Antibacterial and Antifungal Effects of Alcoholic Extracts of 41 Medicinal Plants growing in Turkey

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Abstract

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The antibacterial and antifungal activities of crude ethanolic extracts of 41 traditional medicinal plant species belonging to 26 families were tested against four bacteria and two fungi: *Bacillus subtilis*, *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Candida albicans,* and *Aspergillus niger*. Of the 41 plants tested, 39 showed antimicrobial activity against one or more species of microorganisms. While the crude extracts from *Nigellea arvensis* did not show antimicrobial activity against the test microorganisms, *Pistasia lentiscus* showed only antifungal activity against *A. niger.* The most active antimicrobial plants were *Cuminum cyminum, Jasminium officinale, Thymus capitatus, Viscum album, Tanecetum sorbifolium, Pimpinella anisum, Galega officinalis, Liguidamber orientalis, Rhus coriaria, Alnus glutinosa, Pimental officinalis, Achillea coarctata*, and *Cameli sinensis.*

Keywords: antimicrobial activity; medicinal plants; *Bacillus subtilis; Staphylococcus aureus*; *Escherichia coli*; *Pseudomonas aeruginosa*; *Candida albicans*; *Aspergillus niger*

Even though pharmacological industries have produced a number of new antibiotics in the last three decades, the resistance to these drugs by microorganisms has increased. In general, bacteria have the genetic ability to transmit and acquire resistance to drugs, which are utilised as therapeutic agents (Cohen 1992). There are many approaches to search for new biologically active principles in higher plants (Farnsworth & Loub 1983). One such approach is systematic screening, which may result in the discovery of novel effective compounds (Janovská *et al.* 2003). Many efforts have been done to discover new antimicrobial compounds from various kinds of sources such as soil, microorganisms, animals, and plants. One of such resources is folk medicine, while systematic screening of medicinal plants may result in the discovery of novel effective compounds (Janovská *et al*. 2003).

Various medicinal plants have been used for years in daily life to treat diseases all over the world. Turkey is an internationally important floristic center because of its geographic location, climate and the presence of nearly 10 000 natural plant species. According to a study performed by the WHO based on the publications on pharmacopoeias and medicinal plants in 91 countries, the number of medicinal plants is nearly 20 000 (Kalaycioğlu & Öner 1994). The characteristics of the plants that inhibit microorganisms and are important for human health have been researched in laboratories since 1926 (Vonderbank 1949; Erdoğrul *et al*. 2001; Erdoğrul 2002). Traditional medical treatments in daily life are now being tested with the use of empiric methods (Sökmen *et al*. 2000).

Since plants contain a variety of chemical compounds in their leaves, roots, and flowers, they

have been used in the treatment of various human diseases for thousands of years all over the world (Larhsini *et al*. 2001. Similarly, a lot of plants have been used by rural people in Turkey for the treatment of several diseases, including microbial infections, for emetic and strengthening effects, and for increasing urine and decreasing tension (Baytop 1984). Most of the plants used for medicinal purposes have been identified, and their uses are well documented and described by different authors (Nadkarni 1876; Dastur 1985; Saradamma 1990), but the efficacy of many of these plants is yet to be verified. Natural plant extracts have also been tested in laboratories against bacteria and fungi (Sökmen *et al*. 1999).

The first compound with antimicrobial activity was found in the 1930s (Goodman *et al*. 1991). Since that period, the development and use of these subtances has increased, especially with the appearance of resistant strains (Zimhener & Mear 1972).

In this study, ethanolic extracts of different parts of 41 plants, which had been described in herbal books and folk medicine of the Turks, were screened for their antimicrobial activity.

MATERIALS AND METHODS

Plant materials. The plant materials were collected during April–May 2000 and March–January and May (2002–2003) from different parts of Turkey. The identification of these specimens was carried out using the Flora of Turkey (Davis 1966–1988). A few plant samples were obtained from local markets.

Preparation of extracts. Fresh leaves and shoots twigs of the plants were dried at 45°C for 5 to 6 hours. The extracts of the plants were prepared according to the methods described by Abdelaziz *et al*. (1990) and Holopainen *et al*. (1988), with a slight modification. Dried leaves and twigs of the plants were extracted with 95% ethanol (50 g 1/5 ethanol) at room temperature. The extracts were kept at 4°C for 5 days, and were then filtered through 0.45 µm membrane filter. The solvent was evaporated. The crude extracts were stored at –20°C until used.

Microorganisms tested and culture media. The strains of bacteria and fungi were obtained from ATCC (American Type Culture Collection, Rockville, Maryland). Antimicrobial activities of the crude extracts of 41 plants were assayed against *Bacillus subtilis* (ATCC 6633), *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 10145), *Aspergillus niger* (ATCC 9642) and *Candida albicans* (ATCC 60192). The species of bacteria were grown in Mueller Hinton Agar (Merck & Co., Inc., Whitehouse Station, New Jersey, USA) and Mueller Hinton Brot (Merck & Co., Inc., Whitehouse Station, New Jersey, USA). *C. albicans* and *A. niger* were grown in Sabouraud Dextrose Broth (Difco, New York, USA) and Sabouraud Dextrose Agar (Oxoid, Cambridge, UK). The concentration of bacterial suspensions was adjusted to 10^8 cells/ml, and that of fungal suspension to 10^7 cells/ml.

Antibacterial assay. Antibacterial activity was measured using the method of diffusion disc plates on agar (Ronald 1990). In order to test antibacterial activity, the extracts of 41 plant samples were dissolved in 70%. Mueller Hinton Agar medium (Merck & Co., Inc., Whitehouse Station, New Jersey, USA) (20 ml) was poured into each 15 cm Petri dish. All bacterial strains were grown in Mueller Hinton Broth medium (Merck & Co., Inc., Whitehouse Station, New Jersey, USA) at 37°C for 24 hours. The growth was adjusted to OD (600 nm) of 0.1 by dilution with Mueller Hinton Broth medium (Merck & Co., Inc., Whitehouse Station, New Jersey, USA). The respective suspension (100 µl) with approximately 10^8 bacteria per millilitre was placed in Petri dishes over agar and dispersed. Then, sterile paper discs (6 mm diameter) were placed on agar to load 10 µl of each plant sample (40 mg/ml). For bacteria, Amoxicillin and Cefazolin of 10 µl (40 mg/ml) were used as the positive control and 70% ethanol was used as the negative control. The inhibition diameters were determined after incubation at 37°C for 24 hours. All tests were made in triplicates.

Antifungal assay. *C. albicans* and *A. niger* were grown in Sabouraud Dextrose Broth (Difco, New York, USA) at 27°C for 48 h and Sabouraud Dextrose Agar (Oxoid, Cambridge, UK) was employed in agar diffusion experiments. The fungal suspensions tested were adjusted to 10^7 cells/ml as explained above. One hundred units of nystain was used as the positive control and alcohol as the negative control. The inhibition zones were determined after incubation at 27°C for 48 hours. All tests were made in triplicates.

Minimum inhibition concentration. The agar dilution method described by Vanden Berghe

and Vietinck (1991) was used for the antibacterial screening with slight modifications. Instead of 96 well microtitre plates, 24 well tissue culture (Corning, New York, USA) plates were used. The crude extracts were dissolved in 70% ethanol, physiological Tris buffer (Amresco 0826-500G) mixture (1:4), and mixed at 45°C with an equal amount of 3% agar solution (Sabouraud Dextrose Agar (Oxoid, Cambridge, UK) for fungi and Mueller Hinton Agar (Merck & Co., Inc., Whitehouse Station, New Jersey, USA) for bacteria. Each of the crude extract sample was tested at concentrations of 40, 20, 10, 5, 2.5, and 1.25 mg/ml. From the test solutions, 400 µl was transferred into each well of the tissue culture plate. After solubilisation each well was inoculated with 10 µl of freshly prepared bacterial suspension of 10^8 bacteria, 10^7 fungus/ml, and incubated at 37°C for 24 hours. For bacteria, as positive control Amoxicillin and Cefazolin of 40, 20, 10, 5, 2.5, and 1.25 mg/ml, and for fungi nystain and as negative control 70% ethanol were used. The bacterial and fungal growth was assessed by a stereo microscope after the incubation period. All tests were made in triplicates.

Statistical analysis. The statistical analyses were done with SPSS for Windows (Ver. 13.0) software. The differences between the means of the inhibition zones were tested with one-way variance analysis followed by Tukey HSD test. The results were evaluated in the confidence limit of 0.05.

RESULTS AND DISCUSSION

A total of 41 ethanolic extracts from different organs of the 41 plant species were investigated. The determination of the MIC by means of agar dilution and inhibition zones by diffusion disc plates on agar method (Table 1) showed that 39 plant extracts tested exhibited an antimicrobial effect against some of the six microorganisms tested. The results proved that the extract from *N. arvensis* showed antibacterial and antifungal activity against all the strains tested. However, the extract from *P. lentiscus* showed only antifungal activity against *A. niger* but did not show any antimicrobial activity against the bacteria tested. The extracts from *C. cyminum, J. officinale, T. capitatus, V. album, T. sorbifolium, P. anisum, G. officinalis, L. orientalis, R. coriaria, A. glutinosa, P. officinalis*, and *C. sinensis* showed high antibacterial and antifungal activities against all the strains tested.

Among the 41 plants screened, the largest inhibitory zones were observed with the extracts of *Achillea coarctata* and *Pimpinella anisum* (35 mm) against, *B. subtilis,* with that of *Aesculus hippocastanum* (29 mm) against *B. subtilis* with that of *Cameli sinensis* (30 mm) against *S. aureus,* with that of *Jasminium officinale* (30–25 mm) against *B. subtilis* and *C. albicans,* with that of *Tanecetum sorbifolium* (25 mm) against *S. aureus,* with that of *Liguidamber orientalis* (26–25 mm) against *B. subtilis* and *S. aureus.* All the plant extracts were more effective against Gram negative bacteria than against Gram positive ones. As shown in Table 1, the MIC values ranged from 0.25 mg/ml as the most potent to 8 mg/ml as the least potent. The most potent plant extracts with MIC < 0.25 to 0.5 µg/ml proved to be *C. cyminum, J. officinale, T. capitatus, V. album, T. sorbifolium, P. anisum, G. officinalis, L. orientalis, R. coriaria, A. glutinosa, P. officinalis,* and *C. sinensis*. Some plants previously screened by other investigators were included in this study. But the concentrations and proportions of the active compounds in essential oils and other substance extracts components depend on the plant variety, origin, time of harvest, and conditions of processing and storage (Deans & Ritchie 1987). Because of the fact that different methods and different microorganisms or strains were used in the assay. Medicinal plants are used by a large proportion of the Turkey population. The reasons for this include, harmful side effects and the high cost of forms of treatment and the other cause. In the present study, the results were encouraging as 39 out of 41 plants appeared to contain substances possessing antimicrobial properties (Baytop 1984). This correlates well with the observations obtained in previous investigations made in different parts of the world (Belachew Desta 1993; Mehta *et al*. 1993).

The activities of some of the crude extracts tested in this study were similar to those of the antibacterial standards Cefazolin and Amoxicillin (10 mg/ml) against *P. aeruginosa, S. aureus*, *B. subtilis*, and *E. coli.* In addition, the antifungal activity of these crude extracts was more potent against *C. albicans* and *A. niger* than the standard antifungal Nystatin (100 unit).

In this study, the antimicrobial effects of the crude extracts from 41 plants against bacteria and fungi were determined. These plants are known by their healing properties and are used for the treatment of various human diseases.

Table 1. Results of antimicrobial screening of medicinal plant extracts determined by the agar-dilution method (minimum inhibitory concentration, MIC, in mg/ml) and agar disc diffusion method (inhibition zone in mm)

Plant species and family	Part used	Collection time	Collection site	Microorganisms											
				inhibition zone (mm)						MIC (mg/ml)					
				E.c.	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*	*E.c.*	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*
Arum italicum Mill	Lf	October 2002	Giresun	7.67 ± 0.44^{b}	12.00 ± 0.42^{a}	7.33 ± 0.42^{b}	– ± 0.34^{e}	5.67 ± 0.44^{ef}	0.33 ± 0.45^{hij}	4	–	–	2	2	1
Lathyrus sativus L. Legüminosae	Lf, Fr	une 2002	market	2.67 ± 0.44^{cd}	12.00 ± 0.42^{e}	7.33 ± 0.42^{a}	– ± 0.34^{e}	5.67 ± 0.44^{kl}	0.33 ± 0.45 ^{ghi}	8	4	4	–	0.5	1
Cuminum cyminum L. Umbelliferae	Fr	une 2002	market	2.67 ± 0.44^{cd}	12.00 ± 0.42^{e}	11.33 ± 0.42^{hi}	2.00 ± 0.34^{d}	8.67 ± 0.44^{n}	10.00 ± 0.45^{bc}	8	4	1	4	0.25	2
Aesculus hippocastanum L. Hippocastanaceae	Ft, Lf	October 2002	Ordu	0.67 ± 0.44^{b}	10.33 ± 0.42^{c}	22.00 ± 0.42^{l}	14.67 ± 0.34^{a}	0.67 ± 0.44^{efg}	3.00 ± 0.45^{e}	2	8	8	4	2	2
Jasminium officionale L. Oleaceae	Lf	June 2002	market	9.67 ± 0.44^{il}	18.67 ± 0.42^{i}	22.67 ± 0.42^{l}	3.33 ± 0.34^{e}	8.67 ± 0.44^{n}	1.67 ± 0.45^{jkl}	2	0.5	0.5	1	1	1
Thymus capitatus L. Labiatae	Fr, Lf	August 2002	Trabzon	– ± 0.44^{b}	14.33 ± 0.42^{f}	9.33 ± 0.42^{efg}	6.00 ± 0.34^{b}	7.67 ± 0.44^{mn}	5.00 ± 0.45^{m}	8	2	4	0.5	1	0.5
Viscun album L. Loranthaceae	Lf, Fr	October 2002	Giresun	7.00 ± 0.44^{g}	10.33 ± 0.42^{c}	11.33 ± 0.42^{hi}	4.33 ± 0.34^{c}	3.67 ± 0.44^{hij}	1.00 ± 0.45^{ijk}	0.5	–	0.5	–	1	1
Ammi visnaga Lam. Umbelliferae	Lf, Fr	June 2002	market	5.00 ± 0.44^{ef}	15.00 ± 0.42^{f}	3.00 ± 0.42^{cd}	0.33 ± 0.34^{e}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	4	1	1	0.5	4	8
Nigella arvensis L. Ranunculaceae	Fr, Lf	June 2002	market	0.33 ± 0.44^{b}	8.67 ± 0.42^{bc}	7.33 ± 0.42^{a}	14.67 ± 0.34^{a}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	8	8	4	4	4	4
Coriandrum sativum L. Umbelliferae	Fr, Lf	June 2002	market	11.00 ± 0.44^{cd}	– ± 0.42^{a}	0.33 ± 0.42^{b}	6.67 ± 0.34^{b}	14.00 ± 0.44^{a}	11.33 ± 0.45^{b}	2	–	4	4	–	4
Ocimum basillicum L. Labiatae	Sd	June 2002	market	5.00 ± 0.44^{ef}	11.67 ± 0.42^{d}	11.33 ± 0.42^{hi}	6.00 ± 0.34^{b}	14.00 ± 0.44^{a}	3.67 ± 0.45^{e}	4	4	0.5	8	8	1
Tanecetum sorbifolium Boiss. Compositae	Fr, Ft, Lf	June 2002	Gümüşhane (Kösedağ)	10.00 ± 0.44^{lm}	7.67 ± 0.42^{b}	1.33 ± 0.42^{bc}	10.33 ± 0.34^{g}	2.33 ± 0.44^{cd}	8.33 ± 0.45^{c}	2	8	8	2	2	4
Achillea biebersteinii Afan. Compositae*i*	Fr, Lf	June 2002	Gümüşhane (Kösedağ)	7.67 ± 0.44^{a}	– ± 0.42^{a}	9.33 ± 0.42^{efg}	14.67 ± 0.34^{a}	14.00 ± 0.44^{a}	11.00 ± 0.45^{b}	–	–	8	–	–	4
Buxus sempervirens L. Buxaceae	Sd, Lf	October 2002	Giresun	4.33 ± 0.44^{def}	15.00 ± 0.42^{f}	12.33 ± 0.42^{i}	4.00 ± 0.34^{g}	1.33 ± 0.44^{fg}	10.00 ± 0.45^{bc}	4	1	2	0.5	1	4
Alkanna tinctoria L. Boraginaceae	Fr, Lf	JJune 2000	market	1.00 ± 0.44^{bc}	13.67 ± 0.42^{e}	7.33 ± 0.42^{a}	14.67 ± 0.34^{a}	3.67 ± 0.44^{hij}	10.00 ± 0.45^{bc}	8	1	4	2	0.5	0.5
Pimpinella anisum L. Umbelliferae	Fr, Lf	June 2000	market	13.67 ± 0.44^{klm}	20.33 ± 0.42^{j}	10.33 ± 0.42^{gh}	4.33 ± 0.34^{c}	6.00 ± 0.44^{lm}	3.00 ± 0.45^{l}	0.5	1	0.5	8	1	1
Artemisia absinthium L. Compositae	Fr, Lf	May 2002	market	4.00 ± 0.44^{de}	– ± 0.42^{a}	10.00 ± 0.42^{fgh}	14.67 ± 0.34^{a}	14.00 ± 0.44^{a}	10.00 ± 0.45^{bc}	2	–	0.5	–	–	4

Table 1. to be continued

Plant species and family	Part used	Collection time	Collection site	Microorganisms											
				inh. Zone (mm)						MIC (mg/ml)					
				E.c.	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*	*E.c.*	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*
Origanum vulgare L. Labiatae	St, Fr	June 2002	market	22.00 ± 0.44^{p}	17.33 ± 0.42^{h}	15.33 ± 0.42^{j}	10.33 ± 0.34^{i}	14.0 ± 0.44^{a}	11.00 ± 0.45^{b}	0.5	0.5	0.5	0.5	–	4
Colutea arborescens L. Legüminosae	Lf, Ft	June 2002	market	7.67 ± 0.44^{gh}	15.00 ± 0.42^{f}	9.67 ± 0.42^{efgh}	7.00 ± 0.34^{b}	5.33 ± 0.44$_{b}$	5.67 ± 0.45^{d}	4	8	0.5	8	8	8
Diospyrus lotus L. Ebenaceae	Ft, Lf	October 2002	Ordu (Perşembe)	4.00 ± 0.44^{de}	17.67 ± 0.42^{h}	8.00 ± 0.42^{e}	14.67 ± 0.34^{a}	2.33 ± 0.44^{ghi}	1.00 ± 0.45^{ijk}	8	1	2	–	2	0.5
Erica verticillata Forsk. Ericaceae	Fr, St	May 20022	Market	– ± 0.44^{b}	– ± 0.42^{a}	10.33 ± 0.42^{gh}	14.67 ± 0.34^{a}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	8	–	1	–	–	4
Galega officinalis L. Legüminasae	Fr, Lf	August 2002	Ordu (Perşembe)	1.00 ± 0.44^{bc}	17.00 ± 0.42^{g}	12.33 ± 0.42^{i}	5.33 ± 0.34^{g}	5.67 ± 0.44^{kl}	1.00 ± 0.45^{ijk}	8	0.5	0.5	1	2	1
Sambucus nigra L. Caprifoliaceae	Fr, Sd, Lf	October 2002	Giresum (Görele)	1.00 ± 0.44^{bc}	– ± 0.42^{a}	4.33 ± 0.42^{d}	14.67 ± 0.34^{a}	5.33 ± 0.44^{b}	10.00 ± 0.45^{bc}	8	–	4	2	4	8
Laurus nobilis L. Lauraceae	Lf, Fr	June 2000	Ordu	12.33 ± 0.44^{jkl}	16.67 ± 0.42^{g}	15.67 ± 0.42^{j}	10.33 ± 0.34^{i}	5.67 ± 0.44^{kl}	18.67 ± 0.45^{a}	0.5	0.5	1	0.5	1	4
Vitex agnus costus L. Verbenaceae	Fr, Lf	June 2002	market	15.33 ± 0.44^{mn}	18.67 ± 0.42^{i}	16.67 ± 0.42^{j}	3.33 ± 0.34^{e}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	0.5	0.5	0.5	0.5	–	–
Alhagi camelorum Fisch. Legüminosae	Lf, St	June 2002	market	12.33 ± 0.44^{jkl}	– ± 0.42^{a}	9.33 ± 0.42^{m}	0.67 ± 0.34^{ef}	4.00 ± 0.44^{ijk}	3.67 ± 0.45^{e}	0.5	–	2	0.5	2	1
Pistacia lentiscus L. Anacardiaceae	Fr, Lf	June 2002	market	7.67 ± 0.44^{a}	– ± 0.42^{a}	7.33 ± 0.42^{efg}	14.67 ± 0.34^{a}	14.00 ± 0.44^{fg}	3.33 ± 0.45^{ijk}	–	–	–	–	–	2
Vicia faba L. Leguminasae	Sd	June 2002	market	2.67 ± 0.44^{cd}	– ± 0.42^{a}	8.00 ± 0.42^{e}	14.67 ± 0.34^{a}	1.67 ± 0.44^{fg}	3.67 ± 0.45^{e}	2	–	2	–	2	2
Liguidamber orientalis Mill. Hamamelidaceae	Fr. Lf	June 2002	market	14.00 ± 0.44^{lm}	20.61 ± 0.42^{k}	18.67 ± 0.42^{k}	10.33 ± 0.34^{i}	6.00 ± 0.44^{lm}	1.00 ± 0.45^{ijk}	0.5	2	0.5	0.5	0.5	0.5
Rhus coriaria L. Anacardiaceae	Lf	June 2002	market	9.00 ± 0.44^{hi}	15.33 ± 0.42^{f}	0.33 ± 0.42^{b}	0.67 ± 0.34^{ef}	5.67 ± 0.44^{kl}	2.33 ± 0.45^{ef}	0.5	2	4	0.5	1	0.5
Prunus laurocerasus L. *Rosaceae*	Ft, Lf	May 2002	Giresun (Görele)	5.00 ± 0.44^{ef}	15.33 ± 0.42^{f}	9.33 ± 0.42^{a}	14.67 ± 0.34^{a}	1.33 ± 0.44^{a}	1.00 ± 0.45^{e}	2	0.5	0.5	–	1	0.5
Alnus glutinosa Goertn Betulaceae	Lf	October 2002	Gresun (Görele)	13.33 ± 0.44^{kl}	19.67 ± 0.42^{j}	12.67 ± 0.42^{i}	2.00 ± 0.34^{f}	6.00 ± 0.44^{lm}	– ± 0.45^{hij}	2	1	0.5	0.5	0.5	1
Camelia sinensis L. Theaceae	Lf	June 2000	market	2.67 ± 0.44^{jk}	25.00 ± 0.42^{l}	16.67 ± 0.42^{j}	15.33 ± 0.34^{j}	5.67 ± 0.44^{kl}	11.00 ± 0.45^{n}	4	0.5	4	1	0.5	0.5
Linum bienne Mill. Linacaceae	Lf	June 2000	Gümüşhane (Kösedag)	7.67 ± 0.44^{a}	11.67 ± 0.42^{d}	8.00 ± 0.42^{e}	14.67 ± 0.34^{a}	1.33 ± 0.44^{fg}	10.00 ± 0.45^{bc}	–	8	4	8	0.5	8

Table 1. to be continued

Plant species and family	Part used	Collection time	Collection site	Microorganisms											
				inh. Zone (mm)						MIC (mg/ml)					
				E.c.	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*	*E.c.*	*P.a.*	*B.s.*	*S.a.*	*C.a.*	*A.n.*
Tamarix smyrensis Bunge. Tamarixaceae	Lf, Fr	June 2000	Gümüşhane (Kösedag)	14.00 ± 0.44^{ij}	20.67 ± 0.42^{k}	8.33 ± 0.42^{ef}	5.00 ± 0.34^{i}	3.67 ± 0.44^{bc}	2.00 ± 0.45^{kl}	2	0.5	2	8	4	0.5
Artemisia santonicum L. Compositae	Fr, St	June 2000	Gümüşhane (Kösedag)	7.33 ± 0.44^{gh}	15.33 ± 0.42^{e}	3.00 ± 0.42^{cd}	14.67 ± 0.34^{a}	3.33 ± 0.44^{c}	1.00 ± 0.45^{fgh}	4	2	8	–	4	1
Scorzonera mollis Bieb. Compositae	Lf, Fr	June 2000	Gümüşhane (Kösedag)	7.67 ± 0.44^{a}	18.67 ± 0.42^{i}	9.33 ± 0.42^{efg}	2.33 ± 0.34^{d}	1.00 ± 0.44^{de}	18.67 ± 0.45^{a}	–	2	2	4	1	–
Hypericum perforatum L. Compositae	Fr, Lf, St	August 2002	Rize	10.00 ± 0.44^{ij}	$- \pm 0.42^{a}$	15.00 ± 0.42^{j}	5.33 ± 0.34^{g}	4.67 ± 0.44^{jkl}	$- \pm 0.45^{hij}$	0.5	–	0.5	1	0.5	2
Achillea coarciata Poir. Compositae	Fr, Lf	August 2002	Trabzon	6.00 ± 0.44^{fg}	$- \pm 0.42^{a}$	27.67 ± 0.42^{efg}	0.67 ± 0.34^{ef}	4.00 ± 0.44^{ijk}	10.00 ± 0.45^{bc}	1	2	0.5	0.5	0.5	4
Pimenta officinalis Lindl Myrtaceae	Sd	June 2002	market	17.00 ± 0.44^{n}	19.67 ± 0.42^{j}	28.00 ± 0.42^{m}	8.33 ± 0.34^{h}	8.67 ± 0.44^{n}	2.00 ± 0.45^{efg}	0.5	2	0.5	1	0.5	0.5
Cocos nucifera L. Arecaceae	Ft	June 2002	market	12.00 ± 0.44^{k}	10.00 ± 0.42^{c}	9.33 ± 0.42^{efg}	0.67 ± 0.34^{ef}	5.67 ± 0.44^{kl}	1.00 ± 0.45^{ijk}	0.5	8	0.5	2	1	1
Amoxicillin				26.67 ± 0.44^{r}	36.67 ± 0.42^{m}	37.33 ± 0.42^{o}	33.00 ± 0.34^{l}	14.00 ± 0.44^{a}	18.67 ± 0.45	0.5≤	0.5≤	0.5≤	0.5≤	ND	ND
Cefazolin				25.00 ± 0.44^{r}	19.67 ± 0.42^{j}	34.67 ± 0.42^{n}	21.33 ± 0.34^{k}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	0.5≤	0.5≤	0.5≤	0.5≤	ND	ND
Nystatin				7.67 ± 0.44^{a}	$- \pm 0.42^{a}$	7.33 ± 0.42^{a}	14.67 ± 0.34^{a}	2.00 ± 0.44^{gh}	3.67 ± 0.45^{e}	ND	ND	ND	ND	2≤	2≤
70% alcohol				7.67 ± 0.44^{a}	$- \pm 0.42^{a}$	7.33 ± 0.42^{a}	14.67 ± 0.34^{a}	14.00 ± 0.44^{a}	18.67 ± 0.45^{a}	–	–	–	–	–	–

The differences between the means in the same column followed by the same letter are not statistically significant. $P > 0.05$

– no inhibition. NT – not tested. Parts used: Fr – flower; Ft – fruit; Lf – leaf; Sd – seed

Microorganisms: *E.c. – E. coli; P.a. – P. aeruginosa; B.s. – B. subtilis; S.a. – S. aureus*; S.e. – *S. epidermidis*; *C.a. – C. albicans*; *A.n. – A. niger*

The antimicrobial activities of the extracts of 41 plant against bacteria were more effective than those against fungi, which is similar to the results of Avato *et al*. (1997), Valsaraj *et al*. (1997) and Zavala *et al*. (1997). The two fractions of the crude extract from *V. album* were found to be active against *P. aeruginosa, S. aureus, B. subtilis, E. coli*, and *C. albicans* by Ertürk *et al*. (2003).

The isolation of the compounds with antimicrobial and antifungal activities will lower the required doses as compared to the crude extracts. In addition, it is noteworthy that these plants are best used in lukewarm meals, since the extraction yields will be lower in the cold while the active compounds will be transformed into less active or inactive products when heated.

From the results given in the present work, it can be concluded that some plant extracts possess compounds with antibacterial and antifungal potential that can be used as antimicrobial compounds and in the treatment of infectious diseases caused by resistant microorganisms. *C. cyminum, A. hippocastanum, J. officinale, P. anisum, O. vulgare, G. officinalis, L. nobilis, C. sinensis, L. orientalis*, and *H. perforatum* showed high antibacterial and antifungal activities, thus these plant extracts can be used for the search for bioactive natural products that may help in the development of new drugs for the treatment of infectious diseases.

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