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FULL PAPER

Comparative Evaluation of Medicinal Plant Extracts and Antimicrobial Magistrals

Hager Muftah[a], Berrin Özçelik[a], Ozlem Oyardi[a*], Didem Deliorman Orhan[b]

[a*] *Department of Pharmaceutical Microbiology, Faculty of Pharmacy, Gazi University, 06330, Ankara Turkey;*
[b] *Department of Pharmacognosy, Faculty of Pharmacy, Gazi University, 06330, Ankara, Turkey*

SUMMARY

The *in vitro* antimicrobial activity of the active ingredient in antimicrobial magistral drug formulations and plant extracts used in folk medicine were investigated comparatively. Borax, sulfur colloid, hydrogen peroxide, benzoic acid, rivanol, brilliant green and plant extracts as active ingredients, namely: *Helianthus tuberosus* tuber-H_2O (aqueous extract), *Cydonia oblonga* leaves-H_2O, *Allium porrum* whole plant-H_2O, *Cistus laurifolius* leaves-EtOH, *Solanum muricalum*-H_2O, and *Fumaria cilicica* leaves-EtOH were studied to determine their antimicrobial activity against different bacteria and fungi (*S. pyogenes, S. aureus, S. epidermidis*, *E. faecalis, K. pneumonia, H. influenza, P. aeruginosa, A. baumannii, E. coli*, *Candida albicans, C. tropicalis, C. parapsilosis, C. krusei*) by using the microdilution method. The active ingredients and plant extracts showed different activities as MIC between 1->128 µg/mL. Brilliant green and rivanol as active ingredients had MIC values of 1 µg/mL against all tested microorganisms. *C. oblonga* leaves-H_2O as well as *C. laurifolius* leaves-EtOH as plant extracts were indicated as having the highest antimicrobial effect in MIC value of 16 µg/ml against *A. baumannii* and *S. pyogenes,* respectively. On the other hand, *F. cilicica* leaves-EtOH and *C. laurifolius* leaves-EtOH showed the highest antifungal activity (MIC; 16 µg/mL).

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In general, magistral formulations are drugs which are prepared specifically for individuals by pharmacists, as opposed to commercial drugs. If commercial drugs cannot meet the needs of patients, physicians can prescribe magistral drugs according to the appropriate ingredients. Pharmacists, in addition to compounding, are also responsible for the safety and efficacy of these drugs. Pharmacists use reference books named pharmacopoeias, which are compiled by government authorities, to prepare magistral drugs (Allen, 2012).

The antimicrobial activity of plants makes them important in folk medicine. Herbal ingredients as well as chemical substances may also be included in magistral formulations. Some of the active substances used to obtain antiseptic magistrals are borax, sulfur colloid, hydrogen peroxide, benzoic acid, rivanol, and brilliant green.

Borax is odorless, occurs as translucent crystals or white crystalline powder, is freely soluble in boiling water or glycerin, and insoluble in ethanol. Borax has a mild antiseptic activity. It used as an antiseptic and disinfectant in the treatment of skin infections such as; acne, bedsores, eczema, and herpes (Pharmacopoeia Commission of People's Republic of China, 1992). Sulfur is a bright yellow, slightly fragrant crystalline solid and insoluble in water. It is obtained from natural sulfur of the natural elemental mineral group. Colloidal suspension of sulfur particles (colloidal sulfur) and sulfur has antiseptic, antifungal and antiparasitic properties and is used in the treatment of skin diseases such as acne, dandruff, psoriasis, asthma, rheumatic pain, and has been widely used in wound healing for a long time (Weld and Gunther, 1947). Hydrogen peroxide is a clear, odorless, colorless liquid used as a biocide for disinfection, sterilization, and antisepsis. It has broad spectrum antimicrobial activity against viruses, bacteria, yeast and bacterial spores (Pharmacopoeia Commission of People's Republic of China, 1992). Benzoic acid occurs as white crystals or crystalline powder. It is odorless, found in nature particularly in plants, and is freely soluble in ethanol, in acetone and in diethyl ether, soluble in hot water, and slightly soluble in water. It is used as an antiseptic in lotions, topical ointments and mouth washes. It is more effective when used as a preservative in foods and pharmaceuticals products (Japanese Pharmacopoeia, 2006). Rivanol, also known as ethacridine lactate, occurs as a yellow, crystalline powder. It is soluble in water, methanol, and ethanol. Ethacridine derivatives are widely used as antibacterial agents (Japanese Pharmacopoeia, 2006). Brilliant green,

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Corresponding author:
Ankara/Türkiye
E-mail: microberr@yahoo.com, berrin@gazi.edu.tr

a small, bright, green colored crystal, is a triphenylmethane dye that inhibits the growth of bacteria in low concentrations more effectively than other dyes. Brilliant green dye is used in the isolation of typhoid and paratyphoid bacteria and is most widely used in selective media (Narat, 1931).

Jerusalem artichoke, known in Turkey as 'Yerelması,' belongs to the *Asteraceae* family. It is 1.5-3 meters tall and in general this tree is found in eastern North America and Turkey. It has a variety of pharmacological activities, such as a diuretic, somatic, laxative, tonic effect (Chen *et al*., 2013). *Cydonia oblonga*, known in Turkey as 'Ayva,' belongs to the *Rosaceae* family. It originated in Turkey, the Caucasus, and Turkestan and spread to Europe and Mediterranean countries. It is a fruit tree 4-5 meters tall. *Cydonia oblonga* seeds are used in traditional medicine to treat diarrhea, dysentery, cough, sore throat, bronchitis, colic, and constipation disorders (Sajid, 2015). The common name of *Allium porrum,* known in Turkey as 'pırasa,' is 'Leek.' It is a plant rich in folic acid, copper, potassium, iron, and vitamins C, B, and E. The leek has anti-infective, antioxidant, antitumor activities (Naem-Rana and Hadi-Noora, 2012). *Cistus laurifolius*, known in Turkey as 'Defne yapraklı laden,' belongs to the *Cistaceae* family. In Turkey it plays a very important role in traditional treatments of high fever, rheumatism, and stomach and urinary tract disorders (Ustun *et al*., 2006). *Solanum muricatum* belongs to the *Solanaceae* family. It is an exotic plant grown in the south of Turkey. Its fruit has high proportions of water, potassium, and vitamin C. Its antioxidant, diuretic, and antitumor activity effects on hypertension have been tested (Shing *et al*., 2013). *Fumaria cilicica*, known in Turkey as 'Şahtere,' belongs to the *Fumaria* genus. *Fumaria cilicica* is traditionally used all over the world to treat hepatobiliary diseases (Orhan *et al*., 2007).

This study aimed to compare the antimicrobial activity of *Helianthus tuberosus* tuber-H_2O (aqueous extract), *Cydonia oblonga* leaves-H_2O, *Allium porrum* whole plant-H_2O, *Cistus laurifolius* leaves-EtOH, *Solanum muricalum*-H_2O, *Fumaria cilicica* leaves-EtOH and active ingredients in magistrals (borax, sulfur colloid, hydrogen peroxide, benzoic acid, rivanol, brilliant green) against gram-positive bacteria *(S. pyogenes, S. aureus, S. epidermidis, E. faecalis),* gram-negative bacteria *(K. pneumoniae, H. influenza, P. aeruginosa, A. baumannii, E. coli),* and fungi (*Candida albicans, C. tropicalis, C. parapsilosis, C. krusei)* by using the microdilution method to determine minimum inhibitory concentrations (MIC; µg mL^{-1}).

METHODS

Plant materials

Helianthus tuberosus L. (Asteraceae) tubers and *Allium porrum* L. (Amaryllidaceae) bulbs were purchased at a bazaar (February, 2015); fresh *Cydonia oblonga* L. (Rosaceae) leaves were gathered in Ankara (September, 2014); *Cistus laurifolius* L. (Cistaceae) leaves were collected in Kurtboğazı, Ankara, Turkey in June 2009; fruits of *Solanum muricatum* Aiton. (Solanaceae) were purchased at a bazaar (August 2014); aerial parts of *Fumaria cilicica* Hausskn. (Fumariaceae) were gathered in Lalahan, Ankara, Turkey in May 2010. Voucher specimens were identified by comparison with authentic specimens that had already been identified by Prof. Dr. Didem DELIORMAN ORHAN. Authenticated voucher specimens were stored in the Herbarium of Faculty of Pharmacy at Gazi University (GUE 2489), Ankara, Turkey. One voucher specimen was authenticated by Prof. Dr. Mecit VURAL (Department of Biology, Gazi University) and deposited in the Herbarium of Faculty of Pharmacy, Gazi University, Ankara, Turkey (GUEF 3226).

Preparation of plant extracts

Shredded *H. tuberosus* (500 g), *A. porrum* (500 g), and *C. oblonga* (50 g) samples were extracted separately with 80% aqueous EtOH (2 L×2 times) for 6 hours in a 50°C water bath. Each extract was filtered and concentrated to dryness under reduced pressure in a rotary evaporator. Yields of the extracts were 24.1 % for *C. oblonga*, 3.5 % for *A. porrum*, and 12.3% (w/w) for *H. tuberosus*.

C. laurifolius leaves were separated and extracted with 80% ethanol in the shaker for 24 h. Extracts were filtered and evaporated to dryness under vacuum (yields: ethanol extract 16.5% w/w).

Fruits of *S. muricatum* were cut into small pieces, weighed (372.05 g), and then squeezed. The fruit juice was filtered and condensed under reduced pressure. The soft extract obtained was placed in a freeze-dryer until dryness (yield of fruit juice: 4.8 % w/w)

Dried and powdered aerial parts of *F. cilicica* (192 g) were extracted with 80% ethanol in a 40°C water bath for three days. The extract was filtered and concentrated using a rotary evaporator at 45°C. The yield of the ethanol extract (EtOH) from *F. cilicica* was 21.63% (w/w).

Active ingredients in magistral formulations

Borax, sulfur colloid, hydrogen peroxide, benzoic acid, rivanol, and brilliant green were purchased from Botofarma Co.

Antimicrobial activity

Four gram-positive bacterial strains (*Streptococcus pyogenes* ATCC 49766 *Staphylococcus aureus* ATCC 10145, *Staphylococcus epidermidis* ATCC 02026, *Enterococcus faecalis* ATCC 29212), five gram-negative bacterial strains (*Klebsiella pneumonia* ATCC 07005, *Haemophilus influenza* ATCC 6633, *Pseudomonas*

aeruginosa ATCC 25923, *Acinetobacter baumannii* ATCC 12228, *Escherichia coli* ATCC 25922), and four fungi (*Candida albicans* ATCC 10231, *Candida tropicalis* ATCC 13803, *Candida parapsilosis* ATCC 90028, *Candida krusei* ATCC 6258), were used for the determination of antimicrobial activity. Culture suspensions, stock solutions, and inoculums were prepared according to the methods of the Clinical and Laboratory Standards Institute (CLSI; formerly the National Committee for Clinical Laboratory Standards (NCCLS)). All materials were dissolved in dimethylsulfoxide (DMSO), sterilized by filtration using 0.22 mm Millipore (MA 01730, USA), and used as the stock solutions. Mueller-Hinton Broth (MHB; Difco) and Mueller-Hinton Agar (MHA; Oxoid) were applied to grow and dilute the bacteria suspensions. The synthetic medium RPMI-1640 with L-glutamine was buffered to pH 7 with 3-[N- morpholino]-propanesulfonic acid and culture suspensions were prepared as described previously (Özçelik *et al*., 2012; Piras *et al*., 2013; Muftah *et al*., 2022). Reference antimicrobial agents were purchased from Sigma Chemical Co. (St. Louis, MO, USA) and dissolved in phosphate buffer solution (ampicillin, pH 8.0; 0.1 mol/mL), dimethylsulphoxide (ketoconazole), or in water (gentamicin, fluconazole, meropenem). Broth microdilution assay was carried out for antibacterial and antifungal activity tests. Media were placed in all 96 wells of the microplates. Solutions to be tested at 512 µg/mL were added to the first rows of microplates and two-fold dilutions of the solutions (256–0.125 µg/mL) were made by dispensing the solutions to the remaining wells. The lowest concentration of the compounds that completely inhibited macroscopic growth was determined and MICs were recorded (Özçelik *et al*., 2012; Piras *et al*., 2013; Muftah *et al*., 2022).

RESULTS

Medical plant extracts (*Helianthus tuberosus* tuber-H_2O, *Cydonia oblonga* leaves-H_2O, *Allium porrum* whole plant herb-H_2O, *Cistus laurifolius* leaves-EtOH, *Solanum muricalum*-H_2O, *Fumaria cilicica* leaves-EtOH), and active ingredients in some magistral formulations (borax, sulfur colloid, hydrogen peroxide, benzoic acid, rivanol, brilliant green) were tested by using microdilution assay to determine antimicrobial activity against gram-positive bacteria *Streptococcus pyogenes*, *Staphylococcus aureus,*

Table 1 - *Antibacterial activity against bacteria of compounds and references and the control drugs as minimum inhibition concentration (MICs; in µg mL^{-1}).*

Compounds	Microorganism								
	Gram negative bacteria					Gram positive bacteria			
	K. pneumonia ATCC 07005	*H. influenza ATCC 6633*	*P. aeruginosa ATCC 25923*	*A. baumanii ATCC 12228*	*E. coli ATCC 25922*	*S. pyogenes ATCC 49766*	*S. aureus ATCC 10145*	*S. epidermidis RSKK 02026*	*E. faecalis ATCC 29212*
H. tuberosus T-H_2O	128	64	128	16	128	32	32	32	32
C.oblonga L-H_2O	128	64	128	16	128	16	32	32	32
*A. porrum*H-H_2O	128	64	128	16	128	64	32	32	32
C. laurifolius L-EtOH	128	128	128	16	128	32	32	32	32
S. muricalum fruit-H_2O	128	128	128	16	128	128	32	32	32
F. cilicica L-EtOH	128	128	64	16	128	128	32	32	32
Borax	32	32	32	16	32	32	32	32	32
Sulfur colloid	32	32	32	16	32	32	32	32	32
Hydrogen peroxide	16	16	16	16	16	16	16	16	16
Benzoic acid	16	16	16	16	16	8	16	8	16
Rivanol	1	1	1	1	1	1	1	1	1
Brilliant green	1	1	1	1	1	1	1	1	1
AMX-CLA	<0.12	–	1	<0.12	–	1	<0.12	<0.12	<0.12
MRP	–	–	1	–	<0.12	1	0.25	0.25	–
GEN	–	0.5	1	–	–	–	–	–	–

H: Helianthus; *C: Cydonia*; *A: Allium*; *C: Cistus*; *S: Solanum*; *F: Fumaria*; *T: tuber*; *L: leaves*; *H: Herba*; AMX-CLA: Ampicilline-clavunate; MRP: Meropenem; GEN: Gentamicin; EtOH: Ethanol extract; H_2O: Water extract; - not done.

Table 2 - *Antifungal activity against yeast like fungi of compounds and references and the control drugs as minimum inhibition concentration (MICs; in μg mL^{-1}).*

Compounds and references	Yeast like fungi			
	C. albicans ATCC 10231	*C. tropicalis ATCC 13803*	*C. parapsilosis ATCC 90028*	*C. krusei ATCC 6258*
H. tuberosus T-H_2O	64	64	64	64
C. oblonga L-H_2O	64	64	64	64
A. porrum H-H_2O	64	64	64	64
C. laurifolius L-EtOH	64	16	128	64
S. muricalum fruit-H_2O	64	64	128	64
F. cilicica L-EtOH	64	16	128	64
Borax	64	64	64	64
Sulfur colloid	32	32	32	32
Hydrogen peroxide	64	32	64	64
Benzoic acid	64	64	64	64
Rivanol	< 1	1	1	1
Brilliant green	1	1	1	1
FLU	2	2	2	64
KET	1	1	1	2

H: Helianthus; *C: Cydonia*; *A: Allium*; *C: Cistus*; *S: Solanum*; *F: Fumaria*; *T: tuber*; *L: leaves*; *H: Herba*; FLU Flukonazol; KET Ketokonazol; EtOH: Ethanol extract; H_2O: Water extract; - not done.

Staphylococcus epidermidis, and *Enterococcus faecalis,* gram-negative bacteria *Klebsiella pneumoniae, Haemophilus influenza, Pseudomonas aeruginosa, Acinetobacter baumannii*, and *Escherichia coli,* as well as fungi *Candida albicans, C. tropicalis, C. parapsilosis*, and *C. krusei*. Antimicrobial activities were recorded as Minimum Inhibitory Concentration (MIC μg mL^{-1}) (*Table 1*, *Table 2*).

According to the results, the highest antibacterial activity was detected against Gram-positive bacteria (*S. pyogenes, S. aureus, S. epidermidis, E. faecalis*), with an MIC value of 1μg/mL; the lowest antibacterial activity had an MIC value of 128 μg/mL. Some active ingredients (rivanol, brilliant green) showed high activity against gram-positive bacteria. In the other plant extracts and active ingredients, antibacterial activity against gram-positive bacteria ranged between 8-128 μg/mL. The highest antibacterial activity against gram-negative bacteria *H. influenza* was shown by rivanol and brilliant green (MIC: 1 μg/mL). The minimum inhibitory concentration of brilliant green was the same (MIC: 4 μg/mL) against all tested microorganisms. The MIC of the active ingredients and plant extracts for gram-negative bacteria was determined to be 1–128 μg/mL (*Table 1*, *Table 2*).

Table 1 shows the minimum inhibitory concentration of active ingredient, plant extract and control antibiotic against gram-positive bacteria *S. pyogenes, S. aureus, S. epidermidis,* and *E. faecalis*, and gram-negative bacteria *K. pneumoniae, H. influenza, P. aeruginosa, A. baumannii*, and *E. coli*.

According to results shown in *table 2*, the minimum inhibitory concentrations of active ingredients and plant extracts against fungi *C. albicans, C. tropicalis, C. parapsilosis,* and *C. krusei* ranged between 1–128 μg/mL. The highest antifungal activity was detected for rivanol and brilliant green: MIC 1μg/mL.

DISCUSSION

The antimicrobial activity of a number of medical plant extracts (*Helianthus tuberosus tuber*-H_2O*, Cydonia oblonga leaves*-H_2O*, Allium porrum whole plant*-H_2O*, Cistus laurifolius leaves*-EtOH*, Solanum muricalum*-H_2O*, Fumaria cilicica leaves*-EtOH) that are used to prevent and treat many diseases were investigated against *Streptococcus pyogenes, Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus faecalis, Klebsiella pneumoniae, Haemophilus influenza, Pseudomonas aeruginosa, Acinetobacter baumannii*, *Escherichia coli*, and the fungi *Candida albicans, Candida tropicalis, Candida parapsilosis*, and *Candida krusei* by using the microdilution method. As shown in *Table 1* and *Table 2*, antibacterial and antifungal activity were detected between MIC 1-128 μg/mL.

The antimicrobial activity of borax was examined by using the broth dilution method. The MIC of borax was determined for *S. aureus* (MIC 23.80 mg/mL) and for *E. coli* as well as *P. aeruginosa* (MIC 23.80 mg/mL) (Yilmaz, 2012). According to our results, the antibacterial activity of borax against *S. aureus, E. coli, P. aeruginosa* found by using the broth microdilution is moderate, with MIC values of 32 μg/mL.

The antimicrobial activity of sulfur-containing compounds derived from *Petiveria alliacea L* was investigated against bacteria *S. aureus, E. coli, P. aeruginosa,* and *K. pneumonia*, and fungi *C. albicans* and *C. tropicalis* by using the microdilution method. The

minimum inhibitory activity ranged between 16-512 µg/mL (Kim *et al*., 2006). According to our results, sulfur colloid has moderate antibacterial and antifungal activity.

The antimicrobial efficacy of hydrogen peroxide alone or combined with iodine was studied against several bacterial strains (*E. coli, P. aeruginosa*, and *S. aureus*), and fungal strains (*C. albicans* and *C. tropicalis*). The result of this study showed that the mixture of hydrogen peroxide and iodine converted their inhibitory effect from static to cidal, and *P. aeruginosa* and *S. aureus* were killed more effectively by iodine and hydrogen peroxide used in a mixture rather than individually (Zubko and Zubko, 2013). In our study, the antimicrobial activity of hydrogen peroxide was investigated individually against some bacteria and fungi. Hydrogen peroxide was determined to have antimicrobial activity with an MIC ranging from 16-64 µg/mL.

The effect of pH on the bacteriostatic and bacteriocidic action of benzoic acid and inorganic salts was studied. The results of this study specify that the efficacy of benzoic acid increases with an increase in pH. This study showed that benzoic acid is not effective in the neutral range but had a bacteriocidic effect against *S. aureus* when pH was increased (Goshorn. *et al*., 1938). In our study, benzoic acid possessed antimicrobial activity with an MIC ranging from 8-64 µg/mL under normal conditions.

In a study, the antimicrobial activity of ethacridine was screened against bacterial cultures *S. aureus*, *E. coli*, and *K. pneumoniae* and fungal cultures *C. albicans*, *C. krusei*, *C. tropicalis*, and *C. parapsilosis* by using the microdilution method. The result of this study was that ethacridine derivatives showed effective antimicrobial activity against the studied microorganisms. The minimum inhibitory concentration of ethacridine derivatives for bacteria was found to be between 62.5-1000 µg/mL, while the minimum fungistatic concentration ranging between 10.0-750 µg/mL (Petrikaite *et al*., 2006). In our study, using the same method, we found that Rivanol is very effective against microorganisms (MIC; 1 µg/mL).

The antimicrobial activity of 24 different combinations of brilliant green and bile salts concentrations (Brilliant green: 5, 10, 20, 40 mg/l; bile salts: 0, 0.25, 0.50, 1.0, 2.0, 4.0 g/l) was evaluated against *S. aureus* and *E. coli* by using the MPN (most probable number) assay. The result of this study showed that the inhibitory effect of brilliant green decreased as the bile salts concentration increased. Indeed, a 10 mg/l concentration of brilliant green showed a higher inhibitory effect (Miller and Banwart, 1965) The data obtained from our study showed that brilliant green had very strong antimicrobial activity against all tested microorganisms (MIC; 1 µg/mL).

The antifungal activity of crude extract of *Jerusalem artichoke* (*Helianthus tuberosus*) leaves was investigated against nine fungi (*Botrytis cinerea, Colletotrichum gloeosporioides, Phytophthora capsici Leonian, Rhizoctonia cerealis, Exserohilum turcicum, Gaeumannomyces graminis, Gibberella, Pyricularia grisea*, and *Sclerotinia sclerotiorum*) by using the microdilution method. The result of this study showed that the crude extract of *Jerusalem artichoke* leaves achieved 16.9% to 98.2% growth inhibition of nine phytopathogenic fungi (Chen *et al*., 2013). According to our study with *Jerusalem artichoke* tuber-H_2O extract, we founded that the minimum inhibitory concentration was 64 µg/mL against all fungi tested.

The antibacterial activity of fruit decoction and crude extract of *Cydonia oblonga* was tested against six bacteria by using the disc diffusion method. The crude extract derived from leaves of *C. oblonga* showed partial inhibition against *Streptococcus agalactiae*. There was no activity by the extract detected against the other bacteria (Silva and Oliveira *et al*., 2013). In our study, the aqueous extract of *Cydonia oblonga* leaves was found to have different antimicrobial activity with MIC ranging from 16-128 µg/mL. By using the broth microdilution method, *A. baumanii* and *S. pyogenes* were determined to be the most sensitive microorganisms (MIC: 16 µg/mL).

The antimicrobial activity of aqueous extract *of Allium porrum* against gram-positive bacteria (*Bacillus subtilis, Streptococcus pneumonia, Staphylococcus aureus*) and gram-negative bacteria (*Escherichia coli, Proteus vulgaris* and *Pseudomonas aeruginosa*) was studied by using disc diffusion method. The result of this study showed that the inhibition zone formed by the aqueous extract *of A. porrum* against *B. subtilis, S. aureus,* and *S. pneumonia* was 31, 30, and 30 mm, respectively, while the inhibition zone against *P. aeruginosa, P. vulgaris* and *E. coli* was found to be 26, 25, and 24 mm, respectively. Based on the results of this study, the extract of *A. porrum* showed high antibacterial activity against gram-positive bacteria rather than gram-negative bacteria (Naem-Rana and Hadi-Noora, 2012). In our study, by using the broth microdilution method, we also showed that the aqueous extract *of Allium porrum* herb was more effective against gram-positive bacteria.

The anti-*Helicobacter pylori* activity of six compounds isolated from *Citrus laurifolius* was tested by using the agar dilution method. The minimum inhibitory concentration ranged between 3.9-62.5 µg/mL. The highest inhibitory effect on *Helicobacter pylori* was detected by the second compound (Isorhamnetin) whose MIC was 3.9 5 µg/mL (Ustun *et al*., 2006). In our study, the aqueous extract of *Citrus laurifolius* leaves showed antimicrobial activity especially against gram-positive bacteria.

The antimicrobial activity of the chloroform, ethyl acetate, ethanol, methanol and aqueous extracts derived from the fruits of *Solanum muricatum* (pepino) was examined using colorimetric broth microdilu-

tion methods against bacteria *S. aureus, B. cereus, K. pneumoniae, P. aeruginosa, E. coli* and *A. baumannii*, and fungal strains *C. albicans, C. parapsilosis, Issatchenkia orientalis, Cryptococcus neoformans, Aspergillus brasiliensis*, and *Trichophyton mentagrophytes*. The result of this study was that none of the extracts showed activity against *E. coli*. The extract of hexane showed the highest activity against bacteria and fungi: MIC 0.31-0.63 mg/mL and 0.08-1.25 mg/mL, respectively (Shing *et al*., 2013). In our study, the aqueous extract of *Solanum muricatum* (pepino) fruits also did not show antimicrobial activity against *E. coli*. However, the most sensitive microorganism was determined to be *A. baumannii*, with an MIC value of 16 µg/ml.

The antiviral and antimicrobial activity of alkaloids derived from *Fumaria* against *E. coli*, *P. aeruginosa*, *Proteus mirabilis, S. aureus, Bacillus subtilis*, *K. pneumoniae*, *A. baumannii*, *C. albicans*, *herpes simplex* virus (*HSV*), and *parainfluenza*-3 (*PI*-3) viruses were studied by using the microdilution method. The alkaloids derived from *Fumaria* were highly active against fungi *C. albicans* (MIC 4 µg/mL), whereas it did not possess significant antibacterial activity. Alkaloids were found to be completely inactive against *HPV*, whereas they had selective inhibition against the *PI*-3 virus ranging between 0.5 and 64 µg/mL (Orhan *et al*., 2007). According to our results, *F. cilicica* leaves-EtOH extract has antimicrobial activity with an MIC ranging between 16-128 µg/mL.

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