turkey [13]. The medical value of plants depends on their phytochemical components such as alkaloids, tannins, flavonoids and phenolic compounds, which are probably the most important [14]. Dry leaves and fruits are astringent and have antipyretic effects. Elaeagnus flowers are used to flavor some liqueurs. Fruits and flower of this plant have also been applied to treat nausea, vomiting, jaundice, asthma and abdominal distention [15]. Leaves are known to be used in the production of tea, animal feed and paper clay while fruits can be used in jam and liquor production. This plant is highly resistant to diseases and insect damages [16]. Due to these properties, it is frequently used in afforestation of roadsides in Europe and the US. Elaeagnus is a species that should be considered important for erosion sensitive areas with its ability to make degraded soils available and their soil protection properties [17].

Elaeagnus species provide nectar for bees in natural life. It is also widely used as a medicinal and aromatic plant by the residents in Europe and the US since it has less insect and disease problems [15, 18, 19].

The aim of this current study was to determine the biochemical content of four varieties of *E. angustofolia* L., widely and naturally grown in the Western part of Turkey. The analyses of fatty acid composition and nitrogen content in endocarp tissues, and total phenolic and total flavonoid contents and antioxidant activity in mesocarp and exocarp tissues of *E. angustofolia* L. were performed. Limited number of studies are available on the fatty acid composition of endocarp tissues of *E. angustofolia* or on the antioxidative nutrient data of their mesocarp and exocarp tissues of these native varieties.

MATERIALS and METHODS

Materials

Ripe fruits of Elaeagnus species were directly obtained from local farmers in Western Mediterranean Region in Turkey in 2017 (Figure 1). About two kilograms of fruits for each variety (Sugar, Native, Hurma and Red varieties of *Elaeagnus angustofolia* L.) at a commercial maturity were stored at -20°C in a freezer until use. Each batch was randomly divided into three parts, and endocarp, mesocarp and exocarp tissues (Figure 2) of each part were carefully and separately removed from fruits. They were used as triplicates for further analyses.

Trolox®, sodium carbonate, NaOH, $AlCl_3.6H_2O$, chromatographic grade methanol and n-hexane and HCl (35%) were purchased from Sigma-Aldrich (St. Louis, MO, USA) while Folin-Ciocalteu reagent, $NaNO_2$ and chromatographic grade ethanol were obtained from Merck (Darmstadt, Germany). 1,1-Diphenyl-2-picrylhydrazyl radical (DPPH) was obtained from Fluka (Kenilworth, NJ, USA).

Aqueous ethanol (70%, v/v) was used for the extraction in total phenolic and flavonoid contents and antioxidant activity assays. Mesocarps and endocarps of Elaeagnus fruits were carefully separated from each other and crushed separately in a porcelain mortar into a powder form. Powders were mixed with aqueous ethanol at a ratio of 1:10 (w/v), and the mixture was subjected to ultrasonication (WUCD06H, Daihan Scientific Co. Ltd.,

Korea) for 10 minutes in an ultrasonic water bath (100% at 40kHz). Then, they were shaken on the orbital shaker (Widhshake, Daihan Scientific Co. Ltd., Korea) for 15 minutes at room temperature and centrifuged at 10,000*g* at 10°C. Supernatants were transferred in a volumetric flask. This process was repeated twice for each sample. Clear supernatants were collected in the amber flasks and stored at -24°C until analysis.

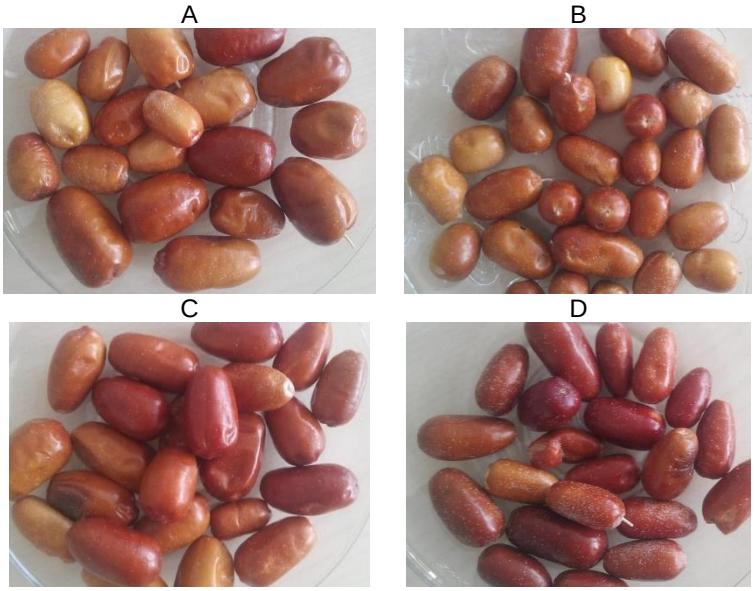

Figure 1. Pictures of four varieties of Elaeagnus (A: Sugar, B: Native, C: Hurma and D: Red)

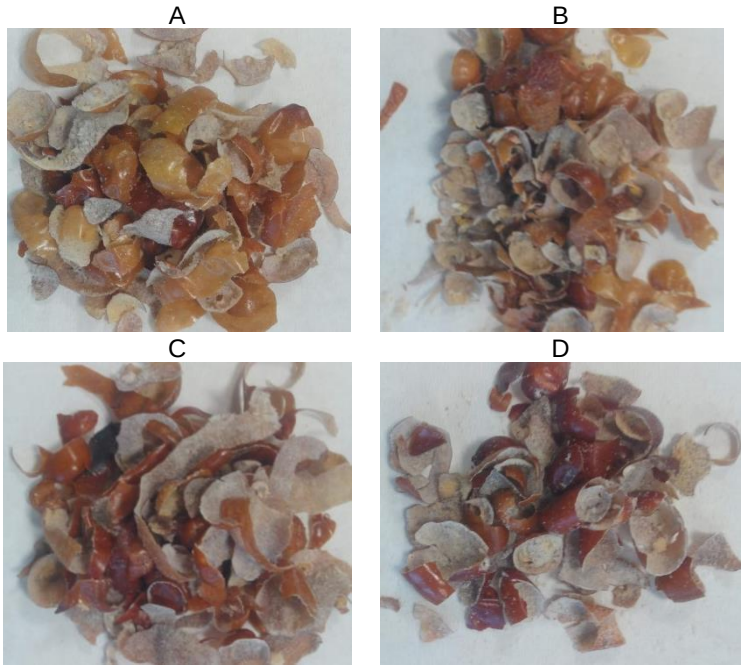

Figure 2. Pictures of exocarp tissues of four Elaeagnus varieties (A: Sugar, B: Native, C: Hurma and D: Red)

Analysis for Fatty Acid Methyl Esters

Apparatus GC-MS was Agilent 7890A gas chromatograph equipped with a 5975 mass detector (MSD), a 7693B automatic sampler and a MSDCHEM (Agilent, USA) data system. Analytes were separated in a fused silica capillary column CP-Wax stationary phase (50 m x 0.25 mm; film thickness 0.2 µm) (Agilent, USA). Oven temperature program was as follows: initial temperature 60°C, held for 1 min, increase by 13°C/min to 175°C, increase at 4°C/min to 215°C, and then hold at 215°C for 25 min, total run was 76 min. The split ratio was 1:20 and the carrier gas (helium) flow rate was 2 mL/min. Temperature of the detector was 250°C, and injector was fixed at 250°C. MSD conditions were ion source temperature, 230°C; electron energy, 70 eV; mass scan range, 30–500 amu [20].

FAMEs were obtained by methylation with HCl in methanol (1.5 M). 200 µL lipid fraction was mixed and

shaken vigorously for 15 min in an ultrasonic shaker (Bandelin Berlin, Germany). Lipid fraction was methylated 2 h (70°C), and then 1 mL hexane was added to collect the FAME in hexane as above and analyzed by GC-MS.

Nitrogen Content

Nitrogen contents of endocarps were determined by the Dumas method, which is based on the combustion of a sample in an oxygen-enriched atmosphere at a high temperature in order to ensure complete combustion chamber. Gerhardt Dumas Analyser (Gerhardt GmbH & Co. KG, Königswinter, Germany) was used. Each sample (0.4 g) was weighed into a porcelain holder for its introduction into the combustion chamber utilizing an automated sample loader.

Total Phenolic and Flavonoid Contents and Antioxidant Activity

Total phenol contents (TPC) were determined by the Folin-Ciocalteu method [21]. Gallic acid was used as a standard. A UV-Vis spectrophotometer with a rotary type 8 position multi cell holder (Optizen Pop, Mecasys Co., Ltd., Daejeon, Korea) was used to determine the total phenol contents of mesocarp and endocarp tissues in terms of Gallic Acid Equivalents (GAE). Total flavonoid contents were determined by the method described by [22]. Catechin (20-100 mg/L) was used as a standard, and total flavonoid contents of mesocarp and endocarp tissues were determined in terms of Catechin Equivalents (CE). DPPH assay procedure described by Thaipong et al. [23] was used to determine antioxidant activities of mesocarp and endocarp tissues. For this assay, the absorbance readings of extracts were taken at 515 nm wavelength. The linear standard curve was between 10 and 50 µM Trolox®. Antioxidant activities of mesocarps and endocarps in DPPH assay were expressed in µmol TE/g of dry matter.

Physical Properties of Fruits

A digital caliper with 1% precision (Wert W2325, Ningbo Sun Group Tools Co., Ltd., Yuyao, Zhejiang, China) was used to determine the size of Elaeagnus fruits. The measurements on samples were made randomly from four different Elaeagnus varieties.

Dry Matter Content of Endocarps

The method described by the AOAC (1990) was used to determine dry matter contents of endocarps of four different Elaeagnus varieties. Briefly, the sample (5 g) was weighed into aluminum containers and dried to a constant weight at 105°C.

Statistical analysis

Data were analyzed using the Statistical Analysis System software (SAS Institute Inc., Carry, North Carolina, USA). The significant differences among means were determined by the Duncan multiple comparison test at α=0.05 and the results were expressed as mean ± standard deviation.

RESULTS and DISCUSSION

Physical Properties of Elaeagnus Fruits

Physical properties of fruits of four different Elaeagnus varieties are shown in Table 1. The ranges for the fruit width (maximum diameter) and length values were 13.5-17.1 mm and 15.5-29.5mm, respectively. Native variety had the smallest fruit width and length values while Hurma variety had the highest fruit length ($p<0.05$). In a study by Akbolat et al. [24], the fruit length for Elaeagnus species grown in Turkey ranged from 17.8 to 33.7 mm while the range for the fruit width was 12.3 to 22.0 mm. Cansev et al. [8] reported the fruits of Elaeagnus species grown in northwest Turkey had a mean width of 16.2 and length of 24.8mm. Bartha and Csiszár, [25] reported that the fruits of Elaeagnus species are usually “10-16 mm long, ovoid or elliptic, silvery grey colored, densely covered by scale hairs” and maturated fruits are yellowish or reddish brown in color. In our study, ranging from 18.5 to 29.5 mm, the length of Elaeagnus species was in good agreement with Akbolat *et al*. [24] and Cansev et al. [8] but it was about twice higher than the value reported by Bartha and Csiszár [25], which indicated significant differences among Elaeagnus species grown in different geographical locations.

Table 1. Physical properties of fruits of different Elaeagnus varieties

Elaeagnus variety	Fruit width* (mm)	Fruit length (mm)
Sugar	17.1±1.6^{a}	24.7±1.6^{b}
Native	13.5±0.6^{b}	18.5±0.8^{c}
Hurma	16.1±1.2^{a}	29.5±1.7^{a}
Red	15.8±0.4^{a}	24.4±0.5^{b}

*Means followed by different superscripts within a column are significantly different at α=0.05.

Approximate Composition of Endocarp Tissues of Elaeagnus Varieties

Approximate composition of endocarp tissues in four different Elaeagnus varieties are shown in Table 2. The crude fat content of endocarp tissues in Native variety was about 30%, which was the highest in wet basis ($p<0.05$). Dry matter content of endocarp tissues of this variety was also the lowest (80%) ($p<0.05$). Results indicated that endocarp tissues of Elaeagnus varieties were low in nitrogen content, thus crude protein content (Table 2).

Dry matter content of the fruits (mesocarp tissues) of Elaeagnus species grown in Turkey was reported between 82.4 and 83.6% while their protein content ranged from 11.8 to 12.8% [24]. Cansev et al. [8] reported that the dry matter, total soluble sugar, crude fat and protein contents of Elaeagnus species grown in Bursa (Northwest of Turkey) were 73.5, 70.6, 0.5 and 4.6%, respectively. Focusing on the endocarp tissue of the Elaeagnus species grown in the Western Mediterranean Region of Turkey, our study indicated that this tissue was low in protein content but significantly high in crude fat content. To the best of our knowledge, the literature on the crude fat content of the seeds of Elaeagnus species is very limited, and in a study by Kadir and Kuerban-Jiang [26] the crude fat content of the seeds of wild Elaeagnus species in Xinjiang (China) was reported as 8.2%. In our study, three times higher crude fat contents were determined in the Elaeagnus species studied.

Table 2. Approximate composition of kernels in four different Elaeagnus varieties

Elaeagnus variety	Crude fat* (%, dw)	Nitrogen (%)	Dry matter (%)
Sugar	26.88±0.12^{b}	0.052±0.003^{b}	89.4±0.4^{a}
Native	30.13±1.39^{a}	0.205±0.006^{a}	80.0±2.5^{b}
Hurma	25.18±0.96^{b}	0.047±0.004^{b}	87.9±0.3^{a}
Red	24.45 ±0.21^{b}	0.004±0.001^{c}	89.8±0.4^{a}

*Means followed by different superscripts within a column are significantly different at α=0.05.

Fatty Acid Composition of Endocarp Lipids in Elaeagnus Varieties

Endocarp tissues of Elaeagnus varieties are not consumed or utilized by human; however, they can be used as a feed material for animals. Fatty acid composition of Elaeagnus endocarp tissue lipids are shown in Table 3. More than 55% of the lipids in these tissues consisted of polyunsaturated fatty acids. With about 48%, linoleic acid (C18:2) was the most dominant fatty acid in endocarp lipids, which was followed by the oleic (C18:1), linolenic (C18:3), palmitic (C16:0) and stearic acids (C18:0) in decreasing order (Table 3). About one third of the lipids in endocarp tissues were monounsaturated. In a study by Yıldırım et al. [27] the ratios of C16:1, C18:0, C18:1, C18:2 and C18:3 fatty acids in *E.angustifolia* were reported as 10.40, 16.95, 8.64, 16.31 and 5.13%, respectively. Kadir and Kuerban-Jiang [26] reported that the ratios of C18:0, C18:1, C18:2 and C18:3 fatty acids in the endocarp tissue lipids of *E.angustifolia* from Xinjiang Uigur Autonomous Region of China were 5.31, 33.17, 46.52 and 9.21%, respectively. In the current study, varietal differences were found among the ratios of dominant fatty acids in endocarp tissue lipids but results were generally in good agreement with those reported by Kadir and Kuerban-Jiang [26] for wild Elaeagnus species grown in Xinjiang (China).

Table 3. Fatty acid composition (%) of kernel lipids extracted from four different varieties of Elaeagnus fruits

Fatty acid methyl ester	Sugar*	Native	Hurma	Red
C14:0	0.28±0.01^{u-x}	0.25±0.05^{u-x}	0.32±0.08^{u-x}	0.20±0.00^{v-x}
C15:0	0.18±0.00^{wx}	0.12±0.01^{wx}	0.21±0.01^{u-x}	0.13±0.00^{wx}
C16:0	6.84±0.01^{m}	6.29±0.04^{n}	5.43±0.05^{o}	5.42±0.08^{o}
C16:1	0.42±0.08^{s-w}	0.42±0.03^{s-w}	0.62±0.10st	0.48±0.03^{s-v}
C17:0	0.17±0.06^{wx}	0.08±0.03^{x}	0.25±0.01^{u-x}	0.09±0.01^{x}
C17:1	0.30±0.20^{u-x}	0.13±0.02^{wx}	0.14±0.02^{wx}	0.08±0.01^{x}
C18:0	4.16±0.00^{p}	3.34±0.01^{q}	2.72±0.03^{r}	2.70±0.02^{r}
C18:1n-9	27.97±0.30^{h}	33.65±0.12^{e}	31.14±0.08^{f}	30.52±0.00^{g}
C18:2n-6	47.86±0.04^{b}	47.03±0.34^{c}	46.18±0.07^{d}	49.14±0.01^{a}
C18:3n-6	10.34±0.02^{j}	7.55±0.04^{l}	10.81±0.06^{i}	9.94±0.02^{k}
C20:0	0.40±0.27^{s-w}	0.68±0.42^{s}	0.28±0.08^{u-x}	0.29±0.02^{u-x}
C20:1	0.40±0.05^{s-w}	0.34±0.20^{t-x}	0.50±0.01^{s-u}	0.70±0.03^{s}
Others	0.69±0.27^{b}	0.16±0.04^{d}	1.41±0.39^{a}	0.32±0.08^{c}
SFA**	12.16±0.44^{a}	10.79±0.44^{b}	9.09±0.22^{c}	8.82±0.08^{c}
MUFA	28.71±0.30^{d}	34.18±0.07^{a}	32.10±0.07^{b}	31.44±0.00^{c}
PUFA	58.21±0.06^{b}	54.58±0.38^{d}	56.99±0.13^{c}	59.08±0.03^{a}

*Means followed by different superscripts across the table are significantly different at α=0.05. **SFA, MUFA and PUFA are saturated, mono- and poly-unsaturated fatty acids, respectively.

TPC, TFC and DPPH Values of Mesocarp and Exocarp Tissues in Elaeagnus Varieties

Mesocarp tissues of Elaeagnus varieties are generally consumed after exocarp tissues (peels) were removed. Total phenolic and flavonoid contents and antioxidant activity of mesocarp and exocarp tissues of four different Elaeagnus varieties are shown in Table 4. Current study showed that mesocarp tissues were a better source of total phenolics than exocarp tissues in general. Varietal differences were found among total phenolic and flavonoid contents of mesocarp and exocarp tissues. Among mesocarp tissues, Sugar variety had the highest total phenolic content (161.9 mg GAE/100 g of dm)

($p<0.05$). Mesocarp and endocarp tissues of Hurma variety had a similar TPC value ($p>0.05$). In terms of flavonoid content, exocarp tissues of Native variety had the highest value (216.5 mg CE/ 100 g of dm). Mesocarp tissues of Sugar variety had the highest antioxidant value (118.3 µmol TE/ g of dm) followed by the Red variety.

Table 4. Total phenolic and flavonoid contents and antioxidant activity of mesocarp and exocarp tissues of four different Elaeagnus varieties

Elaeagnus variety	Part of fruit	Total phenolic content* (mg GAE/100 g of dw)	Flavonoid content (mg CE/100 g of dw)	Antioxidant activity (µmol TE/g of dw)
Sugar	Mesocarp	161.9±4.9^{a}	102.4±10.5^{cbd}	118.3±4.8^{a}
	Exocarp	54.2±11.1^{e}	84.3±20.6^{cd}	12.4±3.7^{cd}
Native	Mesocarp	136.6±7.3^{b}	33.3±0.4^{ef}	20.7±8.2^{c}
	Exocarp	113.5±13.7^{c}	216.5±4.0^{a}	50.0±12.2^{b}
Hurma	Mesocarp	46.1±1.0^{e}	8.01±0.8^{f}	1.4±0.6^{d}
	Exocarp	55.4±13.3^{e}	121.9±37.8^{bc}	15.3±0.5^{cd}
Red	Mesocarp	138.7±10.4^{b}	64.3±8.9^{de}	50.3±14.1^{b}
	Exocarp	84.7±0.7^{d}	135.2±12.5^{b}	21.6±1.1^{c}

*Means followed by different superscripts within a column are significantly different at α=0.05.

In a study by Gökbulut [28], fruits and flowers of Elaeagnus species were reported to be high in antioxidant activity (0.03-4.64 ABTS and 0.54-4.45 µg Trolox/g of dm) and fruit extracts had a total phenolic content of 0.12-6.39 mg GAE/ g of dm. Saboonchian et al. [11] reported that the methanol extraction of Elaeagnus leaves resulted in a total phenolic content of 8.64-10.28 mg GAE 100/g fresh weight (fw) while ethanol extraction was 7.78-10.91. Total phenolic contents of the flower were 5.86-6.36mg GAE/ 100 g of fw in methanol extracts and 4.63-6.24 in ethanol extracts. Leaves had a total flavonoid content of 3.34-3.36 mg QE/ 100 g of fw in methanol extracts and 4.81-5.80 in ethanol extracts. Cansev et al. [8] determined the total phenolic content and antioxidant activity (DPPH assay) of exocarp and mesocarp tissues of *E. angustifolia* L., and reported that methanolic extracts of exocarp and mesocarp tissues had a total phenolic content of 524.40 and 413.95 mg GAE/100 g of fw, respectively. Antioxidant activity of exocarp and mesocarp tissues was about 27 mmol Trolox/g of fw, and the difference in the antioxidant activity of the aqueous, acetone and methanol extracts of both tissues was found insignificant.

In a recent study by Hassanzadeh and Hassanpour [29], total phenolic and flavonoid contents and antioxidant capacities of thirty-eight genotypes of *E. angustifolia* L. from five different locations in Iran were determined. The total phenolic content ranged from 262.4 to 1179.0 mg GAE/100 g of fw in exocarp tissues of *E. angustifolia* L. while it ranged from 250.6 to 850.9 mg GAE/100 g of fw in mesocarp tissues. Flavonoid contents of exocarp tissues were between 23.5 and 313.50 mg CE/100 g of fw while mesocarp tissues had a flavonoid content ranging from 16.5 to 266.3 mg CE per 100 g fw. In general, the flavonoid contents of mesocarp and endocarp tissues in four native varieties of *E. angustifolia* L. in our study were in good agreement with the results of this recent study. On the other hand, the total phenolic contents of mesocarp and endocarp tissues in four native varieties of *E. angustifolia* L. were lower than those reported by Hassanzadeh and Hassanpour [29].

CONCLUSION

Results of the current study indicated that four varieties of *E. angustifolia* L. naturally grown in Western Mediterranean Region of Turkey had significant differences in their crude fat contents of endocarp tissues. Fatty acid composition of the endocarp tissues showed that most of the lipids were polyunsaturated while saturated fatty acids were about 10%. In general, mesocarp tissues of the four varieties had a higher total phenolic content than exocarp tissues, but this trend was not evident for the flavonoid content and antioxidant activity of these varieties of *E. angustifolia* L. Containing highly unsaturated fatty acids, lipids of the endocarp tissues of *E. angustifolia* L. could be utilized in food, feed and cosmetic industries.

REFERENCES

[1] Dirr, M. (1990). Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses, Stipes Publishing Company, Champaign, Illionis, USA, pp. 301-306.

[2] McKean, D.R. (1982). In Flora of Turkey and the East Aegean Islands, Vol. 7, (Ed. P. H. Davis), Edinburgh University Press, Edinburgh, pp. 533-534.

[3] Baytop, T. (1984). Curing by Plants in Turkey (Past and Present). Istanbul University Press, No. 3255, Faculty of Pharmacy, No. 40, Istanbul, pp. 260.

[4] Carman, J.G., Brotherson, J.D. (1982). Comparisons of sites infested and not infested with saltcedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*). *Weed Science*, 30, 360-364.

[5] Kalyoncu, I.M., Ersoy, N., Yılmaz, M.A. (2008). Research on the effects of some hormone and relative humidity levels on rooting of softwood top cuttings of Russian olive (*Elaeagnus angustifolia* L.) determined by the selection of breeding. *Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi*, 3(1), 9-18.

[6] Anonymous (2017). https://www.eyasamrehberi.com/photo/meyva_agaclari/igde.htm (accessed on 19.11.2017).
[7] Hays Jr., J.F. (1990). Wildlife considerations in windbreak renovation. In: Great Plains Agricultural Council, Compiler. Windbreaks: Living with the wind: Proceedings, Windbreak Renovation Workshop, pp. 23-25.
[8] Cansev, A., Sahan, Y., Celik, G., Taskesen, S., Ozbey, H. (2011). Chemical properties and antioxidant capacity of *Elaeagnus angustifolia* L. fruits. *Asian Journal of Chemistry*, 23(6), 2661-2665.
[9] Ercisli, S., Orhan, E. (2007). Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. *Food Chemistry*, 103, 1380-1384.
[10] Güler, N., Liman, B.C. (2005). The investigation of vitamin B12, folic acid and biotin content of different plant species by enzyme immuno assay. *Sağlık Bilimleri Dergisi*, 14(3), 184-190.
[11] Saboonchian, F., Jamei, R., Sarghein, S.H., (2014). Phenolic and flavonoid content of *Elaeagnus angustifolia* L. (leaf and flower). *Avicenna Journal of Phytomedicine*, 4, 231-238.
[12] Shariff, Z.U. (2001). Modern herbal therapy for common ailments, Spectrum Books Ltd., Ibadan, Nigeria in Association with Safari Books Ltd. Nature Pharmacy Series, UK, 1, 9-84,
[13] Akgül, M., Akça, M. (2014). Chemical analysis in Russian olive wood (*Elaeagnus angustifolia* L.) and barks. II. National Mediterranean Forest and Environment Symposium: The future of Mediterranean forests: Sustainable society and environment, Isparta, Turkey.
[14] Ge, Y., Liu, J., Su, D. (2009). *In vivo* evaluation of the anti-asthmatic, antitussive and expectorant activities of extract and fractions from *Elaeagnus pungens* leaf. *Journal of Ethnopharmacology*, 126, 538-542.
[15] Peterson, G.W. (1976). Disease of Russian olive caused by *Botryodiplodia theobromae*. *Plant Disease Reporter*, 60, 490-494.
[16] Gülcü, S., Çelik-Uysal, S. (2010). The effects of seedling density on morfological characteristics of oleaster (*Elaeagnus angustifolia* L.) seedlings. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi*, A(2), 74-81.
[17] Shaw, D.L. (1988). The design and use of living snow fences in North America. *Agriculture, Ecosystems & Environment*, 22(23), 351-362.
[18] Carrol, R.B., Morehart, A.L., Stuart, M. (1976). Phomopsis canker of Russian-olive in Delaware. *Plant Disease Reporter*, 60, 787-788.
[19] Krupinsky, J.M., Frank, A.B. (1986). Effects of water stress on Tubercularia canker of Russian olive. *Great Plains Agriculture [i.e. Agricultural] Council Publication*, 117, 171-172.
[20] Seçilmiş Canbay, H., Bardakçı, B. (2011). Determination of fatty acid, C, H, N and trace element composition in grape seed by GC/MS, FTIR, elemental analyzer and ICP/OES. *SDU Journal of Science*, 6, 140-148.
[21] Vernon, L.S., Orthofer, R., Lamuela-Raventos, R.M., (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology*, 299, 152-178.
[22] Zhishen, J., Mengcheng, T., Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry*, 64, 555-559.
[23] Thaipong, K., Boonprakop, U., Crosby, K., Cisneros-Zevallos, L., Byrne, D.H. (2006). Comparison of ABTS, DPPH, FRAP and ORAC assays for estimating antioxidant activity from guava fruit extracts. *Journal of Food Composition and Analysis*, 19, 669-675.
[24] Akbolat, S., Ertekin, C., Menges, H.O., Guzel, E., Ekinci, K. (2008). Physical and nutritional properties of oleaster (*Elaeagnus angustifolia* L.) growing in Turkey. *Asian Journal of Chemistry*, 20(3), 2358-2366.
[25] Bartha, D. Csiszár, A. (2008). Russian Olive (*Elaeagnus angustifolia* L.). In: The most important invasive plants in Hungary, edited by Zoltán Botta-Dukát and Lajos Balogh, Institute of Ecology and Botany, Hungarian Academy of Sciences, Vácrátót, Hungary, pp. 85-93.
[26] Kadir, M., Kuerban-Jiang, B. (2011). Research on fat and protein compositions in seeds of wild *Elaeagnus angustifolia* from Xinjiang Uigur Autonomous Region. *Medicinal Plants*, 2, 51-53.
[27] Yıldırım, I., Gökçe, Z., Yılmaz, Ö. (2015). The investigation of biochemical content of *Elaeagnus angustifolia*. *Journal of the Turkish Chemical Society, Section A: Chemistry*, 2(1), 34-41.
[28] Gökbulut, İ. (2014). Volatile composition, antimicrobial and antioxidant properties of different parts from *Elaeagnus angustifolia* L. *Journal of Essential Oil Bearing Plants*, 17(6), 1187-1202.
[29] Hassanzadeh, Z. Hassanpour, H. (2018). Evaluation of physicochemical characteristics and antioxidant properties of Elaeagnus angustifolia L. *Scientia Horticulturae*, 238, 83-90.