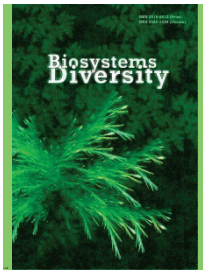

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Antibacterial and fungicidal activities of ethanol extracts of 38 species of plants

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Galenic preparations are broadly used against microorganisms pathogenic to humans, thought their poteintial in this aspect is not studied completely. In our *in vitro* experiment we studied the influence of alcohol tinctures from 38 species of plants on 15 species of bacteria and one species of fungus. Zones of growth inhibition of colonies measuring over 8 mm were observed during the use of ethanol extracts of *Maclura pomifera* against eight species of microorganisms (*Escherichia coli*, *Proteus mirabilis*, *Serratia marcescens*, *Yersinia enterocolitica*, *Salmonella typhimurium*, *Rhodococcus equi*, *Campylobacter jejuni* and *Corynebacterium xerosis*), *Ginkgo biloba* – against eight species (*Enterococcus faecalis*, *S. marcescens*, *Y. enterocolitica*, *Klebsiella pneumoniae*, *Listeria innocua*, *L. monocytogenes*, *P. aeruginosa* and *C. jejuni*), *Genista tinctoria* – against seven species (*E. coli*, *Enterobacter aerogenes*, *Proteus mirabilis*, *K. pneumoniae*, *S. typhimurium*, *P. aeruginosa* and *Rh. equi*), *Phellodendron amurense* – against seven species (*E. faecalis*, *S. marcescens*, *S. typhimurium*, *Rh. equi*, *C. jejuni*, *C. xerosis* and *Candida albicans*), *Berberis vulgaris* – against seven species (*P. mirabilis*, *S. marcescens*, *K. pneumoniae*, *S. typhimurium*, *C. jejuni*, *P. aeruginosa* and *C. xerosis*), *Vitex negundo* – against six species (*E. faecalis*, *E. coli*, *P. mirabilis*, *K. pneumoniae*, *S. typhimurium* and *Rh. equi*), *Koelreuteria paniculata* – against six species (*E. faecalis*, *P. mirabilis*, *S. marcescens*, *S. typhimurium*, *C. jejuni* and *E. coli*), *Magnolia kobus* – against six species (*E. faecalis*, *E. coli*, *P. mirabilis*, *S. marcescens*, *S. typhimurium*, *C. jejuni* and *C. xerosis*), *Liriodendron tulipifera* – against six species (*K. pneumoniae*, *Listeria innocua*, *P. aeruginosa*, *C. jejuni*, *Rh. equi* and *C. albicans*), *Clematis flammula* – against six species (*E. faecalis*, *P. mirabilis*, *L. monocytogenes*, *P. aeruginosa*, *C. jejuni* and *C. xerosis*), *Wisteria sinensis* – against five species (*E. coli*, *S. typhimurium*, *L. monocytogenes*, *Rh. equi* and *C. albicans*), *Chimonanthus praecox* – against five species (*E. faecalis*, *S. marcescens*, *L. monocytogenes*, *C. jejuni* and *Rh. equi*), *Colchicum autumnale* – against five species (*S. marcescens*, *K. pneumoniae*, *L. ivanovi*, *L. monocytogenes* and *P. aeruginosa*). As a result of the study, these plants were found to be the most promising for further study of *in vivo* antibacterial activity. In the search of antibacterial and antifungal activities, the following plants were observed to be less promising: *Ailanthus altissima*, *Aristolochia manshuriensis*, *Artemisia absinthium*, *Callicarpa bodinieri*, *Campsis radicans*, *Catalpa duclouxii*, *Celastrus scandens*, *Dictamnus alba*, *Eucommia ulmoides*, *Geranium sanguineum*, *Laburnum anagyroides*, *Nepeta racemosa*, *Parthenocissus tricuspidata*, *Polygonatum multiflorum*, *Prunus dulcis*, *P. laurocerasus*, *Ptelea trifoliata*, *Pteridium aquilinum*, *Quercus castaneifolia*, *Q. petraea iberica*, *Salvia officinalis*, *Securigera varia*, *Styphnolobium japonicum*, *Tamarix elongata* and *Vitex agnus-castus*.

Keywords: growth inhibition zone; bacterial colonies; multi-resistant strain; candidosis.

Introduction

During recent years there have been reports from all over the globe about resistance to medicine of disease-causing bacteria of human and animals. Emergence of resistance to antibiotics in bacteria is a global problem (Lopes et al., 2018; Zhang et al., 2019). Antibiotic-resistance is now one of the most serious threats to the health of people (Steinberg et al., 2017; Tumen et al., 2018; Khan et al., 2019). Our civilization is approaching the period when antibiotics will be unable to control the courses of common infections, and small traumas could once more lead to people dying (Islam et al., 2019). Antibiotics have allowed humans to live longer and be healthier. Resistance to preparations for treatment of a common intestinal bacterium *Klebsiella pneumonia* (carbapenems) occurs more and more frequently. *K. pneumonia* can cause various nosocomial infections (pneumonia, infections of blood, infections among newborns, etc.). Resistance to fluoroquinolones used for treatment of urinary tract infections caused by *E. coli* has also become widely distributed. In the 1980s, when these preparations were first used, resistance to them was practically absent. Currently, in many countries this treatment is ineffective for over 50% of patients. Cases of no effect on gonorrhea treatment with reserve antibiotics – cephalosporins of the third generation – have been confirmed in many countries of the EU, Australia, Canada, South Africa and Japan. Salević et al. (2019) report that probability of death of humans infected with MRSA (methicillin-resistant *Staphylococcus aureus*) is 64% higher compared with people with medically-non-resistant form of this infection. Resistance to antibiotics among microorganisms also leads to increase in costs for medical services due to the longer period of stay in hospitals. Therefore, there is a necessity of developing alternative antimicrobial preparations for treatment of infectious diseases. Rates of development of new antimicrobial preparations should exceed the rates of development of resistance among microorganisms to currently in-use antibiotics.

In this article we continue to study antibacterial preparations in plant extracts due to spread of antibiotic poly-resistant bacterial strains which are hard to treat (Zazharskyi et al., 2019; Palchykov et al., 2020). Plants produce various secondary metabolites with different biological activity. For galenic preparations of some species of plants we have already found anti-parasitic and antimicrobial activities (Boyko & Brygadyrenko, 2016a; Palchykov et al., 2019; Zazharskyi et al., 2019b).

The objective of this article was determining antibacterial effects of 38 ethanol extracts on 16 species of microorganisms. Up to now, these species of plants have remained poorly studied with respect to antimicrobial activity and can have significant potential in contemporary human and veterinary medicine.

Material and methods

Leaves and shoots of 38 species of plants were collected in the territory of the Botanical Garden of Oles Honchar Dnipo National University (Khromykh et al., 2018; Boyko & Brygadyrenko, 2019), dried at room temperature, fragmented, weighed and kept in 70% ethyl alcohol for 10 days, and then filtered. We took 10 grams of dry fragmented plants per 100 g of 70% ethyl alcohol. Then, 0.1 mL of this filtered alcohol extract was transferred onto one paper disk of 6 mm diameter. The disks were dried in sterile conditions in the temperature of 10 ºC in a microbiological safety cabinet HR1200-IIA2-D (China).

Antibacterial activity of plant tinctures was determined using the disk diffusion method in agar. Out of the daily culture of ethanol strains of microorganisms we prepared a weighed amount according to the standard of opacity of bacterial suspension equaling 0.5 units of density according to McFarland (McF) 1.5 x 10^8 CFU (colony-forming units), which we determined using a densitometer (Densimeter II, Table 1).

The obtained weighed amount was transferred into Muller-Hinton agar (Himedia) with subsequent cultivation in a TCO-80/1 thermostat for 24 h at the temperature of 37 ºC. On top of the inoculations, we put disks (n = 8) saturated with corresponding ethanol tinctures of 38 species of plants (Table 2).

Table 1
Taxonomic composition of 16 species of microorganisms we studied

Phylum, Division	Family	Species, strains
Proteobacteria	Yersiniaceae	*Serratia marcescens* ATCC 8100
		Yersinia enterocolitica ATCC 9610
	Enterobacteriaceae	*Enterobacter aegorenes* ATCC 10006
		Escherichia coli 055
		Klebsiella pneumoniae ATCC 13883
		Salmonella typhimurium ATCC 14028
	Morganellaceae	*Proteus mirabilis* ATCC 14153
	Pseudomonadaceae	*Pseudomonas aeruginosa* ATCC 2353
	Campylobacteraceae	*Campylobacter jejuni* ATCC 11322
Firmicutes	Enterococcaceae	*Enterococcus faecalis* ATCC 19433
	Listeriaceae	*Listeria ivanovii*
		L. innocua ATCC 33090
		L. monocytogenes ATCC 19112
Actinobacteria	Nocardiaceae	*Rhodococcus equi* ATCC 6939
	Corynebacteriaceae	*Corynebacterium xerosis* 1911
Ascomycota	Saccharomycetaceae	*Candida albicans* ATCC 2091

Table 2
Parts of the 38 species of plants we used to prepare ethanol extracts and the most important data on their antibacterial activities

Family	Species	Used part of plant	Most important literature sources about medical properties of plant
Aristolochiaceae	*Aristolochia manshuriensis* Kom.	leaves	Kavitha & Nelson, 2016
Asparagaceae	*Polygonatum multiflorum* (L.) All.	leaves	Bährle-Rapp, 2007
Asteraceae	*Artemisia absinthium* L.	leaves	Obistioiu & Chiurciu, 2014, Al-Ghamdi, 2020
Berberidaceae	*Berberis vulgaris* L.	leaves	Özgen & Geçer, 2012; Anzabi, 2018
Bignoniaceae	*Campsis radicans* (L.) Seem.	leaves	Islam & Haque, 2019
Bignoniaceae	*Catalpa duclouxii* Dode	leaves	Zhang et al., 2018
Calycanthaceae	*Chimonanthus praecox* (L.) Link	leaves	Gui & Qin, 2014
Celastraceae	*Celastrus scandens* L.	leaves	Kumar & Sharma, 2018
Colchicaceae	*Colchicum autumnale* L.	leaves	Adami & Naderi, 2015
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	leaves	Kardong & Saikia, 2013
Eucommiaceae	*Eucommia ulmoides* Oliv.	bark	Liu & Han, 2007; Zhang & An, 2019
Fabaceae	*Genista tinctoria* L.	shoots and leaves	Geraldes & Costa, 2019
Fabaceae	*Laburnum anagyroides* Medik.	leaves	Rivers, 2016
Fabaceae	*Securigera varia* (L.) Lassen	leaves	Behbahani et al., 2013
Fabaceae	*Styphnolobium japonicum* (L.) Schott	shoots and leaves	Lim, 2013
Fabaceae	*Wisteria sinensis* (Sims) Sweet	leaves	Compton, 2015
Fagaceae	*Quercus castaneifolia* C. A. Mey.	shoots and leaves	Bahador & Baserisalehi, 2011
Fagaceae	*Q. petraea iberica* (Steven ex M. Bieb.) Krassiln.	shoots and leaves	Tumen & Sekeroglu, 2018
Geraniaceae	*Geranium sanguineum* L.	shoots and leaves	Bigos & Sienkiewicz, 2012; Wafa & Ouarda, 2017
Ginkgoaceae	*Ginkgo biloba* L.	leaves	Xie & Johnson, 2003
Lamiaceae	*Callicarpa bodinieri* H. Lév.	leaves	Ma & Su, 2015
Lamiaceae	*Nepeta racemosa* Lam.	leaves	Saxena & Mathela, 1996; Mathela & Joshi, 2008
Lamiaceae	*Salvia officinalis* L.	leaves	Salević & Lagaron, 2019; Wali & Alam, 2019
Lamiaceae	*Vitex agnus-castus* L.	leaves	Habbab & Aboul-Enein, 2016
Lamiaceae	*V. negundo* L.	shoots and leaves	Prashith & Raghavendra, 2014; Sharma & Suri, 2016; Triveni & Gaddad, 2016
Magnoliaceae	*Liriodendron tulipifera* L.	leaves	Hufford & Robertson, 1975
Magnoliaceae	*Magnolia kobus* DC.	leaves	Hu & Ge, 2011
Moraceae	*Maclura pomifera* (Raf.) C. K. Schneid.	leaves	Allen, 1985; Dharmaratne & Nanayakkara, 2013
Ranunculaceae	*Clematis flammula* L.	leaves	Khan & Omoloso, 2001; Buzzini & Pieroni, 2003
Rosaceae	*Prunus dulcis* (Mill.) D. A. Webb	fruits and leaves	Thebo, 2014
Rosaceae	*P. laurocerasus* L.	leaves	Akpulat & Enginoğlu, 2019
Rutaceae	*Dictamnus alba* L.	leaves	Lei & Liao, 2007
Rutaceae	*Phellodendron amurense* Rupr.	shoots and leaves	Wang & Zhang, 2009; Han & Meng, 2015
Rutaceae	*Ptelea trifoliata* L.	bark	Steinberg & Setzer, 2017
Sapindaceae	*Koelreuteria paniculata* Laxm.	leaves	Mostafa & Ross, 2015
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	leaves	Albouchi & Hosni, 2013
Tamaricaceae	*Tamarix elongata* Ledeb.	leaves	Saïdana & Helal, 2008
Vitaceae	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	leaves	Park et al., 2008

As a positive control we used disks with 15 μg of azithromycin – broad-spectrum macrolide (Valle et al., 2015). Disck with 15.0 μg amphotericinin were also used as a second control against *Candida albicans*. Twenty four hours later the growth of the culture was measured using a zone scale for reading the sizes of growth inhibition zones of microorganisms (Antibiotic Zone Scale-C, model PW297, India) and software TpsDig2 (2016, F. James Rohlf). The data in the tables are presented as x ± SD (standart deviation).

Results

Growth of separate strains of microorganisms of Enterococcaceae, Enterobacteriaceae, Morganellaceae and Yersiniaceae families was arrested by ethanol extracts of the species of plants we studied (Table 3, 4). We observed inhibition of growth of *E. faecalis* by *Ginkgo biloba* (18.4 mm, hereinafter the average radius of growth inhibition zone is given in mm). Slightly lower than *Ginkgo biloba*, but still high antibacterial effects were exhibited by *Pteridium aquilinum* (14.5), *Polygonatum multiflorum* (12.4), *Clematis flammula* (10.6), *Magnolia kobus* (10.4), *Prunus laurocerasus* (10.2), *Vitex negundo* (10.2). Moderate inhibition of growth of the colonies of *E. faecalis* was seen under the influence of *Dictamnus albus* (9.8), *Koelreuteria paniculata* (8.4), *Chimonanthus praecox* (8.2), *Celastrus scandens* (6.7) and *Callicarpa bodinieri* (6.2). Bacteria of *E. faecalis* were resistant to the influence of alcohol extracts of the rest of the species of plants we studied.

Against *E. aerogenes* bacteria of Enterobacteriaceae, only one ethanol extract demonstrated competition to azithromycin (17.8) – *Genista tinctoria* (12.6). Moderate inhibition of growth of colonies of *E. aerogenes* was exerted by extracts from *Catalpa duclouxii* (5.7), *Liriodendron tulipifera* (4.3), *Pteridium aquilinum* (4.3), *Quercus castaneifolia* (3.8), *Aristolochia manshuriensis* (3.7), *Parthenocissus tricuspidata* (3.6), *Salvia officinalis* (3.5). At the same time, one should note the complete absence of the reaction of this strain (complete absence of arrest of growth of bacterial colonies) to ethyl extracts of such plants as *Vitex negundo*, *V. agnus-castus*, *Styphnolobium japonicum*, *Artemisia absinthium*, *Maclura pomifera*, *Koelreuteria paniculata*, *Phellodendron amurense*, *Prunus dulcis*, *Eucommia ulmoides*, *Wisteria sinensis*, *Laburnum anagyroides*, *Securigera varia*, *Celastrus scandens*, *Quercus petraea*, *Ptelea trifoliata*.

High susceptibility of *E. coli* was seen to 10 ethanol extracts: *Prunus laurocerasus* (12.7), *Polygonatum multiflorum* (11.8), *Koelreuteria paniculata* (11.5), *Wisteria sinensis* (10.9), *Quercus castaneifolia* (10.7), *Prunus dulcis* (10.5), *Styphnolobium japonicum* (10.5), *Vitex negundo* (10.3); moderate susceptibility – to eight species of plants: *Maclura pomifera* (9.8), *Celastrus scandens* (9.5), *Artemisia absinthium* (7.7), *Laburnum anagyroides* (7.4), *Quercus petraea iberica* (6.8), *Catalpa duclouxii* (6.7), *Colchicum autumnale* (6.5) and *Liriodendron tulipifera* (6.4). The poly-resistant strain of *E. coli* was insensitive to *Genista tinctoria*, *Eucommia ulmoides*, *Geranium sanguineum*, *Nepeta racemosa*, *Tamarix elongata* and *Ptelea trifoliata*. We also determined that azithromycin in the control was ineffective against *P. mirabilis*, whereas high antibacterial effects were exerted by some alcohol extracts of plants: *Parthenocissus tricuspidata* (13.6), *Celastrus scandens* (12.7), *Vitex negundo* (12.6), *Maclura pomifera* (12.4), *Magnolia kobus* (12.4), *V. agnus-castus* (11.2), *Catalpa duclouxii* (10.7), *Ailanthus altissima* (10.4) and *Quercus castaneifolia* (10.4).

Table 3

Antibacterial effect of ethanol extracts of plants on *Enterococcus faecalis*, *Enterobacter aerogenes*, *Escherichia coli* and *Proteus mirabilis* (x ± SD, n = 8)

Family	Species	*E. faecalis*		*E. aerogenes*		*E. coli*		*P. mirabilis*	
		test	control*	test	control*	test	control*	test	control*
Aristolochiaceae	*Aristolochia manshuriensis* Kom.	0 ± 0	25.7 ± 3.21	3.7 ± 0.33	17.3 ± 1.79	4.8 ± 0.34	15.4 ± 1.42	5.6 ± 0.44	0 ± 0
Asparagaceae	*Polygonatum multiflorum* (L.) All.	12.4 ± 1.34	26.7 ± 4.34	2.4 ± 0.12	19.9 ± 1.76	11.8 ± 1.42	17.9 ± 1.74	2.8 ± 0.22	0 ± 0
Asteraceae	*Artemisia absinthium* L.	2.2 ± 0.36	25.6 ± 3.12	0 ± 0	16.9 ± 1.88	7.7 ± 0.67	15.7 ± 1.59	2.3 ± 0.23	0 ± 0
Berberidaceae	*Berberis vulgaris* L.	0 ± 0	26.7 ± 3.21	1.6 ± 0.14	17.7 ± 1.66	1.7 ± 0.17	15.8 ± 1.61	8.8 ± 0.87	0 ± 0
Bignoniaceae	*Campsis radicans* (L.) Seem.	0 ± 0	26.5 ± 2.98	2.6 ± 0.39	18.6 ± 1.77	4.6 ± 0.44	13.8 ± 1.73	2.4 ± 0.26	0 ± 0
Bignoniaceae	*Catalpa duclouxii* Dode	2.1 ± 0.34	24.3 ± 2.98	5.7 ± 0.53	19.5 ± 1.88	6.7 ± 0.54	16.3 ± 1.61	10.7 ± 0.87	0 ± 0
Calycanthaceae	*Chimonanthus praecox* (L.) Link	8.2 ± 1.31	24.7 ± 3.38	2.7 ± 0.26	17.4 ± 1.78	3.7 ± 0.25	17.4 ± 1.52	2.2 ± 0.24	0 ± 0
Celastraceae	*Celastrus scandens* L.	6.7 ± 1.22	27.6 ± 2.43	0 ± 0	16.4 ± 1.96	9.5 ± 0.98	16.1 ± 2.58	12.7 ± 1.12	0 ± 0
Colchicaceae	*Colchicum autumnale* L.	0 ± 0	25.7 ± 2.78	3.2 ± 0.34	18.8 ± 1.63	6.5 ± 0.41	14.7 ± 1.59	2.7 ± 0.23	0 ± 0
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	14.5 ± 1.67	24.8 ± 2.67	4.3 ± 0.32	16.4 ± 1.87	2.7 ± 0.32	15.4 ± 1.48	0 ± 0	0 ± 0
Eucommiaceae	*Eucommia ulmoides* Oliv.	0 ± 0	23.7 ± 1.98	0 ± 0	18.8 ± 1.64	0 ± 0	13.7 ± 1.51	0 ± 0	0 ± 0
Fabaceae	*Genista tinctoria* L.	0 ± 0	24.6 ± 1.73	12.6 ± 1.24	17.8 ± 1.51	0 ± 0	17.2 ± 1.77	9.3 ± 0.76	0 ± 0
Fabaceae	*Laburnum anagyroides* Medik.	0 ± 0	27.5 ± 4.67	0 ± 0	18.2 ± 1.57	7.4 ± 0.56	13.4 ± 1.47	0 ± 0	0 ± 0
Fabaceae	*Securigera varia* (L.) Lassen	0 ± 0	26.3 ± 4.33	0 ± 0	18.8 ± 1.73	2.6 ± 0.21	15.9 ± 1.58	2.9 ± 0.31	0 ± 0
Fabaceae	*Styphnolobium japonicum* (L.) Schott	0 ± 0	24.6 ± 1.74	0 ± 0	18.6 ± 1.62	10.5 ± 1.45	15.9 ± 1.68	2.7 ± 0.14	0 ± 0
Fabaceae	*Wisteria sinensis* (Sims) Sweet	0 ± 0	25.8 ± 3.24	0 ± 0	17.7 ± 1.67	10.9 ± 1.45	15.4 ± 1.49	0 ± 0	0 ± 0
Fagaceae	*Quercus castaneifolia* C. A. Mey.	2.5 ± 0.45	24.8 ± 2.16	3.8 ± 0.45	17.5 ± 1.45	10.7 ± 1.32	14.3 ± 1.48	10.4 ± 0.84	0 ± 0
Fagaceae	*Quercus petraea iberica* (Steven ex M. Bieb.) Krassiln.	0 ± 0	26.5 ± 1.98	0 ± 0	18.5 ± 1.61	6.8 ± 0.45	14.6 ± 1.59	1.5 ± 0.13	0 ± 0
Geraniaceae	*Geranium sanguineum* L.	0 ± 0	24.2 ± 1.78	2.3 ± 0.34	16.7 ± 1.45	0 ± 0	14.7 ± 1.63	2.6 ± 0.17	0 ± 0
Ginkgoaceae	*Ginkgo biloba* L.	18.4 ± 1.98	24.8 ± 2.16	2.7 ± 0.15	16.3 ± 1.87	4.5 ± 0.32	15.3 ± 1.34	1.6 ± 0.17	0 ± 0
Lamiaceae	*Callicarpa bodinieri* H. Lév.	6.2 ± 0.76	25.7 ± 2.98	2.2 ± 0.14	15.5 ± 1.65	2.7 ± 0.33	15.5 ± 1.52	2.4 ± 0.15	0 ± 0
Lamiaceae	*Nepeta racemosa* Lam.	0 ± 0	25.8 ± 3.45	1.2 ± 0.11	16.5 ± 1.86	0 ± 0	15.5 ± 1.63	1.6 ± 0.36	0 ± 0
Lamiaceae	*Salvia officinalis* L.	0 ± 0	26.7 ± 3.98	3.5 ± 0.42	18.8 ± 1.77	5.4 ± 0.45	16.7 ± 1.64	3.8 ± 0.31	0 ± 0
Lamiaceae	*Vitex agnus-castus* L.	4.1 ± 0.47	25.4 ± 2.68	0 ± 0	19.3 ± 1.31	2.8 ± 0.17	15.4 ± 1.44	11.2 ± 0.94	0 ± 0
Lamiaceae	*Vitex negundo* L.	10.2 ± 0.94	25.2 ± 2.16	0 ± 0	17.8 ± 1.65	10.3 ± 1.24	15.4 ± 1.64	12.6 ± 0.89	0 ± 0
Magnoliaceae	*Liriodendron tulipifera* L.	0 ± 0	24.7 ± 2.70	4.3 ± 0.47	16.7 ± 1.86	6.4 ± 0.62	15.5 ± 1.58	6.5 ± 0.75	0 ± 0
Magnoliaceae	*Magnolia kobus* DC.	10.4 ± 1.67	25.3 ± 1.89	1.2 ± 0.14	16.5 ± 1.93	3.5 ± 0.23	14.2 ± 1.59	12.4 ± 1.32	0 ± 0
Moraceae	*Maclura pomifera* (Raf.) C. K. Schneid.	0 ± 0	24.7 ± 3.26	0 ± 0	18.7 ± 1.76	9.8 ± 0.65	16.3 ± 1.52	12.4 ± 1.21	0 ± 0
Ranunculaceae	*Clematis flammula* L.	10.6 ± 1.44	24.6 ± 2.87	1.3 ± 0.13	15.4 ± 1.72	2.7 ± 0.32	17.8 ± 1.72	9.3 ± 0.94	0 ± 0
Rosaceae	*Prunus dulcis* (Mill.) D. A. Webb	0 ± 0	26.1 ± 3.54	0 ± 0	16.6 ± 1.76	10.5 ± 1.23	16.3 ± 1.61	1.2 ± 0.11	0 ± 0
Rosaceae	*Prunus laurocerasus* L.	10.2 ± 1.23	23.8 ± 1.97	2.4 ± 0.32	18.1 ± 1.89	12.7 ± 1.45	16.4 ± 1.62	1.3 ± 0.18	0 ± 0
Rutaceae	*Dictamnus alba* L.	9.8 ± 1.24	25.8 ± 2.79	2.8 ± 0.23	17.8 ± 1.89	5.8 ± 0.43	15.3 ± 1.41	6.4 ± 0.34	0 ± 0
Rutaceae	*Phellodendron amurense* Rupr.	4.3 ± 0.56	23.8 ± 2.86	0 ± 0	16.6 ± 1.78	2.3 ± 0.23	17.6 ± 1.56	3.3 ± 0.32	0 ± 0
Rutaceae	*Ptelea trifoliata* L.	4.3 ± 0.89	27.7 ± 4.24	0 ± 0	18.2 ± 1.57	0 ± 0	17.6 ± 1.49	0 ± 0	0 ± 0
Sapindaceae	*Koelreuteria paniculata* Laxm.	8.4 ± 1.21	26.7 ± 4.12	0 ± 0	17.8 ± 1.15	11.5 ± 1.45	13.9 ± 1.74	8.9 ± 0.84	0 ± 0
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	2.2 ± 0.56	24.7 ± 2.87	1.3 ± 0.16	16.7 ± 1.69	3.4 ± 0.32	15.8 ± 1.54	10.4 ± 0.92	0 ± 0
Tamaricaceae	*Tamarix elongata* Ledeb.	2.1 ± 0.35	26.4 ± 3.31	1.6 ± 0.16	15.9 ± 1.69	0 ± 0	15.4 ± 1.52	7.7 ± 0.56	0 ± 0
Vitaceae	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	0 ± 0	24.9 ± 2.98	3.6 ± 0.17	17.8 ± 1.88	4.7 ± 0.32	16.4 ± 1.52	13.6 ± 1.45	0 ± 0

Note: * – disks with 15.0 μg of azithromycin were used for all bacteria as positive control.

Table 4
Antibacterial effect of ethanol extracts of plants on *Serratia marcescens*, *Yersinia enterocolitica*, *Klebsiella pneumoniae* and *Salmonella typhimurium* (x ± SD, n = 8)

Family	Species	*S. marcescens*		*Y. enterocolitica*		*K. pneumoniae*		*S. typhimurium*	
		test	control*	test	control*	test	control*	test	control*
Aristolochiaceae	*Aristolochia manshuriensis* Kom.	0 ± 0	0 ± 0	0 ± 0	14.4 ± 1.42	0 ± 0	0 ± 0	2.6 ± 0.32	19.7 ± 1.45
Asparagaceae	*Polygonatum multiflorum* (L.) All.	7.8 ± 0.77	0 ± 0	11.4 ± 1.21	14.9 ± 1.44	0 ± 0	0 ± 0	4.4 ± 0.87	21.7 ± 1.67
Asteraceae	*Artemisia absinthium* L.	2.8 ± 0.21	0 ± 0	0 ± 0	14.7 ± 1.69	4.1 ± 0.32	0 ± 0	4.3 ± 0.44	22.6 ± 1.75
Berberidaceae	*Berberis vulgaris* L.	12.6 ± 1.34	0 ± 0	0 ± 0	14.8 ± 1.51	9.3 ± 0.89	0 ± 0	10.6 ± 1.21	21.7 ± 1.54
Bignoniaceae	*Campsis radicans* (L.) Seem.	0 ± 0	0 ± 0	2.7 ± 0.21	15.8 ± 1.73	1.6 ± 0.16	0 ± 0	12.6 ± 1.12	21.5 ± 2.31
Bignoniaceae	*Catalpa duclouxii* Dode	2.4 ± 0.21	0 ± 0	0 ± 0	13.3 ± 1.81	10.7 ± 0.89	0 ± 0	0 ± 0	22.3 ± 2.19
Calycanthaceae	*Chimonanthus praecox* (L.) Link	8.2 ± 0.67	0 ± 0	2.9 ± 0.32	13.4 ± 1.62	4.3 ± 0.32	0 ± 0	0 ± 0	22.7 ± 2.64
Celastraceae	*Celastrus scandens* L.	3.7 ± 0.24	0 ± 0	0 ± 0	13.1 ± 1.48	0 ± 0	0 ± 0	4.4 ± 0.21	19.6 ± 2.11
Colchicaceae	*Colchicum autumnale* L.	10.8 ± 1.43	0 ± 0	6.6 ± 0.54	14.7 ± 1.39	12.8 ± 1.45	0 ± 0	2.4 ± 0.22	22.7 ± 2.57
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	1.8 ± 0.21	0 ± 0	8.2 ± 0.78	15.4 ± 1.38	2.3 ± 0.32	0 ± 0	2.4 ± 0.32	19.8 ± 1.45
Eucommiaceae	*Eucommia ulmoides* Oliv.	0 ± 0	0 ± 0	0 ± 0	14.7 ± 1.71	0 ± 0	0 ± 0	0 ± 0	19.7 ± 2.19
Fabaceae	*Genista tinctoria* L.	7.6 ± 0.76	0 ± 0	0 ± 0	15.2 ± 1.67	9.3 ± 0.87	0 ± 0	9.4 ± 1.12	23.6 ± 2.44
Fabaceae	*Laburnum anagyroides* Medik.	1.6 ± 0.13	0 ± 0	0 ± 0	12.4 ± 1.77	3.2 ± 0.34	0 ± 0	1.9 ± 0.33	20.5 ± 1.87
Fabaceae	*Securigera varia* (L.) Lassen	0 ± 0	0 ± 0	0 ± 0	14.9 ± 1.48	1.5 ± 0.21	0 ± 0	0 ± 0	21.3 ± 1.76
Fabaceae	*Styphnolobium japonicum* (L.) Schott	2.3 ± 0.19	0 ± 0	0 ± 0	15.9 ± 0.98	0 ± 0	0 ± 0	0 ± 0	19.6 ± 1.65
Fabaceae	*Wisteria sinensis* (Sims) Sweet	3.4 ± 0.23	0 ± 0	0 ± 0	13.4 ± 1.39	0 ± 0	0 ± 0	8.7 ± 0.98	21.8 ± 1.98
Fagaceae	*Quercus castaneifolia* C. A. Mey.	0 ± 0	0 ± 0	11.8 ± 1.35	15.3 ± 1.48	10.5 ± 1.23	0 ± 0	0 ± 0	21.8 ± 1.98
Fagaceae	*Q. petraea iberica* (Steven ex M. Bieb.) Krassiln.	0 ± 0	0 ± 0	0 ± 0	14.6 ± 1.49	10.4 ± 1.21	0 ± 0	0 ± 0	22.5 ± 2.31
Geraniaceae	*Geranium sanguineum* L.	2.3 ± 0.42	0 ± 0	2.7 ± 0.19	12.7 ± 1.83	0 ± 0	0 ± 0	1.7 ± 0.34	19.2 ± 1.87
Ginkgoaceae	*Ginkgo biloba* L.	11.6 ± 1.34	0 ± 0	9.2 ± 0.76	12.3 ± 1.74	25.5 ± 2.78	0 ± 0	2.2 ± 0.17	23.8 ± 2.45
Lamiaceae	*Callicarpa bodinieri* H. Lév.	2.8 ± 0.18	0 ± 0	0 ± 0	13.5 ± 1.22	0 ± 0	0 ± 0	1.5 ± 0.23	20.7 ± 2.12
Lamiaceae	*Nepeta racemosa* Lam.	1.7 ± 0.12	0 ± 0	0 ± 0	14.5 ± 1.73	1.8 ± 0.17	0 ± 0	2.4 ± 0.31	23.8 ± 2.76
Lamiaceae	*Salvia officinalis* L.	2.4 ± 0.26	0 ± 0	0 ± 0	12.7 ± 1.64	10.7 ± 0.78	0 ± 0	0 ± 0	21.7 ± 2.34
Lamiaceae	*Vitex agnus-castus* L.	10.8 ± 0.89	0 ± 0	1.2 ± 0.12	12.4 ± 1.64	1.6 ± 0.11	0 ± 0	9.7 ± 0.89	23.4 ± 2.45
Lamiaceae	*Vitex negundo* L.	3.2 ± 0.36	0 ± 0	2.2 ± 0.16	13.7 ± 1.37	16.7 ± 1.21	0 ± 0	10.7 ± 0.96	21.6 ± 1.89
Magnoliaceae	*Liriodendron tulipifera* L.	2.4 ± 0.19	0 ± 0	1.2 ± 0.14	15.5 ± 1.78	25.4 ± 2.77	0 ± 0	2.1 ± 0.21	20.7 ± 1.99
Magnoliaceae	*Magnolia kobus* DC.	9.8 ± 0.93	0 ± 0	0 ± 0	15.2 ± 1.39	0 ± 0	0 ± 0	8.7 ± 1.67	22.3 ± 2.19
Moraceae	*Maclura pomifera* (Raf.) C. K. Schneid.	19.4 ± 1.78	0 ± 0	10.7 ± 0.87	13.3 ± 1.72	3.2 ± 0.41	0 ± 0	10.5 ± 1.21	18.7 ± 2.14
Ranunculaceae	*Clematis flammula* L.	5.4 ± 0.34	0 ± 0	0 ± 0	14.8 ± 1.72	0 ± 0	0 ± 0	1.2 ± 0.43	20.6 ± 1.89
Rosaceae	*Prunus dulcis* (Mill.) D. A.Webb	3.4 ± 0.45	0 ± 0	7.2 ± 0.78	15.3 ± 1.81	0 ± 0	0 ± 0	5.2 ± 0.87	19.1 ± 1.98
Rosaceae	*Prunus laurocerasus* L.	0 ± 0	0 ± 0	1.1 ± 0.11	14.4 ± 1.52	0 ± 0	0 ± 0	2.6 ± 0.21	21.8 ± 2.31
Rutaceae	*Dictamnus alba* L.	0 ± 0	0 ± 0	7.8 ± 0.88	14.3 ± 1.71	0 ± 0	0 ± 0	0 ± 0	18.8 ± 1.85
Rutaceae	*Phellodendron amurense* Rupr.	14.2 ± 1.18	0 ± 0	2.2 ± 0.23	13.6 ± 1.96	6.3 ± 0.56	0 ± 0	10.8 ± 1.18	19.6 ± 2.17
Rutaceae	*Ptelea trifoliata* L.	0 ± 0	0 ± 0	2.7 ± 0.28	15.6 ± 1.79	0 ± 0	0 ± 0	2.2 ± 0.14	22.7 ± 2.54
Sapindaceae	*Koelreuteria paniculata* Laxm.	16.7 ± 1.22	0 ± 0	4.5 ± 0.31	12.9 ± 1.34	0 ± 0	0 ± 0	10.7 ± 0.97	18.7 ± 1.86
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	2.1 ± 0.18	0 ± 0	0 ± 0	14.8 ± 1.64	0 ± 0	0 ± 0	1.4 ± 0.43	19.7 ± 1.87
Tamaricaceae	*Tamarix elongata* Ledeb.	3.5 ± 0.34	0 ± 0	3.3 ± 0.41	15.4 ± 1.52	0 ± 0	0 ± 0	0 ± 0	22.4 ± 2.11
Vitaceae	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	13.8 ± 1.31	0 ± 0	4.6 ± 0.24	15.4 ± 1.52	0 ± 0	0 ± 0	3.4 ± 0.19	22.9 ± 2.31

Note: see Table 3.

Two poly-resistant strains of microorganisms of Yersiniaceae and Enterobacteriaceae families – *Serratia marcescens* and *Klebsiella pneumoniae* – were determined to have completely no sensitivity to azithromycin. At the same time, we determined ethanol extracts of *Maclura pomifera* (19.4), *Koelreuteria paniculata* (16.7), *Phellodendron amurense* (14.2), *Parthenocissus tricuspidata* (13.8), *Berberis vulgaris* (12.6), *Ginkgo biloba* (11.6), *Vitex agnus-castus* (10.8) and *Colchicum autumnale* (10.8) to be highly effective in arresting the growth of *S. marcescens* bacteria. Three extracts – *Quercus castaneifolia*, *Polygonatum multiflorum* and *Maclura pomifera* – had high inhibiting effect on *Y. enterocolitica* (11.8, 11.4, 10.7), whereas *Ginkgo biloba* (25.5), *Liriodendron tulipifera* (25.4), *Vitex negundo* (16.7), *Colchicum autumnale* (12.8), *Salvia officinalis* (10.7), *Catalpa duclouxii* (10.7), *Quercus castaneifolia* (10.5) and *Quercus petraea* (10.4) were effective against *K. pneumoniae*. Extracts from *Ginkgo biloba* and *Liriodendron tulipifera* produced 1.5–2.4-fold greater growth inhibition zones of colonies of *K. pneumoniae* than other species of plants.

We also saw high inhibiting impact on the colonies of *S. typhimurium* bacteria exerted by alcohol extracts of *Campsis radicans* (12.6), *Phellodendron amurense* (10.8), *Vitex negundo* (10.7), *Koelreuteria paniculata* (10.7), *Berberis vulgaris* (10.6) and *Maclura pomifera* (10.5) at moderate zones of growth inhibition produced by *Vitex agnus-castus* (9.7), *Genista tinctoria* (9.4), *Wisteria sinensis* (8.7) and *Magnolia kobus* (8.7).

Interesting results were obtained for use of ethanol extracts against microorganisms of the Listeriaceae family (Table 5). While *L. monocytogenes* was highly susceptible to 8 plants (*Ptelea trifoliata* (15.8), *Clematis flammula* (13.5), *Aristolochia manshuriensis* (10.8), *Tamarix elongata* (10.8), *Colchicum autumnale* (10.7), *Wisteria sinensis* (10.4), *Ginkgo biloba* (10.4), *Chimonanthus praecox* (10.1)), *L. innocua* – to 5 (*Ginkgo biloba* (19.7), *Liriodendron tulipifera* (12.3), *Geranium sanguineum* (11.2), *Securigera varia* (10.7), *Prunus laurocerasus* (10.4)), and *L. ivanovi* was susceptible only to ethanol extract of *Colchicum autumnale* (10.8).

During our research we determined that some plants arrest the growth of colonies of *P. aeruginosa*: *Ginkgo biloba* (21.3), *Berberis vulgaris* (16.8), *Liriodendron tulipifera* (14.3), *Geranium sanguineum* (10.8), *Genista tinctoria* (10.7), *Clematis flammula* (10.4), *Colchicum autumnale* (10.4) and *Tamarix elongata* (10.3). Ethanol extract of *Ginkgo biloba* exceeded the other tested plants regarding the width of growth inhibition zone of *P. aeruginosa* by 1.3–2.1 times. We determined tolerance of the tested strains of *L. monocytogenes* and *P. aeruginosa* strains to the action of azithromycin.

High antibacterial activities (Table 6) against *C. jejuni* was confirmed for ten ethanol extracts (*Ptelea trifoliata* (17.5), *Quercus petraea iberica* (16.2), *Koelreuteria paniculata* (13.3), *Tamarix elongata* (11.4), *Geranium sanguineum* (11.3), *Magnolia kobus* (10.8), *Callicarpa bodinieri* (10.7), *Maclura pomifera* (10.5), *Clematis flammula* (10.3) and *Liriodendron tulipifera* (10.3)), and moderate activity for five plants (*Phellodendron amurense* (9.7), *Berberis vulgaris* (9.4), *Chimonanthus praecox* (8.7), *Ginkgo biloba* (8.4) and *Salvia officinalis* (8.2)). We observed the strain of *C. jejuni* to be resistant to azithromycin. Also, high

inhibiting power against *Rh. equi* was displayed by fifteen tested alcohol extracts: *Campsis radicans* (18.6), *Prunus laurocerasus* (16.5), *Vitex negundo* (13.4), *Phellodendron amurense* (12.9), *Genista tinctoria* (12.8), *Liriodendron tulipifera* (11.8), *Tamarix elongata* (11.4), *Pteridium aquilinum* (11.4), *Salvia officinalis* (11.2), *Maclura pomifera* (10.8), *Callicarpa bodinieri* (10.8), *Prunus dulcis* (10.6), *Geranium sanguineum* (10.4), *Ptelea trifoliata* (10.3) and *Catalpa duclouxii* (10.2). We found five alcohol extracts with maximum antibacterial impacts on *C. xerosis*: *Maclura pomifera* (10.9), *Vitex agnus-castus* (10.6), *Clematis flammula* (10.5), *Artemisia absinthium* (10.2) and *Phellodendron amurense* (10.2).

Table 5

Antibacterial effect of ethanol extracts of plants on bacteria of families Listeriaceae (*Listeria ivanovii*, *L. innocua*, *L. monocytogenes*) and Pseudomonadaceae (*Pseudomonas aeruginosa*) (x ± SD, n = 8)

Family	Species	*L. ivanovi*		*L. innocua*		*L. monocytogenes*		*P. aeruginosa*	
		test	control*	test	control*	test	control*	test	control*
Aristolochiaceae	*Aristolochia manshuriensis* Kom.	0 ± 0	14.3 ± 1.54	0 ± 0	28.7 ± 3.44	10.8 ± 1.33	0 ± 0	8.7 ± 0.98	0 ± 0
Asparagaceae	*Polygonatum multiflorum* (L.) All.	0 ± 0	15.9 ± 1.67	0 ± 0	25.7 ± 2.31	0 ± 0	0 ± 0	5.4 ± 0.76	0 ± 0
Asteraceae	*Artemisia absinthium* L.	0 ± 0	15.9 ± 1.61	0 ± 0	26.6 ± 2.31	0 ± 0	0 ± 0	1.7 ± 0.21	0 ± 0
Berberidaceae	*Berberis vulgaris* L.	0 ± 0	17.7 ± 1.65	4.3 ± 0.45	26.7 ± 1.87	0 ± 0	0 ± 0	16.8 ± 1.31	0 ± 0
Bignoniaceae	*Campsis radicans* (L.) Seem.	0 ± 0	16.6 ± 1.85	0 ± 0	27.5 ± 3.22	0 ± 0	0 ± 0	2.1 ± 0.32	0 ± 0
Bignoniaceae	*Catalpa duclouxii* Dode	0 ± 0	17.5 ± 1.87	0 ± 0	26.3 ± 1.87	8.2 ± 0.88	0 ± 0	0 ± 0	0 ± 0
Calycanthaceae	*Chimonanthus praecox* (L.) Link	0 ± 0	17.4 ± 1.66	0 ± 0	27.7 ± 3.11	10.1 ± 0.88	0 ± 0	0 ± 0	0 ± 0
Celastraceae	*Celastrus scandens* L.	0 ± 0	15.4 ± 0.79	0 ± 0	26.6 ± 2.78	0 ± 0	0 ± 0	6.3 ± 0.66	0 ± 0
Colchicaceae	*Colchicum autumnale* L.	10.8 ± 0.86	16.8 ± 1.28	0 ± 0	27.7 ± 2.68	10.7 ± 0.99	0 ± 0	10.4 ± 1.14	0 ± 0
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	2.7 ± 0.19	17.4 ± 1.31	0 ± 0	26.8 ± 2.78	0 ± 0	0 ± 0	6.8 ± 0.77	0 ± 0
Eucommiaceae	*Eucommia ulmoides* Oliv.	0 ± 0	15.8 ± 1.11	0 ± 0	29.7 ± 3.21	0 ± 0	0 ± 0	1.5 ± 0.16	0 ± 0
Fabaceae	*Genista tinctoria* L.	0 ± 0	18.8 ± 1.31	0 ± 0	28.6 ± 3.12	0 ± 0	0 ± 0	10.7 ± 1.21	0 ± 0
Fabaceae	*Laburnum anagyroides* Medik.	0 ± 0	14.2 ± 1.62	0 ± 0	28.5 ± 2.88	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Fabaceae	*Securigera varia* (L.) Lassen	0 ± 0	17.8 ± 1.19	10.7 ± 1.08	27.3 ± 1.89	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Fabaceae	*Styphnolobium japonicum* (L.) Schott	0 ± 0	16.6 ± 0.87	0 ± 0	27.6 ± 2.78	0 ± 0	0 ± 0	2.3 ± 0.32	0 ± 0
Fabaceae	*Wisteria sinensis* (Sims) Sweet	0 ± 0	16.7 ± 1.74	0 ± 0	27.8 ± 2.76	10.4 ± 1.33	0 ± 0	4.2 ± 0.31	0 ± 0
Fagaceae	*Quercus castaneifolia* C. A. Mey.	0 ± 0	15.5 ± 1.89	0 ± 0	29.8 ± 4.01	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Fagaceae	*Q. petraea iberica* (Steven ex M. Bieb.) Krassiln.	0 ± 0	17.5 ± 1.32	0 ± 0	26.5 ± 2.78	4.2 ± 0.67	0 ± 0	0 ± 0	0 ± 0
Geraniaceae	*Geranium sanguineum* L.	0 ± 0	17.7 ± 1.56	11.2 ± 0.78	28.2 ± 2.89	5.3 ± 0.44	0 ± 0	10.8 ± 1.21	0 ± 0
Ginkgoaceae	*Ginkgo biloba* L.	0 ± 0	16.3 ± 1.44	19.7 ± 1.31	27.8 ± 3.21	10.4 ± 1.26	0 ± 0	21.3 ± 2.13	0 ± 0
Lamiaceae	*Callicarpa bodinieri* H. Lév.	0 ± 0	15.5 ± 1.21	0 ± 0	27.7 ± 2.56	0 ± 0	0 ± 0	8.5 ± 0.87	0 ± 0
Lamiaceae	*Nepeta racemosa* Lam.	0 ± 0	16.5 ± 1.32	0 ± 0	26.8 ± 2.77	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Lamiaceae	*Salvia officinalis* L.	0 ± 0	16.8 ± 1.11	0 ± 0	26.7 ± 2.18	0 ± 0	0 ± 0	8.4 ± 0.78	0 ± 0
Lamiaceae	*Vitex agnus-castus* L.	0 ± 0	16.3 ± 0.96	0 ± 0	26.4 ± 2.56	0 ± 0	0 ± 0	4.2 ± 0.65	0 ± 0
Lamiaceae	*Vitex negundo* L.	0 ± 0	18.9 ± 1.75	0 ± 0	27.3 ± 2.51	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Magnoliaceae	*Liriodendron tulipifera* L.	0 ± 0	17.7 ± 1.34	12.3 ± 2.11	29.7 ± 4.02	0 ± 0	0 ± 0	14.3 ± 0.88	0 ± 0
Magnoliaceae	*Magnolia kobus* DC.	0 ± 0	16.5 ± 1.33	0 ± 0	25.3 ± 2.20	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Moraceae	*Maclura pomifera* (Raf.) C. K. Schneid.	0 ± 0	14.7 ± 1.32	0 ± 0	27.7 ± 3.29	0 ± 0	0 ± 0	2.2 ± 0.43	0 ± 0
Ranunculaceae	*Clematis flammula* L.	0 ± 0	14.4 ± 1.77	0 ± 0	27.6 ± 2.31	13.5 ± 1.77	0 ± 0	10.4 ± 1.33	0 ± 0
Rosaceae	*Prunus dulcis* (Mill.) D. A. Webb	0 ± 0	17.6 ± 1.43	0 ± 0	27.1 ± 2.78	0 ± 0	0 ± 0	2.5 ± 0.21	0 ± 0
Rosaceae	*Prunus laurocerasus* L.	0 ± 0	17.1 ± 1.42	10.4 ± 1.67	27.8 ± 2.33	0 ± 0	0 ± 0	2.8 ± 0.33	0 ± 0
Rutaceae	*Dictamnus alba* L.	0 ± 0	17.8 ± 1.22	0 ± 0	26.8 ± 2.44	0 ± 0	0 ± 0	1.1 ± 0.18	0 ± 0
Rutaceae	*Phellodendron amurense* Rupr.	0 ± 0	15.6 ± 1.31	0 ± 0	29.6 ± 3.65	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Rutaceae	*Ptelea trifoliata* L.	0 ± 0	16.2 ± 1.33	0 ± 0	28.7 ± 3.42	15.4 ± 1.37	0 ± 0	2.4 ± 0.21	0 ± 0
Sapindaceae	*Koelreuteria paniculata* Laxm.	0 ± 0	17.8 ± 0.97	0 ± 0	28.7 ± 3.27	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	0 ± 0	15.7 ± 1.87	0 ± 0	25.7 ± 1.97	9.1 ± 1.27	0 ± 0	0 ± 0	0 ± 0
Tamaricaceae	*Tamarix elongata* Ledeb.	0 ± 0	17.9 ± 1.65	0 ± 0	27.4 ± 2.34	10.8 ± 1.23	0 ± 0	10.3 ± 0.98	0 ± 0
Vitaceae	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	4.3 ± 0.19	15.8 ± 1.76	0 ± 0	26.9 ± 2.13	0 ± 0	0 ± 0	0 ± 0	0 ± 0

Note: see Table 3.

Antifungal impact (Table 6) on *C. albicans* with inhibition zone of over 8 mm was exerted by five extracts: *Artemisia absinthium* (11.7), *Parthenocissus tricuspidata* (10.7), *Liriodendron tulipifera* (9.4), *Phellodendron amurense* (8.7) and *Celastrus scandens* (8.4), which was several-fold higher than the control (amphotericin), for which the growth inhibition zone of *C. albicans* ranged 2.1–2.4 mm.

Discussion

Substances produced by Embryophyta as secondary metabolites were found to be biologically quite active compounds against microorganisms pathogenic for humans and agricultural animals. Some of the plants we studied may become the basis for the development of new pharmaceutical preparations (Zazharskyi et al., 2019c).

Kavitha & Nelson (2016) consider that chloroform extract of leaves of *Aristolochia manshuriensis* will become the alternative for the treatment of threat of pathogenic organisms. The authors found twenty bioactive constituents and functional groups associated with ethanol, carbonic acid, alkanes, aldehides, aroma acids present in chloroform extract of leaves of *A. manshuriensis*. The studied extract inhibited *Vibrio harveyi*, *V. vulnificus* and *Serratia marcescens*. Hydroethanol extract from *Celastrus scandens* L., against the background of high antioxidant activity (2,2-diphenyl-1-picrylhydrazyl, chelation of metals, capabilities to restore three-valent iron in plasm, superoxide radical and nitrogen oxide), good anti-inflammatory activity, displayed low antibacterial and antifungal properties (Kumar & Sharma, 2018).

Artemisia absinthium L. are perennial plants with ubiquitous distribution in deserts and dry places of Eurasia, usually growing on slopes of hills, sides of the roads and fields. It is native to Europe, North Asia and North Africa. The plant can contain toxic substances (thujon for example) responsible for side effects. Absinthe is used in phytotherapy due to its tonic, spasmolytic, antipyretic and anthelmintic properties. Obistioiu & Chiurciu (2014) and Al-Ghamdi (2020) report fungicidal effect of *A. absinthium*.

The structure of *Berberis vulgaris* L. contains some polyphenolic, alkaloid compounds which hinder the activity of bacteria (Özgen & Geçer, 2012). Nanocrystals of zinc oxide prepared using *B. vulgaris* exhibited significant antibacterial activity against *S. aureus* (Anzabi, 2018).

Table 6
Antibacterial effect of extracts of plants on bacteria *Campylobacter jejuni*, *Rhodococcus equi*, *Corynebacterium xerosis* and fungus *Candida albicans* (x ± SD, n = 8)

Family	Species	*C. jejuni*		*Rh. equi*		*C. xerosis*		*C. albicans*	
		test	control*	test	control*	test	control*	test	control**
Aristolochiaceae	*Aristolochia manshuriensis* Kom.	2.5 ± 0.21	0 ± 0	3.1 ± 0.31	20.7 ± 3.44	9.3 ± 0.96	10.7 ± 2.67	3.7 ± 0.33	0 ± 0; 2.4 ± 0.20
Asparagaceae	*Polygonatum multiflorum* (L.) All.	0 ± 0	0 ± 0	0 ± 0	23.7 ± 2.31	2.2 ± 0.12	12.7 ± 1.56	2.4 ± 0.22	0 ± 0; 2.2 ± 0.15
Asteraceae	*Artemisia absinthium* L.	0 ± 0	0 ± 0	9.3 ± 0.91	23.6 ± 2.31	10.2 ± 0.89	11.6 ± 1.98	11.7 ± 1.23	0 ± 0; 2.1 ± 0.15
Berberidaceae	*Berberis vulgaris* L.	9.4 ± 0.78	0 ± 0	0 ± 0	21.7 ± 1.87	9.2 ± 0.76	12.7 ± 1.78	3.7 ± 0.51	0 ± 0; 2.3 ± 0.16
Bignoniaceae	*Campsis radicans* (L.) Seem.	0 ± 0	0 ± 0	18.6 ± 0.94	20.5 ± 2.22	3.3 ± 0.19	13.5 ± 1.11	3.7 ± 0.35	0 ± 0; 2.3 ± 0.20
Bignoniaceae	*Catalpa duclouxii* Dode	4.4 ± 0.44	0 ± 0	10.2 ± 0.78	22.3 ± 1.87	0 ± 0	12.3 ± 1.88	0 ± 0	0 ± 0; 2.2 ± 0.19
Calycanthaceae	*Chimonanthus praecox* (L.) Link	8.7 ± 0.76	0 ± 0	8.5 ± 0.76	23.7 ± 3.11	0 ± 0	10.7 ± 1.49	4.7 ± 0.45	0 ± 0; 2.2 ± 0.16
Celastraceae	*Celastrus scandens* L.	0 ± 0	0 ± 0	4.6 ± 0.44	22.6 ± 2.78	7.2 ± 0.75	12.6 ± 1.67	8.4 ± 0.78	0 ± 0; 2.2 ± 0.18
Colchicaceae	*Colchicum autumnale* L.	0 ± 0	0 ± 0	0 ± 0	22.7 ± 2.68	2.8 ± 0.15	12.7 ± 1.19	1.6 ± 0.18	0 ± 0; 2.4 ± 0.20
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	4.2 ± 0.33	0 ± 0	11.4 ± 1.21	21.8 ± 2.78	3.8 ± 0.23	12.8 ± 1.76	3.2 ± 0.35	0 ± 0; 2.4 ± 0.21
Eucommiaceae	*Eucommia ulmoides* Oliv.	0 ± 0	0 ± 0	0 ± 0	22.7 ± 3.21	6.7 ± 0.24	13.7 ± 0.87	0 ± 0	0 ± 0; 2.2 ± 0.17
Fabaceae	*Genista tinctoria* L.	0 ± 0	0 ± 0	12.8 ± 1.23	23.6 ± 2.12	3.1 ± 0.23	13.6 ± 1.67	1.8 ± 0.32	0 ± 0; 2.2 ± 0.16
Fabaceae	*Laburnum anagyroides* Medik.	0 ± 0	0 ± 0	3.8 ± 0.42	21.5 ± 2.88	0 ± 0	10.5 ± 1.78	3.1 ± 0.32	0 ± 0; 2.4 ± 0.18
Fabaceae	*Securigera varia* (L.) Lassen	2.1 ± 0.11	0 ± 0	3.4 ± 0.33	20.3 ± 1.89	0 ± 0	12.3 ± 1.!8	0 ± 0	0 ± 0; 2.2 ± 0.19
Fabaceae	*Styphnolobium japonicum* (L.) Schott	0 ± 0	0 ± 0	0 ± 0	22.6 ± 2.78	0 ± 0	12.6 ± 1.78	0 ± 0	0 ± 0; 2.3 ± 0.16
Fabaceae	*Wisteria sinensis* (Sims) Sweet	0 ± 0	0 ± 0	9.8 ± 0.31	21.8 ± 2.76	0 ± 0	12.8 ± 1.15	0 ± 0	0 ± 0; 2.4 ± 0.21
Fagaceae	*Quercus castaneifolia* C. A. Mey.	0 ± 0	0 ± 0	2.9 ± 0.21	23.8 ± 4.01	0 ± 0	10.8 ± 1.89	3.2 ± 0.35	0 ± 0; 2.3 ± 0.19
Fagaceae	*Q. petraea iberica* (Steven ex M.Bieb.) Krassiln.	16.2 ± 1.23	0 ± 0	1.7 ± 0.13	20.5 ± 2.78	2.5 ± 0.14	12.5 ± 1.87	0 ± 0	0 ± 0; 2.4 ± 0.21
Geraniaceae	*Geranium sanguineum* L.	11.3 ± 0.97	0 ± 0	10.4 ± 1.02	21.2 ± 2.89	5.4 ± 0.44	9.2 ± 1.38	0 ± 0	0 ± 0; 2.4 ± 0.19
Ginkgoaceae	*Ginkgo biloba* L.	8.4 ± 0.87	0 ± 0	1.9 ± 0.15	22.8 ± 2.21	2.3 ± 0.18	11.8 ± 1.13	1.2 ± 0.15	0 ± 0; 2.2 ± 0.16
Lamiaceae	*Callicarpa bodinieri* H. Lév.	10.7 ± 1.21	0 ± 0	10.8 ± 0.99	23.7 ± 2.56	5.8 ± 0.31	1.7 ± 1.31	1.6 ± 0.16	0 ± 0; 2.3 ± 0.18
Lamiaceae	*Nepeta racemosa* Lam.	0 ± 0	0 ± 0	8.8 ± 0.91	22.8 ± 2.77	0 ± 0	11.8 ± 0.98	0 ± 0	0 ± 0; 2.3 ± 0.20
Lamiaceae	*Salvia officinalis* L.	8.2 ± 0.87	0 ± 0	11.2 ± 1.21	19.7 ± 2.18	4.4 ± 0.34	10.7 ± 1.66	3.4 ± 0.33	0 ± 0; 2.4 ± 0.21
Lamiaceae	*Vitex agnus-castus* L.	0 ± 0	0 ± 0	3.4 ± 0.31	23.4 ± 2.56	10.6 ± 0.78	11.4 ± 0.87	0 ± 0	0 ± 0; 2.4 ± 0.22
Lamiaceae	*Vitex negundo* L.	0 ± 0	0 ± 0	13.4 ± 1.44	21.5 ± 1.67	4.2 ± 0.31	10.1 ± 0.87	1.3 ± 0.13	0 ± 0; 2.4 ± 0.21
Magnoliaceae	*Liriodendron tulipifera* L.	10.3 ± 1.13	0 ± 0	11.8 ± 1.13	21.7 ± 4.02	3.6 ± 0.24	10.7 ± 0.87	9.4 ± 1.23	0 ± 0; 2.2 ± 0.16
Magnoliaceae	*Magnolia kobus* DC.	10.8 ± 1.21	0 ± 0	1.2 ± 0.19	20.3 ± 2.21	8.6 ± 0.56	12.3 ± 1.89	4.4 ± 0.46	0 ± 0; 2.4 ± 0.21
Moraceae	*Maclura pomifera* (Raf.) C. K. Schneid.	10.5 ± 0.88	0 ± 0	10.8 ± 0.87	20.7 ± 3.29	10.9 ± 1.12	9.7 ± 1.56	0 ± 0	0 ± 0; 2.4 ± 0.18
Ranunculaceae	*Clematis flammula* L.	10.3 ± 1.11	0 ± 0	4.5 ± 0.41	23.6 ± 2.31	10.5 ± 1.31	11.6 ± 1.19	1.2 ± 0.12	0 ± 0; 2.4 ± 0.19
Rosaceae	*Prunus dulcis* (Mill.) D. A. Webb	2.3 ± 0.23	0 ± 0	10.6 ± 1.22	20.1 ± 2.78	2.5 ± 0.18	12.1 ± 0.87	1.3 ± 0.15	0 ± 0; 2.4 ± 0.22
Rosaceae	*Prunus laurocerasus* L.	0 ± 0	0 ± 0	16.5 ± 1.34	20.8 ± 2.33	1.3 ± 0.08	10.8 ± 1.32	0 ± 0	0 ± 0; 2.4 ± 0.21
Rutaceae	*Dictamnus alba* L.	2.2 ± 0.19	0 ± 0	2.3 ± 0.21	22.8 ± 2.44	2.7 ± 0.16	13.8 ± 1.78	1.7 ± 0.18	0 ± 0; 2.3 ± 0.18
Rutaceae	*Phellodendron amurense* Rupr.	9.7 ± 0.94	0 ± 0	12.9 ± 1.42	22.6 ± 2.65	10.2 ± 0.76	12.6 ± 1.32	8.7 ± 0.67	0 ± 0; 2.3 ± 0.17
Rutaceae	*Ptelea trifoliata* L.	17.5 ± 1.56	0 ± 0	10.3 ± 0.88	19.7 ± 2.42	1.7 ± 0.09	11.7 ± 1.32	3.3 ± 0.36	0 ± 0; 2.4 ± 0.18
Sapindaceae	*Koelreuteria paniculata* Laxm.	13.3 ± 1.23	0 ± 0	2.4 ± 0.21	21.7 ± 3.27	2.3 ± 0.13	12.7 ± 1.44	6.4 ± 0.42	0 ± 0; 2.5 ± 0.20
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	2.2 ± 0.31	0 ± 0	2.3 ± 0.21	19.7 ± 1.97	0 ± 0	11.7 ± 1.69	3.6 ± 0.47	0 ± 0; 2.3 ± 0.18
Tamaricaceae	*Tamarix elongata* Ledeb.	11.4 ± 1.15	0 ± 0	11.4 ± 0.89	20.4 ± 2.34	0 ± 0	10.4 ± 1.65	0 ± 0	0 ± 0; 2.4 ± 0.21
Vitaceae	*Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.	10.6 ± 0.88	0 ± 0	4.3 ± 0.35	19.9 ± 2.13	5.3 ± 0.34	14.9 ± 1.23	10.7 ± 1.24	0 ± 0; 2.2 ± 0.17

Note: * – disks with 15.0 μg of azithromycin were used for all bacteria as positive control; ** – discs with 15.0 μg amphotericin were used for all bacteria as positive control for *Candida albicans*.

Fungicidal activity of essential oil from *Chimonanthus praecox* L. was observed towards eight phytopathogenic fungi, the inhibiting power measuring 8–32 μg/mL (Gui & Qin, 2014).

Adami & Naderi (2015) think that the most important compound in the plant *Colchicum autumnale* L. is colchicine alkaloid, though its antimicrobial activity is studied poorly.

Ethanolic and petroleum extracts of *Pteridium aquilinum* (L.) exhibit antibacterial properties (Kardong & Saikia, 2013) against four species of tested bacteria (*B. subtilis*, *S. aureus*, *P. vulgaris* and *E. coli*), producing inhibition zones ranging 16–20 mm. Bacteria of *P. aeruginosa* were resistant to extracts of this species (Kardong & Saikia, 2013). However, extracts prepared in methanol, chloroform and distilled water showed no inhibiting activity against all the tested organisms. The observed difference in antibacterial activity while using various methods of extraction may be explained by incomplete transition of active substances into solution in the temperature of environment and loss of active components during boiling (Kardong & Saikia, 2013).

Antimicrobial peptides arrest the growth of bacteria, fungi, plant pathogens and even viruses. They have a powerful pharmaceutical effect. Bark of *Eucommia ulmoides* Oliv. is used in traditional Chinese medicine. Peptide present in *E. ulmoides* had *in vitro* inhibiting effect (Liu & Han, 2007) on *Candida albicans* (MIC = 156 μg/mL). Liu & Han (2007) consider that this plant can be used as a new antibiotic of plant origin for prevention of candidosis. Screening of bioactive secondary metabolites demonstrated that roots of *E. ulmoides* contain 7 compounds, one of them being gliotoxin. Its activity was close to the activity of gentamicin antibiotic, and stronger that the activity of nystatin antifungal preparation (Zhang & An, 2019).

Extracts of *Genista tinctoria* contributed to proliferation of probiotic strains and increased the number of bacterial colonies of *Bifidobacterium animalis* subsp. *lactis*, *B. longum* and *Lactobacillus casei* (Skenderidis & Giavasis, 2019). Prebiotic effect correlates with the concentration of polysaccharides and polyphenols of *G. tinctoria*, the content of which can increase the stress-tolerance of *B. lactis* and *B. longum* in a modelled gastrointestinal environment. Skenderidis & Giavasis (2019) consider that encapsulated extracts from *G. tinctoria* could be used as prebiotic supplements for food products for stimulation of growth and increase in vitality of probiotic strains of *Bifidobacterium* and *Lactobacillus*.

Oak (*Quercus petraea* subsp. *iberica* (Steven ex M. Bieb.) Krassiln) has many medical properties. Tumen & Sekeroglu (2018) report anti-inflammatory, wound-healing, anthelmintic and antioxidant effects of this plant. Extract of leaves of *Q. petraea* had antimicrobial activity against *Listeria monocytogenes*. Inhibiting effect of *Q. petraea* was more strongly expressed at low temperature (4 °C), and addition of EDTA (ethylenediaminetetraacetic acid) increased its antimicrobial activity (Xie & Johnson, 2003).

Quercus castaneifolia is being clinically tested regarding the treatment of patients suffering from intestinal diseases caused by *E. coli*, *S. typhimurium*, *Shigella dysenteriae*, *Y. enterocolitica* (Bahador & Baserisalehi, 2011).

Oil extract from *Geranium sanguineum* L. exhibited antibacterial effects against one standard strain of *S. aureus* ATCC 433000 and seventy clinical strains of *S. aureus*, including strains with multi-drug resistance (Bigos & Sienkiewicz, 2012). Wafa & Ouarda (2017) report high antimicrobial activities of methanol extracts of *G. sanguineum* against *S. aureus* ATCC 25923, *E. coli* ATCC 25922, *P. aeruginosa* ATCC 27853, *B. subtilis* ATCC 6633 and *C. albicans* ATCC1024, while having moderate anti-inflammatory effect.

Iridodial β-monoenol acetate and actinidine obtained from extract of *Nepeta racemosa* Spreng. demonstrated high activity against *Penicillium citrinum* and *Aspergillus* spp. and moderate zone of inhibition of *Bacillus anthracis* and *Streptococcus pyrogenes* (Saxena & Mathela, 1996; Mathela & Joshi, 2008).

Biofilms containing solid dispersion of extract from *Salvia officinalis* L. had high antibacterial activity towards food pathogens *S. aureus* and *E. coli* (Salević & Lagaron 2019; Wali & Alam, 2019).

Habbab & Aboul-Enein (2016) studied the chemical composition and biological activity of essential oils from dry leaves, flowers and seeds of *Vitex agnus-castus* L., obtained using hydrodistillation. Antifungal and antibacterial activities of essential oil was tested against three strains of fungi and eight strains of bacteria. The main constituents of the oil were 1,8-cineol (17.2%), caryophyllene (12.9%) and terpinen-4-ol (10.2%), whereas the dominating compounds in the oil of seeds were 1,8-cineol (14.9%), cedrelanol (13.9%) and 7a-isopropenile-4,5-dimethyloctahydroindene-4-carbonic acid (13.9%). Oil from leaves also contained 1,8-cineol (18.3%). Their compositions were compared to oils of plants from Europe, America and Asia. Essential oils of seeds and leaves exerted antibacterial impact against *K. pneumoniae*, *E. coli* and *P. aeruginosa*. Essential oil from leaves and flowers was highly active against fungi *Penicillium expansum* and *Aspergillus flavus*.

Plant extract of *Vitex negundo* L. was the most effective (Padder & Ganaie, 2015) both against *Streptococcus mutans* (MIC – minimum inhibitory concentration = 0.37 μg/mL) and *P. aeruginosa* (MIC = 0.75 μg/mL). Deogade et al. (2016) determined antibacterial activity of ethanol extract from leaves of *V. negundo* towards bacteria *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella pneumoniae*, producing maximum inhibition zone of *S. aureus* (15 mm at the concentration of 80–100 mg/mL) and minimum ones of *E. coli* and *K. pneumoniae* (12 and 11 mm at the concentration of 100 mg/mL, respectively). The notable inhibiting activity of extract of this plant was due to its high content of phenols and flavonoids (Prashith & Raghavendra, 2014). Extracts and secondary metabolites of *V. negundo*, especially from the roots and leaves, have useful pharmacological properties: anti-inflammatory, anti-tumour, antioxidant and antimicrobial (Tan et al., 2017; Khan et al., 2019). Use of *V. negundo* may be promising for treatment of skin infections caused by *Staphylococcus aureus* (Triveni & Gaddad, 2016). Synthesis of nanoparticles of silver through self-restoration of silver nitrate by extracts of leaves of *V. negundo* is one of the new methods applied in the development of technologies for creation of nanoparticles (Bhavani & Geetha, 2013). Silver nanoparticles (56 nm) exhibited antimicrobial activity against *E. coli* and *K. pneumonia*. Essential oil from seeds of *V. negundo* (Ai, 2014) had significant antifungal impact on *Candida albicans* (MIC = 4.0 μg/mL). Moreover, this extract had hepatoprotectory properties, which could be associated with its antioxidant activity, and also protective effect against heightened level of lipids (Sharma & Suri, 2016).

Alcohol extracts from the pith of *Liriodendron tulipifera* L. showed antimicrobial activity towards *S. aureus*, *Mycobacterium smegmatis*, *Candida albicans* and *Aspergillus niger*. Hufford & Robertson (1975) attribute it to alkaloid fraction of dehydro glaucine and liriodenine as active components. Mechanisms of antimicrobial activity of extract from *Magnolia kobus* DC. on *S. aureus* were studied using light microscopy, transmission electronic microscopy and scanning electron microscopy. After 48 h of exposure to the extract, many cells of *S. aureus* completely decomposed (Hu & Ge, 2011). Methylene chloride extract from fruits of *Maclura pomifera* (Raf.) Schneid exerted strong in vitro antimicrobial and anti-*Leishmania* activities. Fractioning of this extract based on the activity led to production of isoflavons (osajin and pomiferin) as active compounds which demonstrated high activity against *Cryptococcus neoformans*, *Staphylococcus aureus* and *Leishmania donovani* (Dharmaratne & Nanayakkara, 2013). Lectin from *M. pomifera* in a specific way agglutinated bacterial suspensions of various strains of highly-pathogenic bacteria of *Salmonella* genus (Allen, 1985).

Methanol extracts of leaves and bark of *Clematis flammula* L. exhibited a broad spectrum of antibacterial activity due to fraction of ethylacetate (Khan & Omoloso, 2001). Non-filtered extracts of young shoots of the closely related plant *Clematis vitalba* L. were highly-active against pathogenic yeasts and yeast-like microorganisms (MIC = 1.4–12.3 μg/mL). After fractioning with petroleum alcohol, ethylacetate and methanol, antifungal activity was observed only in methanol fractions (Buzzini & Pieroni, 2003).

Thebo (2014) surveyed the extract of the shell of *Prunus dulcis* (Mill.) in its biomedical aspects: antifungal activity of extract of almond shell was observed against the clinically isolated pathogenic fungus *Tinea capitis* using the strip method. The antioxidant potential of non-filtered extract of the coating of the fruits was also assessed using DPPH (2,2-diphenyl-1-picrylhydrazyl) and the system of scaveranging of radicals. The total antioxidant activity ranged 94.4–95.5%; total content of phenols accounted for 4.46 mg/g in the extract of almond shell. This had a great therapeutic potential after 20 days of therapy against *T. capitis*-caused infection of the skin on the head. The survey has proven the clinical efficiency of *Prunus dulcis* for treating dermatological diseases.

Antimicrobial activity of essential oil from *Dictamnus dasycarpus* Turcz. was tested against nine microorganisms using methods of disk diffusions and broth microdilutions. The essential oil displayed bactericidal activity towards *S. aureus* ATCC 25923 and methicillin-resistant strain of *S. aureus* (Lei & Liao, 2007).

Extracts from bark of *Phellodendron amurense* Rupr. were tested for antioxidant, antimicrobial and antiviral activities (against virus of herpes simplex of 1 type – HSV-1). Ethanol extract from the bark of this plant, compared with the aqueous extract, was found to contain more phenols and flavonoids. The ethanol extract was much more active against bacteria than the aqueous extract (Wang & Zhang, 2009). Han & Meng (2015) surveyed essential oil from *P. amurense* extracted from fruits collected in the natural growing environment. This oil contained myrcene (51.7%), 2-methyl-6-methylene-octa-3,7-dien-2-ol (7.4%), 1,2-benzenedioic acid-bi-(2-methylpropyl)-complex ether (7.2%), 2-methyl -6-methylene-octa-1,7-dien-3-ol (7.1%) and α-phellandrene (5.2%). Essential oil from *P. amurense* demonstrated antioxidant (IC_{50} – 2.32 μg/mL) and broad-range fumigant activity and notable antimicrobial effect against all the tested strains of microorganisms (MIC = 0.12–1.36 μg/mL). Han & Meng (2015) assume that the essential oil can be used as an antioxidant and antimicrobial agent.

Bioanalysis-based fractioning of ethanol extract of *Koelreuteria paniculata* Laxm. of the Sapindaceae family, which grows in Egypt, led to isolation of 11 compounds: methyl-myo-inositol, loliloide, gallic acid, methyl gallate, ethyl gallate, monoglyceride of palmitic acid, 5-meth-oxy-luteolin, kaempferol-7-rhamnoside, kaempferol-3- rhamnoside, β-sitosterol and β-sitosterol-glucoside. Methyl gallate and ethyl gallate showed identical anti-malaria activity against chloroquine-susceptible and insusceptible forms of *Plasmodium falciparum*. Ethyl gallate was also acive against *E. coli* bacteria (Mostafa & Ross, 2015).

Methanol extracts from leaves of *Ailanthus altissima* (Mill.) Swingle and their hydrodistilled residuals have antioxidant, phytotoxic and antibacterial activities against Gram-positive bacterial strains (Albouchi & Hosni, 2013).

Methanol extracts of *Parthenocissus tricuspidata* (Siebold & Zucc.) Planch. demonstrated in vitro anti-malaria activity against *Plasmodium falciparum*, and also a schizonticidal activity towards *P. berghei* in blood of mice in the conditions of use of the doses causing no noticeable toxicity: these extracts elevated the share of oxidized hemoglobin in erythrocytes and inhibited synthesis of protein (Park & Moon, 2008).

The antimicrobial impact of the remaining species of plants is covered much less thoroughly in the literature. Thus, according to our results, ethanol extracts inhibit growth of colonies of many species of microorga-

nisms of the Yersiniaceae, Enterobacteriaceae, Morganellaceae, Enterococcaceae, Listeriaceae, Pseudomonadaceae, Campylobacteraceae, Corynebacteriaceae, Nocardiaceae families and fungi of the Saccharomycetacea family. A somewhat disturbing find was that the strains of *P. mirabilis*, *K. pneumoniae*, *S. marcescens*, *L. monocytogenes* and *C. jejuni*, which we studied, were absolutely resistant to azithromycin (growth inhibition zone equaled 0.0 mm), and that *C. albicans* showed a low susceptibility to amphotericin (growth inhibition zone was 2.4 mm).

Conclusion

For the first time a study on the complex inhibitory action of 38 species of plants against 15 bacterial strains and one strain of fungus has been undertaken. Extracts of leaves and shoots of plants of Fabaceae (*Styphnolobium japonicum*, *Securigera varia*), Rutaceae (*Dictamnus albus*), Lamiaceae (*Nepeta racemosa*), Eucommiaceae (*Eucommia ulmoides*), Rosaceae (*Prunus dulcis*), Bignoniaceae (*Campsis radicans*), Simaroubaceae (*Ailanthus altissima*) and Fagaceae (*Quercus petraea*) had no notable effect on multi-ressitant strains of *E. coli*, *P. mirabilis*, *S. marcescens*, *L. ivanovi*, *L. monocytogenes*, *P. aeruginosa*, *C. jejuni* and *C. albicans*. We determined intense inhibiting effect of ethanol extracts from *Maclura pomifera*, *Ginkgo biloba* against 8, *Genista tinctoria*, *Phellodendron amurense*, *Berberis vulgaris* – 7, *Vitex negundo*, *Koelreuteria paniculata*, *Magnolia kobus*, *Liriodendron tulipifera*, *Clematis flammula* – 6, *Wisteria sinensis*, *Chimonanthus praecox*, *Colchicum autumnale* – 5, *Vitex agnus-castus*, *Salvia officinalis*, *Prunus laurocerasus*, *Geranium sanguineum*, *Tamarix elongata*, *Catalpa duclouxii*, *Parthenocissus tricuspidata*, *Quercus castaneifolia* – 4, *Artemisia absinthium*, *Ptelea trifoliata*, *Polygonatum multiflorum*, *Kalicopa bodimerium*, *Aristolochia manshuriensis*, *Celastrus scandens* and *Pteridium aquilinum* – 3 of 16 surveyed multi-drug-resitant strains of bacteria and fungi. We consider it possible to recommend ethanol extracts from *M. pomifera*, *G. biloba*, *G. tinctoria*, *P. amurense*, *B. vulgaris*, *V. negundo*, *K. paniculata*, *M. kobus*, *L. tulipifera*, *C. flammula*, *W. sinensis*, *C. praecox* and *C. autumnale* or the individual compounds these plants contain for further research on combating poly-resistant strains of the abovementioned microorganisms.

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