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Antioxidant properties of some plants growing wild in Turkey

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RESUMEN

Propiedades antioxidantes de algunas plantas que crecen salvajes en Turquía.

En este estudio, la actividad antioxidante de extractos metanólicos al 50% en agua de 38 plantas que crecen en la provincia turca de Afyonkarahisar fueron evaluados con algunos ensayos antioxidantes, incluyendo la actividad captadora de radicales libres y de peróxido de oxígeno (H_2O_2) y la actividad quelatante de metales (Fe^{2+}). Los extractos metanólicos de frutas de las especies *Cornus* y *Morus* (actividades captadoras de H_2O_2 y DPPH y actividad quelatante de Fe^{2+}) y los extractos metanólicos de hojas de especies de *Mentha* (actividad captadora de DPPH) son los que mostraron una actividad mayor. Estas propiedades antioxidantes dependieron de la concentración de la muestra.

PALABRAS-CLAVE: *Actividad antioxidante – Actividad quelatante – Captadores radicalarios – Extractos – Plantas medicinales y aromáticas*.

SUMMARY

Antioxidant properties of some plants growing wild in Turkey.

In this study, the antioxidant activity of 50% aqueous methanol extracts of 38 plants growing in the Afyonkarahisar province of Turkey were evaluated by various antioxidant assay, including free radical scavenging, hydrogen peroxide (H_2O_2) scavenging and metal (Fe^{2+}) chelating activities. The methanolic fruit extracts of the *Cornus* and *Morus* species (H_2O_2 and DPPH scavenging activities, Fe^{2+} chelating activity) and the methanolic leaf extracts of the *Mentha* species (DPPH scavenging activities) examined in the assay showed the strongest activities. These antioxidant properties depended on the concentration of samples.

KEY-WORDS: *Antioxidant activity – Chelating activities – Extracts – Medicinal and aromatic plants – Radical scavenging.*

1. INTRODUCTION

Fruits, vegetables and herbs are recommended at present as optimal sources of chemical constituents with antioxidant activity and supplementing the human diet with plants containing high amounts of compounds capable of deactivating free radicals may have beneficial effects (Madsen and Bertelsen, 1995, Velioglu, Mazza, Gao and Oomah, 1998; Lutomski, 2001).

Antioxidants are compounds which prevent some toxic materials in the body, especially free radicals. Free radicals which lead to oxidation are basically oxygen sourced metabolites (super oxide anions O_2, hydrogen peroxide H_2O_2, hydroxide radical (OH^-), hypochloric acid, chloramines, nitrogen dioxide, ozone and lipid peroxides. Antioxidants such as beta, carotene, ascorbic acid, and alfa- tocopherol are proven to prevent the oxidation of free radicals by *in vitro* and *in vivo* studies (Cross et al. 1987; Aruoma, 1998; Peter, 1993; Brand-Williams *et al*. 1995; Stone and Papas, 1997; Zheng and Wang, 2001; Gümrükçüo lu, 2003). Vitamin A takes part in the regulation of protective epitel in the lungs, stomach, urinary tract and other organs in the defense mechanism of the human body. Another antioxidant, tocopherol, protects cells from free radicals, heavy metals, poisonous compounds, medicines and radiation by stabilizing lipid parts of the cell membrane and transporting molecules. Tocopherols prevent the degenerative effects of free radicals in tissue, skin and blood vessels. Another antioxidant, ascorbic acid (Vitamin C) aids in the growth and well being of the body's cells in bones, ligaments and blood vessels. Besides, it helps the body to respond against infections and stress and assists in the proper use of iron (Cross *et al*. 1987; Aruoma, 1998; Peter, 1993; Brand-Williams *et al*. 1995; Stone and Papas, 1997; Zheng and Wang, 2001; Gümrükçüoğlu, 2003).

Afyonkarahisar is rich in a wide variety of flora and vegetation. This richness in flora and vegetation is especially notable in Sultan, Emir, Akda and the Kumalar Mountains. For this reason, many native and foreign botanists collected plant samples from these mountains and other locations in Afyonkarahisar (Akçiçek, 2003).

Afyonkarahisar is in the middle zone of the Mediterranean and the İran-Turan floristic regions

from the point of view of plant geography and there are plants which also represent the Europa-Syberia flouristic region. Around Afyonkarahisar, there are approximately 2500 natural plant species, almost 350 of them endemic, because of its ecological conditions and especially its microclimate (Akçiçek, 2003; Kargıoğlu, 2003; Köse and Ocak, 2004).

The aim of the present work is to investigate the antioxidant properties of some plants growing wild in the Afyonkarahisar province of Turkey.

2. MATERIALS AND METHODS

2.1. Materials

Plants (*Taxus baccata* L.*, Pistacia terebinthus* L. subsp. *palaestina* (Boiss.) Engler, *Pistacia terebinthus* L. subsp. *terebinthus, Rhus coriaria* L., *Artemisia campestris* L., *Artemisia santonicum* L., *Berberis crataegina* DC., *Berberis integerrima* Bunge, *Berberis vulgaris* L., *Gypsophila eriocalyx* Boiss., *Gypsophila parva* Barkoudah, *Gypsophila perfoliata* L., *Gypsophila pilosa* Hudson, *Gypsophila tubulosa* (Jaub. & Spach) Boiss., *Euonymus latifolius* (L.) Mill. subsp. *latifolius, Cistus laurifolius* L., *Cornus mas* L., *Cornus sanguinea* L. subsp. *australis* (C. A. Mey.) Jav., *Cornus sanguinea* L. subsp. *sanguinea, Mentha aquatica* L., *Mentha longifolia* (L.) Huds. subsp. *longifolia, Mentha longifolia* L. subsp*. typhoides* (Briq.) Harley var. *typhoides, Mentha pulegium* L., *Mentha spicata* L. subsp. s*picata, Mentha spicata* L. subsp. *tomentosa* (Briq.) Harley, *Ficus carica* L. subsp. *carica*, *Jasminum fruticans* L., *Achillea teretifolia* Willd., *Morus alba* L., *Morus nigra* L., *Cerasus mahaleb* (L.) Miller var. *mahaleb, Prunus divaricata* Ledeb. subsp. *divaricata, Sorbus torminalis* (L.) Crantz var. *torminalis, Sorbus torminalis* (L.) Crantz var. *pinnatifida* Boiss., *Chenopodium foliosum* (Moench) Asch., *Pyrus elaeagnifolia* Pall. subsp. *elaeagnifolia, Pyrus elaeagnifolia* Pallas subsp. *kotschyana* (Boiss.) Browicz, *Viburnum lantana* L., *Malus sylvestris* Mill. subsp. *orientalis* (Uglitzk.) Browicz var. *Orientalis*) were obtained from several locations of the Afyonkarahisar province in Turkey in early spring, 2007 . Materials from different periods were brought in Poly Vinyl Chloride containers. Samples were kept in sealed containers at −18 °C during the study.

2.2. Preparation of extracts

The aerial parts of plants were dried in the shade at room temperature. About 2.5 g from each dried plant sample were extracted by homogenizing in a mixer (Ultra turrax) with 50 ml solvent (50% water-methanol). The extracts were centrifuged at 4000xg 3 min at 4 °C (Hettich Zentrfügen-Universal 32 R) after draining through coarse filter paper. The filtrate volume was completed to 50 ml and drained through blue band filter paper (No 589). The filtrats were stored at 4 °C until analysis.

2.3. Methods

Free radical scavenging effect

The radical scavenging activity against the DPPH radical was evaluated according to the method of Brand-Williams et al. (1995) and Lim and Murtijaya (2007) with some minor modifications. The assay mixture contained 1.5 ml of a 0.09 mg/ml of DPPH (Sigma Chem, Co, Str. Lous, USA) in methanol, 1 ml of acetate buffer solution (100 mM, pH 5.5). The dilutions between 0.4 to 4 mg/ml were prepared with methanol. 3.9 ml DPPH solution prepared with 6×10^{-5} M (molar) methanol was added to each 0.1 ml of dilutions and shaken well. The mixture was prepared and incubated for 60 min at room temperature in the dark. The absorbance of the remaining DPPH was determined at 517 nm against a blank. The scavenging activity was expressed as IC50 (mg/ml). All analyses were carried out in duplicate. Linear regression equations of absorbance against concentration were determined by measuring the absorbance of seven different concentrations of DPPH (6×10^{-5} M) stock solution.

A (515 nm) = 17.692 (C DPPH) − 0.0216 (R^2 = = 0.9896)

The remained DPPH concentrations against absorbance values of the sample series of different concentrations were calculated and then the remaining DPPH percentage was calculated:

% Remaining DPPH = [DDPH] sample / [DPPH] control

The exponential regression equation was determined between the rate of the remaining DPPH percentage and the DDPH amount of sample *in vitro* and sample concentrations of plants which decreased their initial DPPH concentrations by 50% (efficient concentration [EC_{50}]). Antiradical activity (AE) was calculated by dividing EC_{50} values into 1.

Fe^{+2} chelating activity

Modified methods of Lim and Murtijaya (2007) were used for the determination of Fe^{+2} chelating activities of samples. 1 ml of extract with different concentrations between 6-45 mg/ml and 3.7 ml deionized water were mixed. A 0.1ml 2 mM $FeCl_2$ solution was added, shaken and kept in the dark at room temperatures for 70 min. Then, 0.2ml 5 mM ferrozin were added and shaken again and the absorbance of obtained Fe^{+2}-ferrozin complex after 10min was measured at 562 nm. 1 ml water was used instead of the sample for the control. The equation is given below (Yen and Wu, 1999).

Chelating activity (%) = [1 − (absorbance of sample / absorbance of control)] × 100

H_2O_2 inhibition effect

The H_2O_2 inhibition effect of spice and plant extracts can be determined by spectrophotometer

(Ruch et al. 1989). 1 ml (2.6 and 10 mg/ml) sample, 3.4 ml 0.1M phosphate buffer (pH 7.4) and 0.6 ml 43mM H_2O_2 were mixed and after 60 minutes the absorbance of the mixture was measured at 230 nm. Control solutions without H_2O_2 were prepared for each sample concentration. To determine the H_2O_2 mM concentration which did not involve the reaction, a linear repression equation was used. 3.4 ml phosphate buffer were added to 0.6 ml 10, 15, 25, 43 and 50 mM H_2O_2 at 230 nm. Linear regression equations were obtained by the diagram of concentration against absorbance.

A (230) = 0.0104 × C (H_2O_2, mM) + 0.0814 (R^2 = = 0.9766) (+) - catechin was used as reference antioxidant. The following equation was used;

H_2O_2 inhibition capacity (%) = [1 − (H_2O_2 conc. of sample / H_2O_2 conc. of control)] × 100

Statistical analyses

Results of the research were analyzed for statistical significance by analysis of variance (Püskülcü and İkiz, 1989). This research was performed in three duplicates with a replicate.

3. RESULTS AND DISCUSSION

3.1. Free radical scavenging activity

DPPH, as a partially organic radical, is used to determine the antioxidant activities of many plant extracts and compounds (Brand-Williams *et a*l.1995). This method is based on a decrease in alcoholic DPPH solution in the presence of H binding antioxidant ($DPPH^{\cdot} + AH \rightarrow DPPH - H + + A^{\cdot}$). A DPPH solution is dark violet colored and has a strong absorption range at 517 nm. It loses its color when transformed to DPPH-H and the absorption level decreases. This decrease in absorption shows the cytochiometric decrease in DPPH.

The DPPH radical scavenging effects of plant leaf and fruit extracts are given in Tables 1 and 2, respectively. While the antiradical activity of the leaf extracts of plants varies from 0.258 (Gypsophila pilosa) to 0.693 (Cornus sanguinea L. subsp. australis), the activities of fruit extracts range from 0.503 (Taxus baccata) to 0.928 (Cornus mas). Generally, the antiradical activity of fruit extracts was found higher than those of leaf extracts. This effect is probably due to the high phenolic compound contents of fruit extracts. The antiradical

Table 1
DPPH radical scavenging effects of plant (leaves) extracts *

Sample	EC_{50}	AE
Artemisia campestris L.	2.467	0.405 ± 0.03 defg
Artemisia santonicum L.	2.498	0.400 ± 0.06 defg
Berberis crataegina DC.	2.145	0.466 ± 0.04 cde
Berberis integerrima Bunge	2.423	0.413 ± 0.08 defg
Berberis vulgaris L.	2.374	0.421 ± 0.04 defg
Cistus laurifolius L.	2.892	0.345 ± 0.03 efg
Cornus mas L.	1.398	0.716 ± 0.07 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	1.442	0.693 ± 0.02 ab
Cornus sanguinea L. subsp. *Sanguinea*	1.487	0.672 ± 0.08 ab
Euonymus latifolius (L.) Mill. subsp. *Latifolius*	2.421	0.413 ± 0.05 defg
Ficus carica L. subsp. *Carica*	1.822	0.549 ± 0.04 bcd
Gypsophila eriocalyx Boiss.	3.678	0.272 ± 0.05 fg
Gypsophila parva Barkoudah	3.453	0.290 ± 0.02 fg
Gypsophila perfoliata L.	3.126	0.320 ± 0.09 efg
Gypsophila pilosa Hudson	3.873	0.258 ± 0.07 g
Gypsophila tubulosa (Jaub. & Spach) Boiss.	3.098	0.323 ± 0.06 efg
Jasminum fruticans L.	1.904	0.525 ± 0.07 bcd
Mentha aquatica L.	1.634	0.612 ± 0.04 abc
Mentha longifolia (L.) Huds. subsp. *Longifolia*	1.678	0.596 ± 0.06 abc
Mentha longifolia (L.) Huds. subsp. *typhoides* (Briq.) Harley var. *Typhoides*	1.612	0.620 ± 0.05 abc
Mentha pulegium L.	1.516	0.659 ± 0.08 ab
Mentha spicata L. subsp. S*picata*	1.656	0.604 ± 0.04 abc
Mentha spicata L. subsp. *tomentosa* (Briq.) Harley	1.714	0.583 ± 0.03 abc
Pistacia terebinthus L .subsp. *palaestina* (Boiss.) Engler	3.214	0.311 ± 0.02 efg
Pistacia terebinthus L. subsp. *Terebinthus*	2.972	0.336 ± 0.01 efg
Rhus coriaria L.	2.356	0.424 ± 0.05 def
Taxus baccata L.	3.456	0.289 ± 0.01 fg

[a] Efficiency coefficient (EC_{50}) (mg sample / mg $DPPH^{\cdot}$):sample amount needed to decrease the DPPH concentration at the beginning by 50%, [b]Antiradical activity (AE): 1 / EC_{50}.
* mean ± standard deviation.

Table 2
DPPH radical scavenging effects of plant (fruit) extracts *

Sample	EC_{50}	AE
Achillea teretifolia Willd.	1.765	0.567 ± 0.04 efgh
Berberis crataegina DC.	1.345	0.743 ± 0.12 bcde
Berberis integerrima Bunge	1.412	0.708 ± 0.06 bcdefg
Berberis vulgaris L..	1.456	0.687 ± 0.16 cdefgh
Cerasus mahaleb (L.) Miller var. *Mahaleb*	1.645	0.608 ± 0.04 efgh
Chenopodium foliosum (Moench) Asch.	1.458	0.686 ± 0.12 cdefgh
Cistus laurifolius L.	1.724	0.580 ± 0.08 efgh
Cornus mas L.	1.078	0.928 ± 0.13 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	1.156	0.865 ± 0.09 abc
Cornus sanguinea L. subsp. *Sanguinea*	1.205	0.829 ± 0.14 abcd
Euonymus latifolius (L.) Mill. subsp. *Latifolius*	1.646	0.608 ± 0.06 efgh
Ficus carica L. subsp. *Carica*	1.562	0.640 ± 0.07 defgh
Jasminum fruticans L.	1.876	0.533 ± 0.03 gh
Malus sylvestris Mill. subsp. *orientalis* (Uglitzk.) Browicz var. *Orientalis*	1.367	0.732 ± 0.12 bcdef
Morus alba L.	1.123	0.890 ± 0.05 ab
Morus nigra L.	1.212	0.825 ± 0.10 abcd
Pistacia terebinthus L. subsp. *palaestina* (Boiss.) Engler	1.875	0.533 ± 0.07 gh
Pistacia terebinthus L. subsp. *Terebinthus*	1.912	0.523 ± 0.05 gh
Prunus divaricata Ledeb. subsp. *Divaricata*	1.692	0.591 ± 0.07 efgh
Pyrus elaeagnifolia Pall. subsp. *Elaeagnifolia*	1.512	0.661 ± 0.07 defgh
Pyrus elaeagnifolia Pallas subsp. *kotschyana* (Boiss.) Browicz	1.467	0.682 ± 0.04 cdefgh
Rhus coriaria L.	1.822	0.548 ± 0.08 efgh
Sorbus torminalis (L.) Crantz var. *pinnatifida* Boiss.	1.874	0.534 ± 0.09 gh
Sorbus torminalis (L.) Crantz var. *torminalis*	1.842	0.543 ± 0.04 fgh
Taxus baccata L.	1.986	0.503 ± 0.08 h
Viburnum lantana L.	1.523	0.657 ± 0.09 defgh

[a] Efficiency coefficient (EC_{50}) (mg sample / mg $DPPH^{\cdot}$): sample amount needed to decrease the DPPH concentration at the beginning by 50%, [b] Antiradical activity (AE): 1 / EC_{50}
* mean ± standard deviation.

activity of Cornus spp. and Morus spp were compared to those of other fruit extracts (Table 2). These plant extracts may be accepted as having a higher H binding capacity against the DPPH radical. The lowest AEs are obtained from *Gypsophila eriocalyx* Boiss (0.272), *Gypsophila pilosa* Hudson (0.258) species and *Gypsophila parva* Barkoudah.

The highest DPPH radical scavenging effects were determined in the fruit extracts of *Cornus* and *Morus* species with values which varied from 1.078-1.212 (EC_{50}). The fruit extracts of *Taxus baccata* L., *Pistacia terebinthus* L .subsp. *palaestina* (Boiss.) Engler and *Pistacia terebinthus* L. subsp. *terebinthus*, *Sorbus* species and *Jasminum fruticans* L. plants showed the lowest DPPH radical scavenging effects.

Termentzi *et al*. (2006) reported the AE values (DPPH radical scavenging) of the methanol extracts of fruit pulp from ripe *Sorbus domestica* fruits as 0.682. Tural and Koca (2008) reported that the methanolic extracts of the Cornelian cherry (*Cornus mas* L.) fruits showed EC_{50} (mg/ml) (DPPH reduction) values as 0.52. Topçu *et al*. (2007) reported that the methanol extracts of *Pistacia terebinthus* fruits showed activity as high as the standard , at 50µg/ml as 95% for DPPH scavenging effect, %). Bae and Suh (2007) reported the scavenging abilities of DPPH radicals of the ethanolic extracts of five major cultivars of mulberry fruits (*Morus alba* L.) from Korea, as between 225.9-537.6 µg (IC_{50}). Effective scavenging concentration (EC_{50}) on DPPH radicals was 0.70 µg/ml in ethyl acetate and tannin fractions and 5.33 µg/ml in the anthocyanin rich fraction of sumac extracts (Koflar *et al*. 2007). Emami, Asili, Mohaghegbi & Hassanzadeh (2007) reported that the methanol extracts of the leaves of *Taxus baccata* L. from Armaniolan, Arasbaran and East Azerbayejan, contained high amounts of alkaloids, tannins and flavonoids while the fruit extracts contained high amounts of tannins and these extracts possessed high antioxidant activity (%) as approximately 90, using the TBA method. According to Cao *et al*. (1996) among the 22 common vegetables studied, garlic had the highest antioxidant activity, with an antioxidant score (automated oxygen radical absorbance capacity assay) of 23.2 based on fresh weight of the vegetable. However, according to Miller *et al*. (2000), garlic is very high in antioxidants, its activity being about sixfold that of yellow onion (1300 Trolox equivalents/100 g vs. 200 Trolox equivalents /100 g). The difference is probably at least partially due to the different methods used. The radical scavenging and antioxidant results for blackcurrant plants obtained in this study are not in agreement with the earlier literature (Cao *et al*.,1996; Gazzani *et al*.,1998). However these contradictory results

are most likely due to differences in methodology and experimental conditions used in the different studies. Due to the wide wariety of potential antioxidant compounds, such as vitamins, flavonoids, phenolic acids and sulphur compounds present in plants, differences in the method of sample extraction can results in a wide variation in the antioxidant activity of the extract (Nuutila *et al*. 2003).

The radical scavenging and antioxidant activity results for these plants show some differences from the earlier reported results above. However these contradictory results are most likely due to differences in methodology and experimental conditions used in the different studies. Due to the wide variety of potential antioxidant compounds, such as vitamins, flavonoids, phenolic acids and sulphur compounds present in plants, differences in the method of sample extraction can results in a wide variation in the antioxidant activity of the extract (Nuutila, Puupponen-Pimia, Aarni & Oksman-Caldentey, 2003). In our study, there was a noticeable correlation between high radical scavenging / antioxidant activity and high amounts of total phenolics. More plants have been used as a source of food, remedy and animal fodder in Turkey (Baytop, 1984). The antioxidant activities of spices and herbs are attributed to their polar phenolic and essential oil contents (Tsimidou and Boskou, 1994; Shahidi, 1997; Özkan and Özcan, 2006).

3.2. Fe^{+2} chelating activity

Chelating agents may have great importance for rancidity of oily foods; even though they are not antioxidant materials. Because iron catalyzes this reaction during lipid peroxidation, Ferrozin forms a complex with Fe^{+2}. The amounts of complex and red color decrease in the presence of the other chelating agents. A decrease in absorption values can be determined by changes in the color. The decrease in absorption shows the effectiveness of chelating agent added with the exception of ferrozin.

Table 3 and 4 show the chelating activities of plant leaf and fruit extracts. The Fe^{2+} chelating activity of fruit extracts of plants was established as higher than that of leaf extracts. The highest chelating activity was found in *Cornus mas* fruit extracts. The Chelating activities of *Cornus* spp. fruit extracts were found higher compared with other fruit extracts (Table 4). The highest chelating activity was observed in the *Cornus* species ranging from 44.64-45.72%. The lowest chelating activities were obtained from the *Gypsophila* species (16.34-20.32%), *Taxus baccata* L. (18.93%) and *Pistacia terebinthus* L .subsp. *palaestina* (Boiss.) Engler (19.26%).

The highest Fe^{+2} chelating activity was determined in the fruit extracts of the *Cornus* species; while the lowest values belong to the *Pistacia* species

Table 3
Fe^{2+} chelating activity (%)of plant (leaves) extracts

Sample	Chelating activity (%)
Artemisia campestris L.	25,42 ± 1,63 ij
Artemisia santonicum L.	26,02 ± 2,01 hi
Berberis crataegina DC.	28,36 ± 2,45 fghi
Berberis integerrima Bunge	27,12 ± 2,9 fghi
Berberis vulgaris L.	28,02 ± 2,71 fghi
Cistus laurifolius L.	28,43 ± 2,79 fghi
Cornus mas L.	45,72 ± 3,55 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	44,64 ± 3,58 ab
Cornus sanguinea L. subsp. *sanguinea*	44,92 ± 3,86 ab
Euonymus latifolius (L.) Mill. subsp. *latifolius*	30,26 ± 2,58 fghi
Ficus carica L. subsp. *carica*	32,86 ± 1,96 efg
Gypsophila eriocalyx Boiss.	17,34 ± 2,2 k
Gypsophila parva Barkoudah	19,32 ± 1,99 k
Gypsophila perfoliata L.	20,32 ± 2,54 jk
Gypsophila pilosa Hudson	16,34 ± 1,80 k
Gypsophila tubulosa (Jaub. & Spach) Boiss.	18,51 ± 1,79 k
Jasminum fruticans L.	31,24 ± 1, 71 fgh
Mentha aquatica L.	38,96 ± 2,2 cd
Mentha longifolia (L.) Huds. subsp. *longifolia*	37,23 ± 2,13 cde
Mentha longifolia (L.) Huds. subsp. *typhoides* (Briq.) Harley var. *typhoides*	38,23 ± 2,8 cd
Mentha pulegium L.	40,22 ± 3,54 bc
Mentha spicata L. subsp. s*picata*	39,64 ± 2,12 bcd
Mentha spicata L. subsp. *tomentosa* (Briq.) Harley	34,42 ± 2,24 def
Pistacia terebinthus L .subsp. *palaestina* (Boiss.) Engler	19,26 ± 1,76 k
Pistacia terebinthus L. subsp. *terebinthus*	24,65 ± 2,28 ij
Rhus coriaria L.	26,34 ± 2,51 hi
Taxus baccata L.	18,93 ± 1,63 k

* mean ± standard deviation.

Table 4
Fe^{2+} chelating activity (%)of plant (fruit) extracts

Sample	Chelating activity (%)
Achillea teretifolia Willd.	32,96 ± 3,04 ijkl
Berberis crataegina DC.	44,76 ± 2,76 cdef
Berberis integerrima Bunge	43,65 ± 3,05 def
Berberis vulgaris L..	42,98 ± 3,99 ef
Cerasus mahaleb (L.) Miller var. *mahaleb*	35,49 ± 2,27 ghijk
Chenopodium foliosum (Moench) Asch.	43,76 ± 2,90 def
Cistus laurifolius L.	36,27 ± 4,42 ghij
Cornus mas L.	54,24 ± 3,41 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	52,34 ± 2,54 ab
Cornus sanguinea L. subsp. *sanguinea*	51,24 ± 4,29 bc
Euonymus latifolius (L.) Mill. subsp. *latifolius*	38,65 ± 2,98 fghij
Ficus carica L. subsp. *carica*	40,69 ± 2,91 fgh
Jasminum fruticans L.	33,54 ± 2,68 ijkl
Malus sylvestris Mill. subsp. *orientalis* (Uglitzk.) Browicz var. *orientalis*	45,32 ± 2,46 cdef
Morus alba L.	49,98 ± 3,69 bcd
Morus nigra L.	48,32 ± 2,96 bcde
Pistacia terebinthus L. subsp. *palaestina* (Boiss.) Engler	30,65 ± 3,13 kl
Pistacia terebinthus L. subsp. *terebinthus*	29,42 ± 2,05kl
Prunus divaricata Ledeb. subsp. *divaricata*	34,29 ± 1,41 hijkl
Pyrus elaeagnifolia Pall. subsp. *elaeagnifolia*	41,83 ± 3,25 efg
Pyrus elaeagnifolia Pallas subsp. *kotschyana* (Boiss.) Browicz	43,74 ± 1,72 def
Rhus coriaria L.	31,82 ± 2,95 jkl
Sorbus torminalis (L.) Crantz var. *pinnatifida* Boiss.	32,61 ± 1,39 ijkl
Sorbus torminalis (L.) Crantz var. *torminalis*	33,65 ± 2,39 ijkl
Taxus baccata L.	28,32 ± 1,67 l
Viburnum lantana L.	39,43 ± 2,69 fghi

* mean ± standard deviation.

Table 5
H_2O_2 inhibition activity of plant (leaves) extracts

Sample	Inhibition (%)
Artemisia campestris L.	28,32 ± 2,87 gh
Artemisia santonicum L.	26,17 ± 2,26 hi
Berberis crataegina DC.	32,76 ± 1,78 efg
Berberis integerrima Bunge	30,46 ± 3,16 fgh
Berberis vulgaris L.	35,54 ± 2,95 def
Cistus laurifolius L.	41,54 ± 3,74 bcd
Cornus mas L.	65,42 ± 5,04 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	62,32 ± 3,82 a
Cornus sanguinea L. subsp. *sanguinea*	61,28 ± 4,43 ab
Euonymus latifolius (L.) Mill. subsp. *Latifolius*	38,03 ± 3,01 cde
Ficus carica L. subsp. *carica*	39,62 ± 2,32 cd
Gypsophila eriocalyx Boiss.	18,64 ± 2,80 jkl
Gypsophila parva Barkoudah	25,43 ± 2,23 hi
Gypsophila perfoliata L.	32,65 ± 2,33 efg
Gypsophila pilosa Hudson	21,54 ± 1,98 ijk
Gypsophila tubulosa (Jaub. & Spach) Boiss.	24,27 ± 2,22 hij
Jasminum fruticans L.	37,02 ± 1,63 de
Mentha aquatica L.	46,32 ± 2,91 b
Mentha longifolia (L.) Huds. subsp. *longifolia*	44,29 ± 2,08 bc
Mentha longifolia (L.) Huds. subsp. *typhoides* (Briq.) Harley var. *typhoides*	47,32 ± 2,70 b
Mentha pulegium L.	59,22 ± 4,74 ab
Mentha spicata L. subsp. s*picata*	54,32 ± 2,57 ab
Mentha spicata L. subsp. *tomentosa* (Briq.) Harley	56,31 ± 3,53 ab
Pistacia terebinthus L. subsp. *palaestina* (Boiss.) Engler	16,78 ± 1,76 jkl
Pistacia terebinthus L. subsp. *terebinthus*	21,67 ± 2,09 ijk
Rhus coriaria L.	24,41 ± 2,44 hij
Taxus baccata L.	13,44 ± 1,36 l

* mean ± standard deviation.

Table 6
H_2O_2 inhibition activity of plant (fruit) extracts

Sample	Inhibition (%)
Achillea teretifolia Willd.	29,61 ± 3,85 hijk
Berberis crataegina DC.	59,43 ± 3,94 cd
Berberis integerrima Bunge	57,34 ± 3,31 d
Berberis vulgaris L.	55,67 ± 2,82 d
Cerasus mahaleb (L.) Miller var. *mahaleb*	31,53 ± 3,64 ghij
Chenopodium foliosum (Moench) Asch.	59,39 ± 4,07 cd
Cistus laurifolius L.	32,79 ± 2,26 ghi
Cornus mas L.	74,35 ± 5,24 a
Cornus sanguinea L. subsp. *australis* (C. A. Mey.) Jav.	71,23 ± 4,02 ab
Cornus sanguinea L. subsp. *sanguinea*	69,03 ± 4,17 ab
Euonymus latifolius (L.) Mill. subsp. *latifolius*	36,53 ± 1,66 fgh
Ficus carica L. subsp. *carica*	47,18 ± 2,29 e
Jasminum fruticans L.	35,32 ± 2,94 gh
Malus sylvestris Mill. subsp. *orientalis* (Uglitzk.) Browicz var. *orientalis*	61,32 ± 3,56 cd
Morus alba L.	66,43 ± 3,34 bc
Morus nigra L.	66,21 ± 4,30 bc
Pistacia terebinthus L. subsp. *palaestina* (Boiss.) Engler	24,65 ± 3,44 jkl
Pistacia terebinthus L. subsp. *terebinthus*	23,18 ± 2,14 kl
Prunus divaricata Ledeb. subsp. *divaricata*	32,65 ± 2,09 ghi
Pyrus elaeagnifolia Pall. subsp. *elaeagnifolia*	54,23 ± 3,31 d
Pyrus elaeagnifolia Pallas subsp. *kotschyana* (Boiss.) Browicz	55,28 ± 3,70 d
Rhus coriaria L.	26,92 ± 1,17 ijkl
Sorbus torminalis (L.) Crantz var. *pinnatifida* Boiss.	34,32 ± 2,20 gh
Sorbus torminalis (L.) Crantz var. *torminalis*	38,94 ± 3,02 fg
Taxus baccata L.	21,28 ± 1,84* l
Viburnum lantana L.	43,37 ± 2,86 ef

* mean ± standard deviation.

and *Taxus baccata* L. *Jasminum fruticans* L., *Rhus coriaria* L., *Achillea teretifolia* Willd. and *Sorbus* species also had lower Fe^{+2} chelating activities than the fruit extracts of other plants used in the assay. Chelating agents may have a great importance for rancidity of oily foods, even if they are not antioxidant materials. Because iron catalyzes this reaction during lipid peroxidation (Yen and Duh, 1994).

3.3. H_2O_2 inhibition activity

This method is used to eliminate $O2^{\bullet -}$, even though the superoxide radical anion ($O2^{\bullet -}$) does not initiate lipid oxidation directly. Super reactive hydroxyl radical (.OH) may be formed from the Fenton reaction ($Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^- + .OH$) in the presence of metal ions. For this reason, H_2O_2 inhibition activity is an important method for the determination of antioxidant characteristics.

The H_2O_2 inhibition activities of plant leaf and fruit extracts are given in Tables 5 and 6, respectively. The *Cornus* species showed the highest H_2O_2 inhibition values (54.32-65.42%) while *Taxus baccata* L. and *Pistacia terebinthus* L .subsp. *palaestina* (Boiss.) Engler had the lowest H_2O_2 inhibition values at 13.44% and 16.78%, respectively. The *Gypsophila* species also showed lower H_2O_2 inhibition values (18.64-25.43%) than the other plant leaf extracts analyzed.

The H_2O_2 inhibition activity of plant (fruit) extracts was determined higher than those of leaf extracts (Table 6). The H_2O_2 inhibition activities of fruit extracts of *Taxus baccata* L. and *Pistacia* species were the lowest among the other fruit extracts (21.28-24.65%). The fruit extracts of *Cornus* and *Morus* species had the highest H_2O_2 inhibition activities ranging from 66.21-74.35%.

4. CONCLUSIONS

The present study demonstrates the antioxidant potential of some herbs and fruits from Turkey which could protect against free radical damage. The information might be useful for the development of food products and additives with appropriate antioxidant properties. It may be noted that *Cornus*, *Morus* and *Mentha* species examined in the assay (*Cornus mas* L. *Cornus sanguinea* L. subsp. *australis* (C. A. Mey.) Jav., *Cornus sanguinea* L. subsp. *sanguinea, Morus alba* L., *Morus nigra* L., *Mentha spicata* L. subsp. s*picata, Mentha spicata* L. subsp. *tomentosa* (Briq.) Harley) show higher antioxidant activities compared to the other plants studied used.

The highest antiradical activity (AE) was observed in the *Cornus* and *Mentha* species with values ranging from 0.549-0.716 ($P<0.05$). These plant extracts may be accepted as having higher H binding capacity against DPPH radical. The highest DPPH radical scavenging effects were determined in fruit extracts from the *Cornus* and *Morus* species

with values varying from 1.078-1.212 (EC_{50}). The highest chelating activity was observed for the *Cornus* species ranging from 44.64-45.72%. It is believed that the detection of natural antioxidant sources and proper consumption of them in the daily diet or the use of isolated compounds in clinical practices would be beneficial for a healthy life.

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