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ORIGINAL ARTICLE

Antibacterial and antioxidant activities of traditional medicinal plants from the Erzurum region of Turkey

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Abstract

Background In this study, 13 different extracts were investigated which are grown in the region of Erzurum.

Objective The aim of this study was to screen various plant extracts that are known and used for medicinal purposes such as *Ferula communis* L., *Rumex patientia* L., *Gundelia tournefortii* L., *Rheum ribes* L., *Asphodeline taurica*, *Polygonum arenastrum*, *Allium schoenoprasum* L., and *Ferula orientalis* L.

Materials and methods Medicinal parts of plants such as leaves, flowers, and stems were investigated by 2,2-diphenyl-1-picrylhydrazyl, ferric reducing antioxidant power, and cupric reducing antioxidant capacity assays: Centaury and Blackthorn. Total phenolic content, total flavonoid content, and antimicrobial properties were also determined. Antibacterial and antifungal activities were investigated by the microdilution method and the agar diffusion method respectively.

Results Accordingly, the results of the *Rheum ribes* L. plant have the highest antioxidant activity among all analyses made. But in almost all antioxidant analysis methods, the lowest antioxidant activity was found in *Ferula orientalis* L. According to the antibacterial analysis applied, it was found that the plant extracts were generally more effective on yeast strains than the test bacteria used; that is, most of the plants have antifungal effect.

Conclusions Due to their antimicrobial, antifungal, and antioxidant properties, the extracts of these plants might be used as natural sources in the pharmaceutical and cosmetic industries.

Keywords Antimicrobial · Antioxidant · *Ferula* · *Rheum* · *Rumex*

Introduction

It is estimated that there are about 1,000,000 plants in the world today. Approximately 500,000 of these species have been identified and named. Twenty thousand of these have been identified as medicinal plants used for therapeutic purposes as a result of research conducted by the World Health Organization (WHO) [1].

Medicinal plants are widely used in daily life as part of folk medicinal remedies in Turkey. The flora in Turkey is remarkable for its diversity and it is a rich source of medicinal plants [2].

Plant extracts and their components have been known to show biological activities, especially antimicrobial [3], antifungal [4], antibacterial [5], and antioxidant activities [6]. The substances that can inhibit pathogens and have little toxicity to host cells could be considered candidates for developing new antimicrobial drugs [7]. These compounds are found in various medicinal plant organs such as leaves, roots, stems, barks, fruits, flowers, and seeds [8]. The most important medicinal compounds are tannins, flavonoids, alkaloids, and phenolic compounds [9].

Natural products are defined as natural sources-derived substances having biological activities. Natural products have long been implemented as an alternative health care treatment and in the discovery of modern drugs [10].

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Many diseases such as atherosclerosis, heart disease, diabetes mellitus, and cancer are caused by oxidative stress and can produce free radicals in foods, drugs, and even in living systems [11]. Antioxidants such as ascorbic acid, carotenoids, and phenolic compounds are substances produced by the medicinal plants possessing free radical scavenging activity which can prevent lipid peroxidation [12].

For some years, the human population has been affected by bacterial and fungal infections due to uncontrolled growth and improper food habits, and there is also an increase in immunocompromised diseases. The abovementioned factors are in combination with resistance to antibiotics and toxicity of antibacterial and antifungal drugs due to their prolonged use to control such diseases [13].

Numerous studies have shown that aromatic and medicinal plants are sources of various nutrient and non-nutrient molecules, many of which display antioxidant and antimicrobial properties which can protect the human body against both cellular oxidation reactions and pathogens. Thus, it is important to characterize different types of medicinal plants for their antioxidant and antimicrobial potential. The purpose of the present study is to investigate the antioxidant and antimicrobial properties of 13 different samples of non-wood forest products and also edible plants of aerial parts, leaves, and stem of some species such as the giant fennel (*Ferula communis* L.), rumex (*Rumex patientia* L.), acanthus (*Gundelia tournefortii* L.), isgin (*Rheum ribes* L.), asphodelus (*Asphodeline taurica*), polygonum (*Polygonum arenastrum*), chives (*Allium schoenoprasum* L.), and ferula (*Ferula orientalis* L.) plant extracts used for medicinal purposes in the Erzurum region of Turkey.

Materials and methods

The chemicals

Methanol, Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), 2,4,6-tripyridyl-*s*-triazine(TPTZ), Folin-Ciocalteu's phenol reagent, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were purchased from Sigma Chemical Co. (St. Louis, MO, USA).

Sodium carbonate, acetic acid, neocuproine (2,9-dimethyl-1,10-phenanthroline), aluminum nitrate nonahydrate, and ammonium acetate were purchased from Merck Chemical Co. (Darmstadt, Germany). The chemicals were of analytical grade.

The plant material

The plants used in the experiments were obtained from the Buyuk Tuy and Kucuk Tuy districts of the Erzurum province by field work. All plants used in the study are edible and these plants have been used as medicinal plants by regional people for many years. Collected plant materials were dried in an oven at 40 °C before analysis. Approximately 10 g of dried samples was used to prepare methanolic extracts for each species, and then mixed for 24 h at room temperature. The methanolic extracts were filtered with filter papers. These extracts were used to determine antioxidant activities. Analyses were done three times. Spectrophotometric methods were used on total polyphenols, total flavonoids, and antioxidant analyses. Spectrophotometric methods are frequently used for the standardization of natural raw materials. Local (Turkish), English, and Latin names of the plants are given in Table 1.

Total phenolic assay

The total phenolic content of plants was determined by using the Folin-Ciocalteu assay [14]. In this study, gallic acid (1, 0.5, 0.25, 0.125, 0.0625, and 0.03125 mg/mL) was used as a standard. Briefly, 20 μL of various concentrations of gallic acid and 20 μL methanolic samples (1 mg/mL), 400 μL of 0.5 N Folin-Ciocalteu reagents, and 680 μL of distilled water were mixed, and the mixture was vortexed. Following 3-min incubation, 400 μL of Na_2CO_3 (10%) solution was added and after the process of vortexing, the mixture was incubated for 2 h. After the incubation period at room temperature, absorbances of the mixtures were measured at 760 nm. The concentrations of total phenolic compounds were calculated as milligram of gallic acid equivalents per gram of dry weight sample.

Total flavonoid assay

The total flavonoid content was measured by using the aluminum chloride assay [15]. Quercetin was used as a standard. 0.5 mL of quercetin (1, 0.5, 0.25, 0.125, 0.0625, and 0.03125 mg/mL), 4.3 mL methanol, 0.1 mL 10% $Al(NO_3)_3$, and 0.1 mL 1 M NH_4CH_3COO were added in the test tubes and then they were mixed. Mixtures were incubated for 40 min. After incubation, absorbance was measured at 415 nm. The total flavonoid contents of plants were expressed

Table 1 Names of plant used in this study

Local names (Turkish)	English names	Latin names
Çakşır otu	Giant fennel	*Ferula communis* L.
Evelik	Rumex	*Rumex patientia* L.
Kenger	Acanthus	*Gundelia tournefortii* L.
Işgın otu	Isgin	*Rheum ribes* L.
Çiriş otu	Asphodelus	*Asphodeline taurica*
Kuş ekmeği	Polygonum	*Polygonum arenastrum*
Çayır soğanı	Chives	*Allium schoenoprasum* L.
Yabani çaşır	Ferula	*Ferula orientalis* L.

as milligram quercetin equivalents per gram of dry weight sample.

The determination of antioxidant activity

The antioxidant activities of the samples were determined by using ferric reducing power (FRAP) and cupric reducing power (CUPRAC) methods. The FRAP method was used for the determination of total antioxidant capacity, based on the reduction of yellow Fe^{3+}-TPTZ complex to the blue Fe^{2+}-TPTZ complex by electron-donating substance under acidic condition [16]. The 3 mL of FRAP reagent (containing TPTZ, $FeCl_3$, and acetate buffer) and 100 μL of the test sample or the blank (solvents used for extraction) were added to the test tube and mixed. Maximum absorbance values at 593 nm were recorded for 4 min at 25 °C. The final absorbance was compared with the standard curve (100–1000 μmol/L). The data were expressed as micromole $FeSO_4 \cdot 7H_2O$ equivalents per gram of dry matter.

The CUPRAC method is comprised of mixing the antioxidant solution (directly or after acid hydrolysis) with a copper(II) chloride solution, a neocuproine alcoholic solution, and an ammonium acetate aqueous buffer at pH 7, and subsequently measuring the developed absorbance at 450 nm after 60 min [17]. One milliliter 10 mM $CuCl_2$, 1 mL 7.5 mM neocuproine, and 1 mL 1 M NH_4Ac were added to test tubes, and then 0.2-mL sample and 0.9 mL H_2O were added and mixed. The final volume was 4.1 mL. Then, the final absorbance was measured at 450 nm after incubated for 1 h. The test results were evaluated by Trolox® equivalent antioxidant capacity (TEAC).

The scavenging activity of DPPH radical was determined using the method of Molyneux [18]. Different concentrations of 0.75 mL of sample extracts were mixed with 0.75 mL of a 0.1 mM of DPPH solution (dissolved in methanol). Then, extracts were incubated at room temperature in the dark for 50 min. Absorbance was measured by spectrophotometry at 517 nm. Trolox is used as a standard and the values are expressed as IC_{50} (mg sample per mL).

The biological materials

A total of 12 microorganisms were used in this study: as bacteria, *Staphylococcus aureus* ATCC 6538, *Proteus vulgaris* NRRL B-123, *Salmonella typhimurium* ATCC 13311, *Staphylococcus epidermidis* ATCC 12228, *Bacillus subtilis* NRRL B-4378, *Streptomyces griseolus* NRRL B-1062, *Pseudomonas citronellosis* NRRL B-2504, *Bacillus velezensis* NRRL B-14580, *Gordonia rubripertincta* NRRL B-3906, and *Escherichia coli* ATCC 8739 and as yeast, *Candida albicans* ATCC 90028, *Candida glabrata* ATCC 2001, and *Candida krusei* ATCC 6258 strains were used. All test microorganisms were obtained from the US Agricultural Research Service Culture Collection (NRRL), the American Type Culture Collection (ATCC), the Faculty of Pharmacy of Anadolu University, and the commercial culture collections.

All microorganisms were stored at − 85 °C (ultrafreezer, New Brunswick) in 15% glycerol and maintained on nutrient agar (Merck, 1.05450) and malt extract agar (Merck, 1.05398) slants at 4 °C, respectively. They were subcultured in Petri dishes prior to being used for purity checking.

Microorganisms, which are important plant and human pathogens, were selected for their antimicrobial activity studies which produce biofilms and which have been the subject of research done by many researchers in recent studies.

In vitro antimicrobial activity

The broth microdilution method recommended by CLSI (Clinical Laboratory Standards Institute) was used for assessing in vitro antibacterial and antifungal activities of compounds [19]. Chloramphenicol was used as a standard antibacterial agent whereas amphotericin B and ketoconazole were used as standard antifungal agents. They were purchased from Sigma. All tests were assayed in duplicate in two independent experiments.

Broth microdilution test for bacteria

Broth microdilution testing was performed in accordance with the guidelines of the CLSI M100-S16 [20]. The minimum inhibitory concentration (MIC) of abietic acid and its metabolites was studied by broth microdilution method using 96-well microtiter plates (Sigma, Germany). Overnight-grown microbial suspensions in double-strength Mueller-Hinton broth (MHB) (Merck, Germany) were standardized by turbido metrically to approximately 108 CFU 1/mL (using McFarland no. 0.5). Test compounds were dissolved in DMSO (50%) and diluted in MHB to get a concentration range of 15.62–4000 g/mL. DMSO was used as the negative control. The solution was then twofold diluted in MHB (100 L), inoculated with bacterial strains, and then incubated at 37 °C for 24 h. Resazurin (Sigma, Germany) solution was added to confirm the MICs. The MIC endpoint was defined as the lowest concentration with complete (100%) growth inhibition. The results of antimicrobial testing are compared with those of standards, ampicillin (Sigma, Germany) and chloramphenicol (Sigma, Germany) as antibacterial agents (the final concentrations were between 0.04 and 40 g/mL). DMSO was assayed as the negative control.

Broth microdilution test for yeasts

CLSI broth microdilution testing was also performed exactly as outlined in document M27-A2 by using 96-well microtiter plates, RPMI-1640 (Sigma, Germany) medium, and inocula of 0.5–2.5 × 103 cells /mL (McFarland 0.5). The final

concentrations of abietic acid and its metabolites were between 15.62 and 4000 g/mL. MIC values were determined for 24 h at 37 °C incubation. Resazurin solution was added to confirm the MICs. The MIC endpoint was defined as the lowest concentration with complete (100%) growth inhibition [21].

Statistical analysis

All analyses were performed in triplicate and results were shown as mean ± standard deviation (SD). The mean values were statistically analyzed by ANOVA and Duncan's multiplication range test by using SPSS version 23.0. $p < 0.05$ was considered to be significant.

Results and discussion

There are many different antioxidants in plants and it is very difficult to measure each antioxidant component separately. The chemical complexity of extracts, often a mixture of dozens of compounds with different functional groups, polarity, and chemical behavior, could lead to scattered results, depending on the test employed. For this reason, it is more informative to use different tests to assess the antioxidant potential of each individual [22, 23].

In this study, mainly three methods, CUPRAC, FRAP, and DPPH radical scavenging activity, were used. The concentrations of total phenolic and flavonoids were also calculated for the extracts. The total phenolic and total flavonoid contents and FRAP and CUPRAC values are shown in Table 2. The IC_{50} values determined from analysis of DPPH are shown in Fig. 1.

Results showed that aerial parts of isgin (*Rheum ribes* L.) samples were found to have the highest total phenolic and total flavonoid content. Similarly, it has the highest antioxidant activity in all antioxidant analyses. However, stems of rumex (*Rumex patientia* L.) and stems of acanthus (*Gundelia tournefortii* L.) have the lowest total phenolic content and stems of ferula (*Ferula orientalis* L.) have the lowest total flavonoid content. In addition, aerial parts of the giant fennel (*Ferula communis* L.) have the lowest CUPRAC and FRAP values. Aerial parts of isgin had the highest DPPH radical scavenging activity, and the lowest activity was obtained from stems of rumex (*Rumex patientia* L.) and stems of chives (*Allium schoenoprasum* L.).

In leaves, ferula (*Ferula orientalis* L.) has the highest total phenolic content and the highest CUPRAC and FRAP values. In addition, it has the highest DPPH radical scavenging activity.

In stems, chives (*Allium schoenoprasum* L.) have the highest activity in all analyses without FRAP. The best FRAP value was obtained in polygonum (*Polygonum arenastrum*). It is observed that the leaves have higher activity than stems.

The antimicrobial activities of extracts assayed against the microorganisms in the present study were qualitatively and quantitatively assessed by evaluating the presence of inhibition zones, zone diameter, and MIC values. The results of antimicrobial activity of methanolic extracts are shown in Table 3.

As a result of the antimicrobial analysis, it was found that the plant extracts were generally more effective on candidates than the test bacteria; that is, the antifungal effect was higher.

Table 2 Results of phenolic contents, flavonoid contents, FRAP, and CUPRAC for plant samples

Samples	Total phenolics (mg GAE/g)	Total flavonoid (mg QE/g)	CUPRAC (mmol TEAC/g)	FRAP (μmol Fe/g)
Giant fennel	$10.14 \pm 1.13^{d,e}$	$0.23 \pm 0{,}02^{d,e}$	0.53 ± 0.13^{g}	0.37 ± 0.05^{f}
Ferula l.	40.86 ± 10.68^{b}	0.81 ± 0.27^{b}	$5.21 \pm 0.94^{d,e}$	9.08 ± 0.03^{b}
Ferula s.	$11.84 \pm 0.60^{d,e}$	0.07 ± 0.01^{e}	$2.09 \pm 0.45^{f,g}$	0.31 ± 0.03^{f}
Rumex l.	$18.97 \pm 0.33^{c,d}$	$0.78 \pm 0.01^{b,c}$	$3.16 \pm 0.24^{e,f}$	$0.78 \pm 0.03^{d,e,f}$
Rumex s.	6.57 ± 0.97^{e}	$0.23 \pm 0.05^{d,e}$	4.34 ± 0.11^{e}	$0.69 \pm 0.09^{e,f}$
Acanthus l.	$18.04 \pm 1.56^{c,d}$	$0.24 \pm 0.01^{d,e}$	2.83 ± 0.46^{f}	$1.03 \pm 0.01^{d,e,f}$
Acanthus s.	6.38 ± 1.60^{e}	0.12 ± 0.04^{e}	$4.83 \pm 0.33^{d,e}$	$0.97 \pm 0.03^{d,e,f}$
Polygonum l.	$17.68 \pm 3.60^{c,d}$	1.07 ± 0.00^{b}	$3.27 \pm 0.38^{e,f}$	$1.85 \pm 0.07^{c,d,e}$
Polygonum s.	$15.33 \pm 0.53^{c,d,e}$	$0.42 \pm 0.51^{c,d,e}$	11.81 ± 0.93^{c}	$1.42 \pm 0.06^{c,d,e,f}$
Chives l.	24.82 ± 3.05^{c}	$0.38 \pm 0.49^{c,d,e}$	6.60 ± 0.31^{d}	$2.08 \pm 0.44^{c,d}$
Chives s.	21.92 ± 3.25^{c}	$0.65 \pm 0.16^{b,c,d}$	15.39 ± 0.48^{b}	$1.06 \pm 0.12^{d,e}$
Isgin	112.82 ± 11.68^{a}	2.50 ± 0.31^{a}	54.41 ± 3.64^{a}	42.50 ± 2.44^{a}
Asphodelus	24.12 ± 8.48^{c}	$0.65 \pm 0.05^{b,c,d}$	$3.94 \pm 0.88^{e,f}$	2.62 ± 0.03^{c}

Giant fennel, aerial part *Ferula communis* L.; Ferula l, leaves of *Ferula orientalis* L.; Ferula s, stems of *Ferula orientalis* L.; Rumex l, leaves of *Rumex patientia* L.; Rumex s, stems of *Rumex patientia* L.; Acanthus l, leaves of *Gundelia tournefortii* L.; Acanthus s, stems of *Gundelia tournefortii* L.; Polygonum l, leaves of *Polygonum arenastrum*; Polygonum s, stems of *Polygonum arenastrum*; Chives l, leaves of *Allium schoenoprasum* L.; chives s, stems of *Allium schoenoprasum* L.; Isgin, aerial part of *Rheum ribes* L.; Asphodelus, aerial part of *Asphodeline taurica*

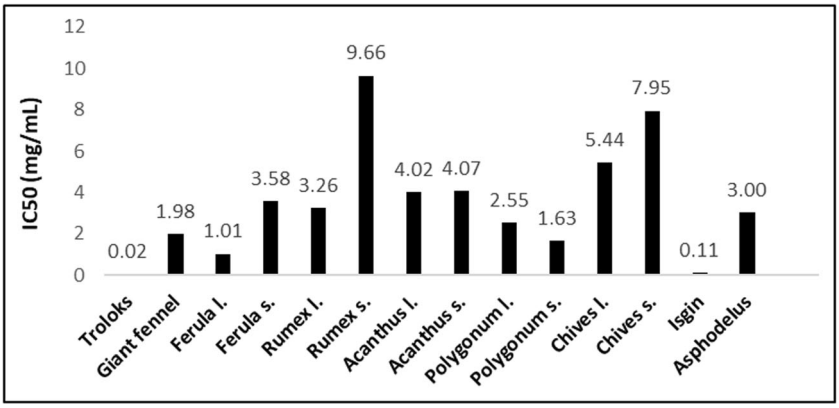

Fig. 1 The results of DPPH for plant extracts

Among all the plants examined, leaves and stems of ferula (*Ferula orientalis* L.) exhibited good activity against test bacteria. While other plants have activity against yeast strains, they have not shown good activity against bacterial strains.

Isgin (*Rheum ribes* L.) was found to have the highest antioxidant activity in almost all antioxidant analysis and was found to have the highest antifungal activity against *Candida albicans* ATCC 90028 (Ca) with the MIC value 0.98 μg/mL, exhibiting similar activity to amphotericin B which is used as a standard antifungal drug.

In a study, Nguir et al. [24] reported that DPPH activity of ferula (*Ferula communis* L.) was determined with IC_{50} = 0.03 mg/mL. Also, the best antimicrobial activity was found on *Pseudomonas aeruginosa* bacterium with 0.156 μg/mL MIC value. Yet, according to our study, DPPH activity was found to be IC_{50} = 1.98 mg/mL and showed no activity on any bacteria but showed good antifungal activity on yeast strains with 125 μg/mL MIC value.

Free radicals have a significant effect on oxidation of unsaturated lipids [25]. DPPH radical was used as a stable free radical to determine antioxidant activity of natural compounds [26].

In an article, methanol extract of the *Ferula orientalis* L. is grown in Sivas, Turkey [27]. DPPH activity was measured as IC_{50} = 0.1 mg/mL. In our study, both leaves and stems of *Ferula orientalis* L. were examined separately. While DPPH activity on leaves was found to be IC_{50} = 1.01 mg/mL, on stems, it was

Table 3 MIC values of compounds against the bacterial strains tested

Samples	Minimum inhibitory concentration values (μg/mL)												
	Sa	Pv	St	Se	Bs	Sg	Pc	Bv	Gr	Ec	Ca	Cg	Ck
Giant fennel	500	500	500	1000	500	500	500	500	1000	500	125	125	125
Ferula l.	125	125	62.5	500	500	250	500	250	500	500	125	62.5	62.5
Ferula s.	7.81	31.25	15.63	500	31.25	31.25	500	7.81	500	500	125	125	125
Rumex l.	2000	1000	500	1000	1000	500	500	500	500	1000	125	250	125
Rumex s.	500	1000	500	1000	1000	500	500	500	1000	500	125	125	125
Acanthus l.	1000	1000	500	1000	1000	500	500	500	500	1000	125	250	125
Acanthus s.	1000	1000	500	1000	500	500	500	500	1000	500	250	125	125
Polygonum l.	1000	1000	500	1000	1000	500	500	500	500	1000	125	250	62.5
Polygonum s.	1000	1000	500	1000	1000	500	500	500	500	1000	125	250	15.63
Chives l.	1000	1000	500	1000	500	500	500	500	500	1000	125	125	125
Chives s.	1000	1000	500	1000	1000	500	500	500	1000	1000	125	125	500
Isgin	500	500	500	1000	1000	500	500	500	1000	500	0.98	<	<
Asphodelus	1000	1000	500	1000	1000	500	500	500	1000	500	125	250	125
Chlor.	0.625	0.625	0.156	1.25	0.156	0.156	1.25	<	0.156	0.313			
AmfB.											0.31	0.16	0.31
Ket.											0.04	0.04	0.16

Sa, *Staphylococcus aureus* ATCC 6538; Pv, *Proteus vulgaris* NRRL B-123; St, *Salmonella typhimurium* ATCC 13311; Se, *Staphylococcus epidermidis* ATCC 12228; Bs, *Bacillus subtilis* NRRL B-4378; Sg, *Streptomyces griseolus* NRRL B-1062; Pc, *Pseudomonas citronellosis* NRRL B-2504; Bv, *Bacillus velezensis* NRRL B-14580; Gr, *Gordonia rubripertincta* NRRL B-3906; Ec, *Escherichia coli* ATCC 8739. As yeast, Ca, *Candida albicans* ATCC 90028; Cg, *Candida glabrata* ATCC 2001; Ck, *Candida krusei* ATCC 6258; Chlor, chloramphenicol; AmfB, amphotericin B; Ket, ketoconazole

found to be $IC_{50} = 3.58$ mg/mL. That is, leaves of *Ferula orientalis* L. have more DPPH activity than of the stems.

A study has been carried out on the rumex (*Rumex tingitanus*) grown in Tunisia. Total polyphenol and total flavonoid contents have been measured for leaves of *Rumex tingitanus* and also have been determined to have antimicrobial activity [28]. It was found for rumex grown in Tunisia that the amount of the total polyphenol in the leaves was 95 ± 2.42 mg GAE/g sample, and the amount of the total flavonoid was 119 ± 4.61 mg GAE/g sample. But according to our study (*Rumex patientia* L.), the amount of the total polyphenol in leaves was 18.97 ± 0.33 mg GAE/g sample, and in stems, the amount was 6.57 ± 0.97 mg GAE/g. The amount of the total flavonoid was measured in leaves as 0.78 ± 0.01 mg que/g sample, and in stems, the amount was 0.23 ± 0.05 mg que/g sample. When antimicrobial activities are compared, it is determined that rumex species growing in Tunisia affect both bacterial and yeast strains, whereas rumex species growing in Erzurum have only antifungal effect. The reason for this difference is that different types of the same genus were studied and collected from different regions.

Phenolic compounds are very important constituents of plants and their radical scavenging ability is due to their hydroxyl groups [29]. The phenolic compounds may contribute directly to antioxidative action [30]. It is suggested that polyphenolic compounds have inhibitory effects on mutagenesis and carcinogenesis in humans, when up to 1.0 g daily ingested from a diet rich in stems and vegetables [31]. Flavonoids are natural phenolic compounds and are well-known antioxidants. In various studies, antioxidant activity of the plant extracts, which are rich in flavonoids, was found to be fairly high [32].

The antioxidant capacity of the isgın (*Rheum ribes* L.) plant grown in Bitlis in Turkey was determined using total polyphenol (35.71 ± 1.23 mg GAE/g sample), total flavonoid (13.66 ± 0.75 mg que/g sample), and DPPH (87.07 ± 0.5%) methods in a study conducted by Ozturk et al. [33]. The same methods were used in our study, but the isgın plant was grown in Erzurum. Comparing antioxidant activities, it has been found that the isgın grown in Erzurum has higher activity. The reason for this difference is that plants grow in different locations and climates.

In an article conducted by Coruh et al. [34], antioxidant capacity was determined using total polyphenol and DPPH methods in leaves and seeds of acanthus (*Gundelia tournefortii* L.) plant grown in Van (Turkey). In our study, antioxidant and antimicrobial activity of leaves and stems of acanthus plant was investigated. The total polyphenols and the DPPH activity of the *Gundelia tournefortii* L. grown in Van were significantly higher than those of the *Gundelia tournefortii* L. grown in Erzurum.

In a study, the total phenolic content of leaves of chives (*Allium schoenoprasum* L.) was found to be 68.5 ± 2 mg GAE/g sample and DPPH activity was $IC_{50} = 6.72$ mg/mL [35]. According to our study, it is seen that it has higher phenolic content. We think that the difference is caused by the extraction method and the collection of the plant from different regions. In our study, the antifungal properties of the *Allium schoenoprasum* L. were investigated and found to have high antifungal properties.

Antioxidant capacity determination analyses were carried out by Hsu et al. on the polygonum (*Polygonum cuspidatum*) [36]. In our study, both leaves and stems of *Polygonum arenastrum* were examined separately but when compared with the literature, *Polygonum cuspidatum* showed better activity in all analyses.

In a research carried out on the asphodelus (*Asphodeline anatolica*), total polyphenol and total flavonoid contents have been measured as 24.21 ± 0.67 mg GAE/g sample, 11.39 ± 0.63 mg que/g sample, respectively [37]. In our study, *Asphodeline taurica* was investigated and total phenolic content was found to be 24.12 ± 8.48 mg GAE/g sample, and total flavonoid content was 0.65 ± 0.05 mg que/g sample. Although total phenolic values were similar in both studies, the total flavonoid value was low in our study.

Although there are antioxidant studies of *Asphodeline lutea* [38], *Asphodeline anatolica* [37, 39], and *Asphodeline taxa* [40] species on asphodelus in the literature, there is no study on *Asphodeline taurica* species that we have studied. Antioxidant assays were performed using total polyphenol, total flavonoid, FRAP, CUPRAC, and DPPH methods, and these antioxidant results have been gained in the literature for *Asphodeline taurica.* At the same time, antimicrobial activities on 13 test microorganisms were investigated and found to have antifungal activity.

The findings of this study indicate that the plant extracts of giant fennel, rumex, acanthus, isgin, asphodelus, polygonum, chives, and ferula contain total phenolic and flavonoid content with antioxidant activity, antimicrobial activity, and antifungal activity. The replacement of synthetic with natural antioxidants may be advantageous. The obtained results might be considered sufficient for further studies on the isolation and identification of the active principles.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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