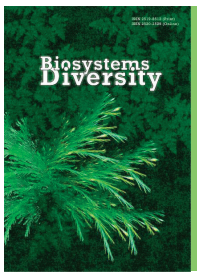

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Antimicrobial activity of 50 plant extracts

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Antibacterial activity of plants is a subject of interest in the search for new antibiotics and fungicidal preparations. This article analyzes the effectiveness of the action of extracts of plants on microorganisms: six species of bacteria (*Salmonella typhimurium*, *Listeria monocytogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Corynebacterium xerosis*, *Proteus vulgaris*) and one fungus (*Candida albicans*). For the assay, we used herbal material of 50 species (seeds, grass, shoots, leaves, compound fruit, peel) obtained at different periods of the growing season. We studied *Levisticum officinale*, *Petroselinum crispum*, *Nerium oleander*, *Vinca minor*, *Eleutherococcus senticosus*, *E. sieboldianus*, *Yucca filamentosa*, *Artemisia annua*, *Echinacea purpurea*, *Matricaria recutita*, *Tanacetum vulgare*, *Betula pendula*, *Corylus avellana*, *Buxus sempervirens*, *Humulus lupulus*, *Crassula ovata*, *Bryophyllum daigremontianum*, *Juniperus communis*, *Platycladus orientalis*, *Cycas revoluta*, *Calluna vulgaris*, *Rhododendron ferrugineum*, *Ceratonia siliqua*, *Trigonella foenum-graecum*, *Ribes nigrum*, *Phellinus tuberculosus*, *Lavandula angustifolia*, *Melissa officinalis*, *Monarda fistulosa*, *Origanum vulgare*, *Salvia sclarea*, *Laurus nobilis*, *Punica granatum*, *Hibiscus rosa-sinensis*, *Menispermum dauricum*, *Ficus benjamina*, *Morus alba*, *Paeonia suffruticosa*, *Picea abies*, *Adonis vernalis*, *Amelanchier ovalis*, *Prunus armeniaca*, *Crataegus monogyna*, *Citrus sinensis*, *Salix babylonica*, *Bergenia crassifolia*, *Schisandra chinensis*, *Taxus baccata* and *Xanthoria parietina*. The alcohol tincture was filtered with sterile multi-layer gauze disc filters. Before the discs were put on the surface of agar with inoculation of the corresponding culture, they were dried in a sterile laminar box under ultraviolet rays. Antibacterial activity of various tinctures was determined by the disk diffusion method in agar with the measurement of the diameter of the growth suppression zone of the culture using a template ruler. Maximum inhibiting effect was achieved for *Punica granatum* on *K. pneumonia*, *L. monocytogenes*, *S. typhimurium*, *P. vulgaris*, *C. xerosis* and *E. coli*, *Lavandula angustifolia* – on *P. vulgaris*, *K. pneumonia* and *S. typhimurium*, *Echinacea purpurea* – on *C. albicans*, *E. coli*, *P. vulgaris*, *K. pneumonia*, *Bergenia crassifolia* – on *P. vulgaris*, *K. pneumonia* and *S. typhimurium*.

Keywords: *Salmonella typhimurium*; *Listeria monocytogenes*; *Escherichia coli*; *Klebsiella pneumoniae*; *Corynebacterium xerosis*; *Proteus vulgaris*; *Candida albicans*.

Introduction

One of the problems in modern veterinary medicine and medicine is antibiotic resistiance of *Salmonella typhimurium*, *Listeria monocytogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Corynebacterium xerosis*, *Proteus vulgaris* and *Candida albicans*, which significantly complicates preventive measures and treatment of these infections and reduces the therapeutic efficiency of existing antibacterial and anti-parasitic preparations (Mendez et al., 2012; Boyko & Brygadyrenko, 2016; Ali et al., 2017; Semeniuc et al., 2017). According to the data of Wasyl et al. (2013), during monitoring of antimicrobial resistance of *E. coli* (n = 3430), isolated from slaughtered broilers, carrier hens, turkeys, swine and cattle in Poland, microbiological resistance to 14 tested antimicrobial substances was determined: highest resistance was exhibited by the bacteria to tetracycline (43.3%), ampicillin (42.3%) and ciprofloxacin (39.0%). The highest distribution of resistance was observed in isolates from broiler chickens and turkeys, at the same time it was rare in cattle. Regression analysis revealed changes in distribution of microbiological resistance and changes in the parameters of MIC, minimum inhibiting concentration (Wasyl et al., 2013).

Ozaki et al. (2011) determined presence of strains of *E. coli* resistant to antimicrobial preparations, which can be observed even at absence of using any antibiotics. Also these authors have suggested a hypothesis that horizontal transmission of genes caused appearance of different phenotypes of resistance on the studied farms. During use of antibacterial preparations for treatment of mink and finding antimicrobial resistence among the most important bacterial pathogens in mink, it was determined (Pedersen et al., 2009) that out of 164 hemolytic staphylococci, 49 hemolytic streptococci, 39 *Pseudomonas aeruginosa*, 13 *Pasteurella multocida* and 1093 isolates of *E. coli* from Danish mink, the highest frequency of resistance was characteristic for tetracyclines (54.7%), penicillin (21.7%), lincosamides (20.4%) and macrolides (19.1%). Highest frequency of resistance among isolates of *E. coli* was recorded for ampicillin, streptomycin, sulfanilamides and tetracyclines, whereas resistance to other antimicrobial preparations was rare. All *P. aeruginosa* were sensitive to gentamicin and colistin, sensitive or low-sensitive to enrofloxacin, whereas most isolates were resistant to all other antimicrobial preparations. All the *P. multocida* and hemolytic streptococci were sensitive to penicillin (Pedersen et al., 2009).

Choi et al. (2011) found bactericidal activity of ethanol extract of *Punica granatum* L. against 16 strains of microorganisms of the *Salmonella* genus. Antibacterial activity *in vivo* of the extract was studied in the model of infection of mice with *S. typhimurium*. First of all, the mice were infected with *S. typhimurium*, and later with PGPE. Extract from *P. granatum* caused death and reduced the number of viable *S. typhimurium* isolated from feces. Though clinical features and histological changes were rarely observed in mice treated with the extract, control animals which did not receive it were observed to have signs of lethargy, histological damage to the liver and spleen. Results of this study indicate that PGPE has potential for effective treatment of salmonellosis (Choi et al., 2011). Dahham et al. (2010) determined a high level of bactericidal activity of ethanol extract of *P. granatum* against *S. aureus*, *As-*

pergillus niger and much lower – against *E. coli*, *K. pneumoniae*, *S. typhimurium*, whereas Millezi et al. (2012) determined high bactericidal activity of ethanol extracts from *Thymus vulgaris* L., *Cymbopogon citratus* (DC.) Stapf., *Laurus nobilis* L. against *S. aureus*, *E. coli*, *L. monocytogenes*, *S. enteritidis* and *P. aeruginosa*.

Evaluation of microbiological activity against food pathogens using different extracts from granulated fruit peels was performed by Al-Zoreky (2009) using methods both *in vitro* (diffusion of agar) and *in situ* (food). 80% methanol extract of the peels (WME) was a strong inhibitor of *L. monocytogenes*, *S. aureus*, *E. coli* and *Yersinia enterocolitica*. Minimum inhibitory concentration (MIC) of WME against *S. enteritidis* was highest (4 mg/mL). Phytochemical analysis revealed presence of activity of inhibitors in the skin, including phenol and flavonoids. Activity of WME of pomegranate fruit peels was related to its high content (262.5 mg/g) of total amount of phenols (Al-Zoreky, 2009). Studies by Natarajan et al. (2008) determined bactericidal activity of extracts from *Humulus lupulus* L. in combination with other antiseptic substances against gram-negative microbiota, particularly *E. coli*, while Mikulášová & Vaverková (2009) also determined bactericidal activity of essential oils of *Tanacetum vulgare* L. and *Salvia officinalis* L. against *E. coli* and yeast-like fungi *C. albicans*.

Hayouni et al. (2011) observed bactericidal activity of ethanol extract from *P. granatum* against *P. aeruginosa*, *S. aureus*, *E. coli*, *K. pneumoniae*, *Salmonella anatum*, S. typhimurium, *Streptococcus pneumoniae* and fungi *C. albicans*, *C. glabrata*, *Trichophyton rubrum* and *Aspergillus niger*. This study for the first time reports about potential of the skin of *P. granatum* for healing wounds of guinea pigs. Ointment significantly increased reduction of wound and period of epithelization, evaluation of mechanical (speed of compression, strength during stretching), biochemical (increase in content of collagen, synthesis of DNA and proteins) and histopathological characteristics. Extracts from pomegranate displayed no toxic effects against *S. aureus*, *Aspergillus niger* and significantly lower parameters against *E. coli*, *K. pneumoniae*, *S. typhimurium* (Hayouni et al., 2011). Extract of the skin of pomegranade improves oxidative stability and quality of preserving cheese and can be used as a natural preservative of cheese products (Mahajan et al., 2015).

The objective of this article was evaluation of in vitro of the antibacterial effect of plant tinctures against reference strains of *S. typhimurium*, *L. monocytogenes*, *E. coli*, *K. pneumoniae*, *Corynebacterium xerosis*, *Proteus vulgaris*, and *C. albicans*.

Materials and methods

A total of 50 species of plant material (seeds, grass, shoots, leaves, compound fruits, thallus, fruit bodies, skin) of different periods of growthe were grown in Dnipropetrovsk Botanical Garden and the recreationnal zone of the city of Dnipro (Table 1).

The collected material was sorted and dried on a ML-309 thermistor pod (Poland) at temperature of 60 ºC during 5–6 days. Further, the obtained material was put into an experimental flour mill LZMK and ground to size of particles of 0.5–1.0 mm. The obtained plant material was sorted into disposable polyethylene bags with zippers and marked with stickers. Using ESJ-200-4 laboratory electric analytic scales (USA), 1 g of corresponding material was weighed and put into sterile flasks of 10 cm^3 capacity and 5 cm^3 was filled with 96% ethanol. Alcohol tincture in 1 : 5 proportion were kept in a cold place over three weeks. After this period, the tinctures were filtered through a glass laboratory funnel with sterile multi-layer cheesecloth filtrates in sterile flasks with 50 sterile disks of filter paper of 6 mm diameter in each one, which were kept in the corresponding variants of the tinctures over 10 days. Before putting disks on the surface of agar with inoculation of corresponding culture, they were dried in a sterile laminar box (BMB-II-Laminar-C-1, 2 CYTOS (Germany) under ultraviolet rays for 30 min.

Antibacterial activity of different plant tinctures was determined using the method of disk-diffusion in agar. From the daily culture of reference cryogenic strains of *Salmonella typhimurium* 144, *Listeria monocytogenes* ATCC 19112, *Escherichia coli* (F 50) ATCC 25922, *Klebsiella pneumoniae* K-56 No 3534/51, *Corynebacterium xerosis* 1911, *Proteus vulgaris* HX 19222, *Candida albicans* ATCC 885-653, a weighed amount of bacteria was prepared according to the standard of turbidity of bacterial suspension of 0.5 units of density according to McFarland 1.5×10^8 CFU (colony-forming units), which was determined using Densitometer II. The obtained suspension was inoculated to Muller-Hinton agar (Himedia) with following cultivation in TSO-80/1 thermostat (Russia) for 24 hours at 37 °C temperature. On the top of the inoculations, disks saturated with corresponding plant tinctures were put, y six disks for each one. As a positive control, in the center, a disk with antibiotic was placed (1 disk contained 6 μg of benzylpenicillin of sodium salt). Discs with 15.0 μg amphotericinin were also used as a second control against *C. albicans*.

Table 1
Part of the plants used and most important data on their antibacterial activity

Family	Species	Used part of the plant
Apiaceae	*Levisticum officinale* W. D. J. Koch	H
–"–	*Petroselinum crispum* (Mill.) Fuss	H
Apocynaceae	*Nerium oleander* L.	AP
–"–	*Vinca minor* L.	H
Araliaceae	*Eleutherococcus sieboldianus* (Makino) Koidz.	AP
–"–	*E. senticosus* (Rupr. and Maxim.) Maxim.	AP
Asparagaceae	*Yucca filamentosa* L.	LF
Asteraceae	*Artemisia annua* L.	H
–"–	*Echinacea purpurea* (L.) Moench	H
–"–	*Matricaria recutita* L.	H
–"–	*Tanacetum vulgare* L.	H
Betulaceae	*Betula pendula* Roth	AP
–"–	*Corylus avellana* L.	AP
Buxaceae	*Buxus sempervirens* L.	AP
Cannabaceae	*Humulus lupulus* L.	FR
Crassulaceae	*Crassula ovata* (Miller) Druce	LF
–"–	*Bryophyllum daigremontianum* (Raym.-Hamet and H. Perrier) A. Berger	LF
Cupressaceae	*Juniperus communis* L.	LF
–"–	*Platycladus orientalis* (L.) Franco	AP
Cycadaceae	*Cycas revoluta* Thunb.	LF
Ericaceae	*Calluna vulgaris* (L.) Hull	AP
–"–	*Rhododendron ferrugineum* L.	AP
Fabaceae	*Ceratonia siliqua* L.	AP
–"–	*Trigonella foenum-graecum* L.	SE
Grossulariaceae	*Ribes nigrum* L.	AP
Hymenochaetaceae	*Phellinus tuberculosus* (Baumg.)	FB
Lamiaceae	*Lavandula angustifolia* Mill.	H
–"–	*Melissa officinalis* L.	H
–"–	*Monarda fistulosa* L.	H
–"–	*Origanum vulgare* L.	H
–"–	*Salvia sclarea* L.	H
Lauraceae	*Laurus nobilis* L.	LF
Lythraceae	*Punica granatum* L.	FR
Malvaceae	*Hibiscus rosa-sinensis* L.	LF
Menispermaceae	*Menispermum dauricum* DC.	LF
Moraceae	*Ficus benjamina* L.	LF
–"–	*Morus alba* L.	AP
Paeoniaceae	*Paeonia suffruticosa* Andrews	AP
Pinaceae	*Picea abies* (L.) H. Karst	AP
Ranunculaceae	*Adonis vernalis* L.	H
Rosaceae	*Amelanchier ovalis* Medik.	AP
–"–	*Prunus armeniaca* L.	SE
–"–	*Crataegus monogyna* Jacq.	AP
Rutaceae	*Citrus sinensis* (L.) Osbeck	FR
Salicaceae	*Salix babylonica* L.	AP
Saxifragaceae	*Bergenia crassifolia* (L.) Fritsch	LF
Schisandraceae	*Schisandra chinensis* (Turcz.) Baill.	AP
Taxaceae	*Taxus baccata* L.	AP
Teloschistaceae	*Xanthoria parietina* (L.) Th. Fr.	T

Note: AP – shoots, FB – fruit body, FR – compound fruit, H – grass, LF – leaves, SE – seeds, T – thallus, R – raw.

After 24 h, we measured the diameter of the zone of inhibition of growth (ZIG) of the culture using a template ruler for measuring sizes of the zone of suppression of growth of the microorganisms (Antibiotic

Zone Scale-C, model PW297, India).

Results

In the study on antibacterial effect of plant tinctures on *S. typhimurium* reference strain we observed (Table 2) that *Punica granatum* (ZIG – 14.3 mm), *Laurus nobilis* (13.3), *Lavandula angustifolia* (10.4) and *Bergenia crassifolia* (8.8) showed the largest zones of inhibition of growth. ZIG of over 4 mm were also produced by *Ficus benjamina* (7.6), *Melissa officinalis* (7.4), *Platycladus orientalis* (7.4), *Artemisia annua* (7.3), *Citrus sinensis* (6.5), *Tanacetum vulgare* (6.4), *Nerium oleander* (6.2), *Origanum vulgare* (5.6), *Adonis vernalis* (5.3), *Betula pendula* (4.3), *Crassula ovata* (4.1) and *Hibiscus rosa-sinensis* (4.1). Therefore 16 of 49 samples (32.7%) of the studied plant material inhibited growth of colonies of *S. typhimurium*.

We found a quite high effect on *E. coli* strain, caused by ethanol tinctures of *Punica granatum* (ZIG – 17.2 mm) and *Crassula ovata* (12.3). The effect of tinctures from *Petroselinum crispum* (4.3), *Echinacea purpurea* (4.2) and *Vinca minor* (4.1), according to the size of ZIG, equaled the effect of the control antibiotic. Although alcohol tinctures of *Morus alba* (4.1) and *Salvia sclarea* (4.3) had less effect than benzylpenicillin sodium salt, they also caused ZIG of over 4 mm against *E. coli*. Thus, only 7 of 49 samples (14.3%) of the studied plant material inhibited growth of colonies of *E. coli*.

Table 2

Antibacterial effect of herbal infusions of family Enterobacteriaceae: *Salmonella typhimurium*, *Escherichia coli*, *Klebsiella pneumoniae* and *Proteus vulgaris* (x ± SD, n = 12)

Family	Species	*S. typhimurium*		*E. coli*		*K. pneumoniae*		*P. vulgaris*	
		test	control	test	control	test	control	test	control
Apiaceae	*Levisticum officinale* W. D. J. Koch	3.4 ± 0.87	23.3 ± 0.56	2.1 ± 0.47	2.3 ± 0.33	0 ± 0	2.7 ± 1.10	0 ± 0	1.8 ± 0.19
Apiaceae	*Petroselinum crispum* (Mill.) Fuss	0 ± 0	18.6 ± 1.67	4.3 ± 0.94	4.3 ± 1.23	7.7 ± 1.29*	4.3 ± 0.88	0 ± 0	2.5 ± 0.54
Apocynaceae	*Nerium oleander* L.	6.2 ± 0.76	12.4 ± 0.67	0 ± 0	7.4 ± 1.09	1.3 ± 0.19	7.6 ± 1.74	0 ± 0	0.8 ± 0.28
Apocynaceae	*Vinca minor* L.	1.3 ± 0.69	23.2 ± 0.78	4.1 ± 0.37	4.2 ± 0.88	1.5 ± 0.45	4.2 ± 1.45	0 ± 0	0.9 ± 0.23
Araliaceae	*Eleutherococcus senticosus* (Rupr. and Maxim.) Maxim.	2.3 ± 0.89	6.3 ± 1.23	2.1 ± 0.77	7.1 ± 1.07	10.5 ± 1.37*	7.1 ± 0.94	0 ± 0	0.9 ± 0.15
Araliaceae	*E. sieboldianus* (Makino) Koidz.	3.6 ± 0.45	7.4 ± 1.12	3.2 ± 0.48	7.2 ± 1.22	0 ± 0	7.4 ± 1.23	0 ± 0	0.8 ± 0.32
Asparagaceae	*Yucca filamentosa* L.	0 ± 0	7.4 ± 1.82	0 ± 0	5.9 ± 1.21	0 ± 0	5.2 ± 1.77	0 ± 0	1.7 ± 0.13
Asteraceae	*Artemisia annua* L.	7.3 ± 0.56	19.1 ± 0.76	0 ± 0	4.4 ± 1.07	12.6 ± 2.78*	4.6 ± 0.78	3.2 ± 0.19	0.7 ± 0.15
Asteraceae	*Echinacea purpurea* (L.) Moench	0 ± 0	17.3 ± 0.47	4.2 ± 0.77	4.2 ± 1.68	8.5 ± 1.47*	4.2 ± 0.94	5.3 ± 0.34	2.4 ± 0.56
Asteraceae	*Matricaria recutita* L.	0 ± 0	19.3 ± 2.36	0 ± 0	5.1 ± 1.09	1.3 ± 0.32	5.4 ± 1.63	0 ± 0	2.7 ± 0.35
Asteraceae	*Tanacetum vulgare* L.	6.4 ± 0.67	27.3 ± 0.54	0 ± 0	4.9 ± 1.33	10.7 ± 2.10*	4.3 ± 0.93	0 ± 0	0.9 ± 0.52
Betulaceae	*Betula pendula* Roth	4.3 ± 0.57	2.2 ± 0.79	1.1 ± 0.73	5.4 ± 1.14	1.2 ± 0.29	5.5 ± 1.33	0 ± 0	1.3 ± 0.18
Betulaceae	*Corylus avellana* L.	1.4 ± 0.54	7.5 ± 2.65	0 ± 0	10.6 ± 1.87	0 ± 0	10.8 ± 1.64	0 ± 0	2.5 ± 0.33
Buxaceae	*Buxus sempervirens* L.	1.2 ± 0.35	12.5 ± 2.76	1.1 ± 0.27	4.1 ± 1.27	5.3 ± 0.99	4.6 ± 1.31	4.1 ± 0.56	2.9 ± 0.45
Cannabaceae	*Humulus lupulus* L.	1.2 ± 0.72	17.4 ± 2.21	3.2 ± 0.97	6.1 ± 1.76	1.1 ± 0.18	6.4 ± 1.93	10.5 ± 3.17*	2.4 ± 1.16
Crassulaceae	*Crassula ovata* (Miller) Druce	4.1 ± 0.47	17.4 ± 1.79	12.3 ± 1.12*	5.2 ± 1.84	0 ± 0	5.5 ± 1.67	0 ± 0	2.6 ± 0.19
Crassulaceae	*Bryophyllum daigremontianum* (Raym.-Hamet & H. Perrier) A. Berger	3.2 ± 0.67	7.2 ± 2.24	3.1 ± 0.97	5.6 ± 0.97	0 ± 0	5.4 ± 1.74	0 ± 0	2.9 ± 0.17
Cupressaceae	*Juniperus communis* L.	1.2 ± 0.87	18.1 ± 3.79	2.1 ± 0.27	10.2 ± 2.19	0 ± 0	10.2 ± 1.78	2.5 ± 0.66	2.7 ± 0.88
Cupressaceae	*Platycladus orientalis* (L.) Franco	7.4 ± 0.61	6.3 ± 1.77	0 ± 0	6.3 ± 2.14	0 ± 0	6.7 ± 1.73	2.2 ± 0.43	2.6 ± 0.31
Cycadaceae	*Cycas revoluta* Thunb.	0 ± 0	18.2 ± 4.79	0 ± 0	7.4 ± 1.37	4.2 ± 0.89	7.9 ± 1.76	0 ± 0	0.8 ± 0.18
Ericaceae	*Calluna vulgaris* (L.) Hull	0 ± 0	12.5 ± 1.88	2.1 ± 0.87	6.2 ± 1.10	0 ± 0	6.2 ± 1.64	0 ± 0	2.6 ± 0.14
Ericaceae	*Rhododendron ferrugineum* L.	2.4 ± 0.69	6.2 ± 0.75	0 ± 0	5.6 ± 1.02	2.1 ± 0.44	5.8 ± 1.56	0 ± 0	1.3 ± 0.16
Fabaceae	*Ceratonia siliqua* L.	0 ± 0	2.3 ± 0.13	3.2 ± 0.74	5.8 ± 1.17	1.1 ± 0.36	5.7 ± 1.21	0 ± 0	0 ± 0
Fabaceae	*Trigonella foenum-graecum* L.	0 ± 0	7.5 ± 0.34	1.0 ± 0.57	5.7 ± 1.13	0 ± 0	5.4 ± 1.72	0 ± 0	1.5 ± 0.11
Grossulariaceae	*Ribes nigrum* L.	3.1 ± 0.73	7.2 ± 0.68	0 ± 0	2.7 ± 0.58	5.6 ± 1.24*	2.6 ± 0.78	0 ± 0	1.6 ± 0.22
Hymenochaetaceae	*Phellinus tuberculosus* (Baumg.)	0 ± 0	23.4 ± 0.59	0 ± 0	10.4 ± 1.66	0 ± 0	10.3 ± 1.76	0 ± 0	2.9 ± 0.63
Lamiaceae	*Lavandula angustifolia* Mill.	10.4 ± 1.53	19.2 ± 3.79	1.0 ± 0.17	6.3 ± 1.34	10.4 ± 1.33*	6.3 ± 0.87	4.3 ± 0.32	2.8 ± 0.21
Lamiaceae	*Melissa officinalis* L.	7.4 ± 0.39	18.6 ± 0.89	2.1 ± 0.44	4.3 ± 1.69	4.6 ± 0.76	4.7 ± 1.23	0 ± 0	0.6 ± 0.32
Lamiaceae	*Monarda fistulosa* L.	2.3 ± 0.76	17.2 ± 0.78	0 ± 0	5.1 ± 1.13	1.3 ± 0.56	5.3 ± 1.85	0 ± 0	2.4 ± 0.14
Lamiaceae	*Origanum vulgare* L.	5.6 ± 0.58	2.2 ± 0.99	2.4 ± 0.36	4.5 ± 1.07	0 ± 0	4.4 ± 1.38	2.8 ± 0.78	2.7 ± 0.75
Lamiaceae	*Salvia sclarea* L.	0 ± 0	6.2 ± 0.68	4.3 ± 0.87	5.2 ± 1.19	0 ± 0	5.8 ± 1.54	2.6 ± 0.62	2.5 ± 0.43
Lauraceae	*Laurus nobilis* L.	13.3 ± 2.28*	7.1 ± 1.59	0 ± 0	7.1 ± 2.18	0 ± 0	7.3 ± 1.81	0 ± 0	0.9 ± 0.14
Lythraceae	*Punica granatum* L.	14.3 ± 3.20*	6.2 ± 1.85	17.2 ± 4.39*	4.3 ± 1.88	10.3 ± 1.96*	4.1 ± 1.30	15.4 ± 3.90*	2.6 ± 1.85
Malvaceae	*Hibiscus rosa-sinensis* L.	4.1 ± 0.94	18.3 ± 5.21	2.1 ± 0.36	5.3 ± 0.98	0 ± 0	5.7 ± 1.45	0 ± 0	2.1 ± 0.16
Menispermaceae	*Menispermum dauricum* DC.	0 ± 0	23.3 ± 0.44	2.2 ± 0.37	10.7 ± 2.25	1.4 ± 0.41	10.4 ± 1.66	0 ± 0	2.7 ± 0.85
Moraceae	*Ficus benjamina* L.	7.6 ± 0.95	17.3 ± 0.88	2.2 ± 0.88	6.9 ± 1.27	1.2 ± 0.22	7.7 ± 1.43	0 ± 0	0.9 ± 0.31
Moraceae	*Morus alba* L.	3.3 ± 0.75	7.3 ± 2.45	4.1 ± 0.83	5.5 ± 1.11	2.2 ± 0.54	5.6 ± 1.19	0 ± 0	1.1 ± 0.22
Paeoniaceae	*Paeonia suffruticosa* Andrews	3.2 ± 0.54	6.6 ± 0.57	0 ± 0	2.4 ± 0.76	0 ± 0	2.4 ± 1.23	6.1 ± 1.43*	1.8 ± 0.81
Pinaceae	*Picea abies* (L.) H. Karst	2.1 ± 0.65	19.6 ± 0.43	0 ± 0	2.5 ± 0.69	0 ± 0	2.5 ± 1.10	2.1 ± 0.12	1.7 ± 0.31
Ranunculaceae	*Adonis vernalis* L.	5.3 ± 0.58	7.5 ± 2.79	0 ± 0	6.4 ± 1.56	1.4 ± 0.42	6.5 ± 1.69	1.2 ± 0.53	2.1 ± 0.23
Rosaceae	*Amelanchier ovalis* Medik.	0 ± 0	17.4 ± 0.78	2.3 ± 0.37	4.1 ± 1.47	0 ± 0	4.1 ± 1.44	1.3 ± 0.36	0.7 ± 0.43
Rosaceae	*Prunus armeniaca* L.	2.3 ± 0.45	19.5 ± 0.24	0 ± 0	10.3 ± 1.47	1.2 ± 0.32	10.7 ± 1.53	0 ± 0	2.9 ± 0.75
Rosaceae	*Crataegus monogyna* Jacq.	0 ± 0	23.4 ± 0.45	1.1 ± 0.21	6.3 ± 1.23	6.3 ± 0.88	6.8 ± 1.63	10.4 ± 2.84*	2.8 ± 1.56
Rutaceae	*Citrus sinensis* (L.) Osbeck	6.5 ± 0.76	7.1 ± 0.79	3.3 ± 0.87	4.2 ± 1.49	5.6 ± 0.79	4.7 ± 1.54	0 ± 0	2.8 ± 0.52
Salicaceae	*Salix babylonica* L.	3.5 ± 0.53	27.6 ± 0.12	1.1 ± 0.12	2.4 ± 0.58	0 ± 0	2.1 ± 0.67	2.5 ± 0.34	1.7 ± 0.45
Saxifragaceae	*Bergenia crassifolia* (L.) Fritsch	8.8 ± 0.79	12.5 ± 0.44	2.2 ± 0.37	2.5 ± 0.87	6.3 ± 1.65*	2.3 ± 0.86	10.6 ± 3.17*	1.9 ± 0.89
Schisandraceae	*Schisandra chinensis* (Turcz.) Baill.	0 ± 0	23.7 ± 0.21	1.1 ± 0.24	4.7 ± 1.55	0 ± 0	23.7 ± 0.21	7.2 ± 2.52*	0.7 ± 0.44
Taxaceae	*Taxus baccata* L.	0 ± 0	17.5 ± 0.33	3.1 ± 0.44	10.3 ± 1.77	0 ± 0	10.6 ± 1.35	0 ± 0	2.5 ± 0.86
Teloschistaceae	*Xanthoria parietina* (L.) Th. Fr.	0 ± 0	2.3 ± 0.44	0 ± 0	10.3 ± 1.85	0 ± 0	10.5 ± 1.89	0 ± 0	2.4 ± 0.47

Note: the control was disks with benzylpenicillin sodium salt (one disk contains 6.0 μg of the preparation, according to Valle et al. (2015), * – $P < 0.05$ compared to the control group.

We obtained ambiguous results on the influence of ethanol extracts from the plants on *K. pneumonia*. We observed effective slowing of growth when the bacteria were exposed to *Artemisia annua* (ZIG – 12.6 mm), *Tanacetum vulgare* (10.7), *Eleutherococcus senticosus* (10.5), *Lavandula angustifolia* (10.4), and *Punica granatum* (10.3). Slightly less potent against the colonies of these bacteria were alcohol tinctures of *Echinacea purpurea* (8.5), *Petroselinum crispum* (7.7), *Bergenia crassifolia* (6.3), *Crataegus monogyna* (6.3), *Citrus sinensis* (5.6), *Ribes*

nigrum (5.6), *Buxus sempervirens* (5.3), *Melissa officinalis* (4.6) and *Cycas revoluta* (4.2). Thus, 14 out of 49 samples (28.6%) of tested plant material inhibited growth of colonies of *K. pneumonia*. Maximum ZIG of colonies of *P. vulgaris* bacteria was presented by *Punica granatum* (15.4 mm). Also, there was determined high efficiency of effect of preparations of *Bergenia crassifolia* (10.6), *Humulus lupulus* (10.5) and *Crataegus monogyna* (10.4). The lowest effect on *P. vulgaris* was exerted by *Schisandra chinensis* (7.2), *Paeonia suffruticosa* (6.1), *Echinacea purpurea* (5.3), *Lavandula angustifolia* (4.3), *Buxus sempervirens* (4.1). Thus, 9 of 49 samples (18.4%) of the studied plant material inhibited growth of colonies of *P. vulgaris*, producing ZIG which exceeded 4 mm.

None of the tested preparations (Table 3) exceeded the control (benzylpenicillin sodium salt) for size of ZIG for *L. monocytogenes*, though *Monarda fistulosa* gave ZGI of 5.3 mm, and *Punica granatum* – even 12.1 mm. We determined high resistance of *C. xerosis* during exposure to ethanol extracts of plants. High antibacterial activity was presented by *Punica granatum* (ZIG – 16.2 mm) against *C. xerosis*. Much lower activity against this species of bacteria was observed for alcohol tincture of *Adonis vernalis* (ZIG – 4.3 mm). Thus, only 2 of 49 samples (4.1%) of the studied plant material inhibited growth of colonies of *L. monocytogenes* and *C. xerosis* with ZIG exceeding 4 mm.

Tinctures of the studied species of plants had low effect on the growth of colonies of *C. albicans*: in none of cases did ZIG exceed 4 mm. At the same time, the parameter of the control (amphotericinin) did not exeed 2.7 mm. Therefore biological effect of the following plant extracts produced a ZIG of over 2 mm: *Juniperus communis* (3.4), *Levisticum officinale* (3.3), *Citrus sinensis* (2.5), *Echinacea purpurea* (2.3), *Prunus armeniaca* (2.3), *Humulus lupulus* (2.1).

Table 3

Antibacterial effect of herbal infusions on *Listeria monocytogenes*, *Corynebacterium xerosis* and *Candida albicans* (x ± SD, n = 12)

Family	Species	*L. monocytogenes*		*C. xerosis*		*C. albicans**	
		test	control	test	control	test	control
Apiaceae	*Levisticum officinale* W. D. J. Koch	0 ± 0	37.4 ± 1.23	2.4 ± 0.65	11.2 ± 1.89	3.3 ± 0.42	1.5 ± 0.34
Apiaceae	*Petroselinum crispum* (Mill.) Fuss	0 ± 0	40.5 ± 1.78	0 ± 0	9.7 ± 1.87	0 ± 0	0 ± 0
Apocynaceae	*Nerium oleander* L.	0 ± 0	37.4 ± 3.79	0 ± 0	7.7 ± 1.30	0 ± 0	1.9 ± 0.26
Apocynaceae	*Vinca minor* L.	0 ± 0	40.4 ± 2.67	0 ± 0	11.3 ± 1.75	0 ± 0	1.5 ± 0.32
Araliaceae	*Eleutherococcus senticosus* (Rupr. and Maxim.) Maxim.	0 ± 0	35.5 ± 2.43	0 ± 0	7.2 ± 1.10	0 ± 0	1.1 ± 0.23
Araliaceae	*E. sieboldianus* (Makino) Koidz.	0 ± 0	36.2 ± 4.64	0 ± 0	7.6 ± 1.24	0 ± 0	1.3 ± 0.19
Asparagaceae	*Yucca filamentosa* L.	1.2 ± 0.33	40.4 ± 2.44	0 ± 0	12.6 ± 1.13	0 ± 0	0 ± 0
Asteraceae	*Artemisia annua* L.	0 ± 0	36.1 ± 2.59	1.3 ± 0.22	11.1 ± 1.54	0 ± 0	1.1 ± 0.14
Asteraceae	*Echinacea purpurea* (L.) Moench	0 ± 0	38.3 ± 1.37	0 ± 0	9.5 ± 1.64	2.3 ± 0.82	0 ± 0
Asteraceae	*Matricaria recutita* L.	0 ± 0	39.5 ± 3.45	0 ± 0	7.1 ± 1.56	0 ± 0	2.3 ± 0.31
Asteraceae	*Tanacetum vulgare* L.	0 ± 0	38.6 ± 1.68	1.1 ± 0.18	11.9 ± 1.79	0 ± 0	1.7 ± 0.21
Betulaceae	*Betula pendula* Roth	0 ± 0	37.4 ± 1.55	0 ± 0	12.7 ± 1.65	0.5 ± 0.03	0 ± 0
Betulaceae	*Corylus avellana* L.	0 ± 0	40.2 ± 1.75	0 ± 0	10.4 ± 1.73	1.2 ± 0.62	1.3 ± 0.43
Buxaceae	*Buxus sempervirens* L.	0 ± 0	37.7 ± 2.17	0 ± 0	9.2 ± 1.39	1.3 ± 0.37	0 ± 0
Cannabaceae	*Humulus lupulus* L.	0 ± 0	37.3 ± 1.27	3.2 ± 0.32	10.8 ± 1.68	2.1 ± 0.72	1.3 ± 0.42
Crassulaceae	*Crassula ovata* (Miller) Druce	0 ± 0	39.2 ± 1.69	0 ± 0	7.2 ± 1.41	0 ± 0	2.2 ± 0.30
Crassulaceae	*Bryophyllum daigremontianum* (Raym.-Hamet and H. Perrier) A. Berger	0 ± 0	38.3 ± 2.58	0 ± 0	7.5 ± 1.54	0 ± 0	2.7 ± 0.45
Cupressaceae	*Juniperus communis* L.	0 ± 0	37.3 ± 2.56	0 ± 0	10.8 ± 1.56	3.4 ± 0.72	1.5 ± 0.54
Cupressaceae	*Platycladus orientalis* (L.) Franco	0 ± 0	35.3 ± 2.87	2.2 ± 0.69	10.8 ± 1.49	1.2 ± 0.12	1.7 ± 0.22
Cycadaceae	*Cycas revoluta* Thunb.	0 ± 0	37.1 ± 3.97	0 ± 0	7.5 ± 1.23	0 ± 0	1.5 ± 0.16
Ericaceae	*Calluna vulgaris* (L.) Hull	0 ± 0	37.7 ± 2.13	0 ± 0	10.8 ± 1.45	1.3 ± 0.22	1.2 ± 0.15
Ericaceae	*Rhododendron ferrugineum* L.	1.3 ± 0.29	37.3 ± 1.52	0 ± 0	12.5 ± 1.35	0 ± 0	0 ± 0
Fabaceae	*Ceratonia siliqua* L.	0 ± 0	35.2 ± 3.57	0 ± 0	12.3 ± 1.54	0 ± 0	0 ± 0
Fabaceae	*Trigonella foenum-graecum* L.	0 ± 0	38.2 ± 2.57	0 ± 0	12.3 ± 1.78	0 ± 0	0 ± 0
Grossulariaceae	*Ribes nigrum* L.	0 ± 0	38.5 ± 1.27	0 ± 0	11.5 ± 1.69	0 ± 0	1.8 ± 0.23
Hymenochaetaceae	*Phellinus tuberculosus* (Baumg.)	0 ± 0	35.2 ± 2.59	0 ± 0	10.3 ± 1.76	0 ± 0	1.7 ± 0.62
Lamiaceae	*Lavandula angustifolia* Mill.	0 ± 0	37.6 ± 1.44	0 ± 0	10.7 ± 1.97	1.3 ± 0.12	1.5 ± 0.18
Lamiaceae	*Melissa officinalis* L.	0 ± 0	35.3 ± 1.17	1.2 ± 0.17	11.4 ± 1.88	0 ± 0	1.4 ± 0.43
Lamiaceae	*Monarda fistulosa* L.	5.3 ± 0.98	37.3 ± 4.98	0 ± 0	7.7 ± 1.54	0 ± 0	2.1 ± 0.43
Lamiaceae	*Origanum vulgare* L.	0 ± 0	36.5 ± 1.44	0 ± 0	9.8 ± 1.71	0 ± 0	0 ± 0
Lamiaceae	*Salvia sclarea* L.	0 ± 0	37.2 ± 1.17	0 ± 0	7.3 ± 1.77	0 ± 0	2.1 ± 0.35
Lauraceae	*Laurus nobilis* L.	0 ± 0	38.2 ± 2.88	2.1 ± 0.65	7.1 ± 1.47	0 ± 0	1.1 ± 0.32
Lythraceae	*Punica granatum* L.	12.1 ± 2.43	38.4 ± 2.08	16.2 ± 2.32*	9.1 ± 1.44	0.5 ± 0.07	0 ± 0
Malvaceae	*Hibiscus rosa-sinensis* L.	0 ± 0	40.5 ± 1.43	0 ± 0	7.2 ± 1.54	1.3 ± 0.12	2.4 ± 0.62
Menispermaceae	*Menispermum dauricum* DC.	0 ± 0	37.3 ± 1.11	1.1 ± 0.12	10.3 ± 1.49	0 ± 0	1.4 ± 0.42
Moraceae	*Ficus benjamina* L.	0 ± 0	35.1 ± 1.88	0 ± 0	7.4 ± 1.33	0 ± 0	1.2 ± 0.34
Moraceae	*Morus alba* L.	1.1 ± 0.25	36.1 ± 4.63	0 ± 0	12.1 ± 1.77	0 ± 0	0 ± 0
Paeoniaceae	*Paeonia suffruticosa* Andrews	0 ± 0	36.1 ± 1.19	0 ± 0	11.1 ± 1.89	0 ± 0	1.4 ± 0.37
Pinaceae	*Picea abies* (L.) H. Karst	0 ± 0	37.2 ± 1.27	0 ± 0	11.7 ± 1.75	0 ± 0	1.5 ± 0.52
Ranunculaceae	*Adonis vernalis* L.	2.5 ± 0.65	36.3 ± 1.17	4.3 ± 0.78	10.3 ± 1.86	1.5 ± 0.12	1.1 ± 0.35
Rosaceae	*Amelanchier ovalis* Medik.	2.4 ± 0.74	36.2 ± 1.98	0 ± 0	11.7 ± 1.73	0 ± 0	1.5 ± 0.17
Rosaceae	*Prunus armeniaca* L.	0 ± 0	38.4 ± 1.04	0 ± 0	10.7 ± 1.69	2.3 ± 0.33	1.2 ± 0.47
Rosaceae	*Crataegus monogyna* Jacq.	0 ± 0	38.4 ± 2.67	0 ± 0	10.6 ± 1.84	0 ± 0	1.1 ± 0.28
Rutaceae	*Citrus sinensis* (L.) Osbeck	0 ± 0	36.2 ± 2.48	0 ± 0	9.4 ± 1.75	2.5 ± 0.65	0 ± 0
Salicaceae	*Salix babylonica* L.	0 ± 0	36.2 ± 2.66	0 ± 0	36.2 ± 2.66	0 ± 0	1.6 ± 0.63
Saxifragaceae	*Bergenia crassifolia* (L.) Fritsch	0 ± 0	37.7 ± 1.37	0 ± 0	11.9 ± 1.54	1.2 ± 0.12	1.3 ± 0.41
Schisandraceae	*Schisandra chinensis* (Turcz.) Baill.	0 ± 0	39.2 ± 1.13	1.1 ± 0.44	11.5 ± 1.96	0 ± 0	1.6 ± 0.25
Taxaceae	*Taxus baccata* L.	0 ± 0	39.4 ± 2.63	2.2 ± 0.54	10.6 ± 1.63	1.3 ± 0.22	1.6 ± 0.38
Teloschistaceae	*Xanthoria parietina* (L.) Th. Fr.	0 ± 0	36.2 ± 1.57	0 ± 0	10.1 ± 1.67	1.5 ± 0.23	1.4 ± 0.27

Note: the control was disks with benzylpenicillin sodium salt (one disk contains 6.0 μg of the preparation; disks with 15.0 μg amphotericinin were used as positive control for C. albicans (according to Valle et al., 2015), * – $P < 0.05$ compared to the control group.

Discussion

Extract from *Adonis vernalis* is used in homeopathic preparations, its cardiac effects were confirmed by prolonged use and presence of cardiac glycosides of cardenolide type (Dragoeva et al., 2015). Ethanol extract from *A. vernalis* in our experiment had low antibacterial effect

against *C. xerosis* (4.3) and *S. typhimurium* (5.3). Tinctures from *Artemisia annua* and *A. afra* exerted effect on the course of schistosomiasis in a large clinical study by Argemi et al. (2018). In our study, we observed high antibacterial for use of *A. annua* against *K. pneumonia* and *S. typhimurium* (12.6 and 7.3 mm), respectively.

Oxidative stress is initiated by reactive oxygen species (ROS), such as superoxide anion, perhydroxy radical and hydroxyl radical. Antioxidant defense systems have coevolved with aerobic metabolism to counteract oxidative damage from ROS. Extracts of *Bergenia* species (*B. ciliata*, *B. ligulata* and *B. stracheyi*) are best suited for lipid peroxidation mechanism by stopping the rupturing of veins. All these activities occur due to chemicals present in this plant, for example flavonoids, inorganic multivalent elements (calcium and iron) (Chauhan et al., 2016). According to the results of our study, the inhibitory effect of *B. crassifolia* was exerted on *P. vulgaris*, *K. pneumonia* and *S. typhimurium* (10.6, 6.3 and 8.8 mm).

Antibacterial and antimicrobial activity of different birch parts in general should be further explored when used as herbs and in herbal preparations (Duric et al., 2013). We confirm low antibacterial effect of *Betula pendula* only against *S. typhimurium* (4.3 mm).

In our experiment we determined the inhibitory effect of *Buxus sempervirens* on *P. vulgaris* and *K. pneumonia* (4.1 and 5.3 mm respectively).

Ethyl acetate extract of *Citrus sinensis* exhibited inhibitory action against against gram-positive *S. aureus*, *B. subtilis*) and gram-negative (*E. coli* and *S. typhi*) bacteria (Haroen et al., 2018). We confirm low antibacterial effect of *Citrus sinensis* on *C. albicans* (2.5 mm) and slightly higher at inhibition of growth of bacteria of *K. pneumonia* and *S. typhimurium* (5.6 and 6.5 mm, respectively).

Our studies confirm the data provided by Muiruri & Mwangi (2016) about inhibitory properties of *Crassula ovata* for *E. coli* (in our experiment, zone of inhibition of growth equaled 12.3 mm), and also we determined antibacterial effect of this plant on *S. typhimurium* (4.1 mm).

The highest antibacterial activities were recorded for the yellow azarole leaf and fruit peel extracts, especially against *S. aureus* and *S. faecalis* (Belkhir et al., 2013). We obtained high antibacterial effect of *Crataegus monogyna* on *P. vulgaris* and *K. pneumonia* (10.4 and 6.3 mm, respectively).

The structural and antimicrobial characteristics of Cy-AMP1 and Cy-AMP2 indicate that they are a novel type of antimicrobial peptide belonging to the plant defensin family (Yokoyama et al., 2008). We noted the inhibitory effect caused by *Cycas revoluta* only on *K. pneumonia* (4.2 mm).

Preparations from *Echinacea purpurea* are broadly used for treating influenza-like illnesses of children and adults (Mandal et al., 2010). We determined inhibitory effect of eastern purple coneflower (*Echinacea purpurea*) against *C. albicans* (2.3 mm), *E. coli* (4.2 mm), *P. vulgaris* (5.3 mm) and *K. pneumonia* (8.5 mm).

Results obtained by Jang et al. (2016) suggest that the fruit of Siberian ginseng may be a good candidate as a source of antioxidant and antimicrobial ingredients – antimicrobial activity was observed against *Kocuria rhizophila* (MIC = 125 μg/mL), *Micrococcus luteus* (MIC = 500 μg/mL), and *Escherichia coli* (MIC = 63 μg/mL). We determined antibacterial effect of *Eleutherococcus senticosus* on *K. pneumonia* (10.5 mm).

Yarmolinsky et al. (2012) observed anti-virus action of *Ficus benjamina*: crude ethanol extracts from leaves of this species strongly inhibited Herpes Simplex Virus 1 and 2 (HSV-1/2) as well as Varicella Zoster Virus (VZV) cell infection *in vitro*; we determined inhibitory effect on *S. typhimurium* (7.6 mm).

Wounds treated with both *Hibiscus rosa-sinensis* leaves water and ethanol extracts showed better healing with slightly visible fine line scar (Ali, 2014). We obtained positive antibacterial effect only against *S. typhimurium* (4.1 mm).

Hop extract inhibited the growth and metabolism of *Streptococcus bovis*, but *Selenomonas ruminantium* and *Megasphaera elsdenii* were not affected (Flythe & Aiken, 2010). According to our data, *Humulus lupulus* has a notable inhibitory effect on *P. vulgaris* (10.5 mm) and insignificant effect on *C. albicans* (2.1 mm).

Results concerning the antifungal activity of *Juniperus communis* demonstrated the potential of needle oil against dermatophytes, particularly for *Microsporum canis* and *Trichophyton rubrum* with MIC and MLC of 0.32 μL/mL (Cabral et al., 2012). We observed only antimicrobial effect of *Juniperus communis* against *C. albicans* (3.4 mm). Maajida Aafreen et al. (2019) determined anti-inflammatory activity of *Laurus nobilis*. We established a strong high inhibiting action on *S. typhimurium* (13.3 mm).

Ebrahimi et al. (2016) discovered that *Levisticum officinale* extracts inhibited the growth of the reference strains of *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Escherichia coli* and *Salmonella enteritidis* within a concentration range of 3125 to 25000 μg/mL. We have confirmed low inhibitory effect only on *C. albicans* (3.3 mm).

Korcan et al. (2018) have reported strong antimicrobial effects of the oils from *Melissa officinalis* against tested bacteria (*Salmonella typhimorium*, *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus*). We confirm inhibitory action of the preparations from this plant on *S. typhimurium* (7.4 mm), and also found antibacterial effect on *K. pneumonia* (4.6 mm).

Monarda showed a lower minimum inhibitory concentration, i.e. a stronger activity, against pathogenic (*Escherichia coli*, *Erwinia amylovora* and *Candida albicans*) than beneficial microorganisms (*Bifidobacterium animalis* and *Lactobacillus casei*) (Mattarelli et al., 2017). We observed antibacterial effect of this plant only against *L. monocytogenes* (5.3 mm).

Significant antibacterial potential of *Morus alba* against *Staphylococcus aureus* (14 mm) was higher than against *Escherichia coli* (10 mm) and was shown at well diffusion method (Arshad, 2018). We confirm inhibitory effect only for *E. coli* (4.1 мм).

Chemical extract of *Nerium oleander in vitro* displayed antibacterial, antifungal activities and antiviral effects in the treatment of Parainfluenza-3 (Avci, 2014). We confirm antibacterial effect only against *S. typhimurium* (6.2 mm).

Various *Origanum vulgare* clones and plant parts showed different activity on the studied microorganisms (Alsiņa et al., 2010). We determined inhibitory effect of oregano on *S. typhimurium* (5.6 mm).

Paeonia suffruticosa is an important Chinese medicinal herb. Studies by Gao & He (2017) indicate strong antiproliferative and antimetastasizing effect of this species. We observed inhibiting effect of *P. suffruticosa* for *P. vulgaris* (6.1 mm).

Seyyednejad et al. (2008) determined antibacterial activity of *Petroselinum crispum* against *Brucella melitensis*, *E. coli* and *Bacillus licheniformis*. We confirm inhibiting activity of parsley against *E. coli* (4.3 mm), and also observed high effect on *K. pneumonia* (7.7 mm).

The data of Fan et al. (2011) indicate that the inhibitory effects of the chloroform fraction and its components (hinokiol and acacetin) on 5-lipoxygenase contribute to the anti-inflammatory activity of *Platycladus orientalis*. We confirm antibacterial effect on *S. typhimurium* (7.4 mm).

The most effective antibacterial activity of *Prunus armeniaca* was observed in the ethanolic extract of the fruits against *Staphylococcus aureus*, *Bacillus subtilis*, *Proteus vulgaris* and *Escherichia coli* (Sehgal, 2012). We observed only low activity in inhibiting *C. albicans* (2.3 mm).

Macrophages are polarized into different phenotypes depending on microenvironment of the tissue where they reside. In obesity-associated inflammation, M_1-type macrophages are predominant in the inflamed tissue, exerting pro-inflammatory responses. Studies by Lee & Lee (2019) demonstrated that blackcurrant consumption attenuates hepatic inflammation and lipopolysaccharide-stimulated inflammatory responses of splenocytes in obese mice. In this study, we determined whether blackcurrant modulates macrophage phenotypes exert anti-inflammatory action. We obtained inhibitory effect of *Ribes nigrum* against *K. pneumonia* (5.6 mm).

The antibiofilm activity of *Salvia sclarea* extracts was determined against *Staphylococcus* aureus and *S. epidermidis* (Küçük et al., 2019). In our experiment, we determined inhibitory effect of *S. sclarea* against *E. coli* (4.3 mm).

Han (2016) reports that Schisandra chinensis extract is effective against *E. coli*, and increase *L. bulgaricus* number and the antibacterial mechanism for *E. coli* is as follows: the extract decreases the number of cell divisions in logarithmic phases and induces the voids of cell walls to increase, thus the materials in the cell leak out. We determined inhibitory effect against *P. vulgaris* (7.2 mm).

Essential oil and extract of costmary was characterized by stronger antibacterial activity (expressed as MIC and MBC values) than tansy. In turn, tansy extract was distinguished by higher antioxidant potential (determined by FRAP and DPPH) in comparison to costmary (Bączek et al., 2017). There was determined positive antibacterial effect of *Tanacetum vulgare* against *K. pneumonia* and *S. typhimurium* (10.7 and 6.4 mm respectively).

Glycosides were isolated and determined as bedelphinidin 3-G *Vinca major* by chemical and spectroscopic methods (Tatsuzawa, 2015). We confirmed inhibitory effect of *Vinca major* only on *E. coli* (4.1 mm).

Minimum inhibitory concentration of 5% ether oil from *Lavandula angustifolia* decreased population of bacteria in the air (Kurniawansyah et al., 2018). We observed positive effect of lavender on *P. vulgaris* and high inhibiting effect on *K. pneumonia* and *S. typhimurium* (4.3, 10.4 and 10.4 mm respectively).

We obtained maximum inhibitory effect against 6 strains of microorganisms exposed to *Punica granatum* on *K. pneumonia*, *L. monocytogenes*, *S. typhimurium*, *P. vulgaris*, *C. xerosis* and *E. coli* (10.3, 12.1, 14.3, 15.4, 16.2 and 17.2 mm respectively).

Conclusion

Maximum inhibitory effect was observed for *Punica granatum* against *K. pneumonia*, *L. monocytogenes*, *S. typhimurium*, *P. vulgaris*, *C. xerosis* and *E. coli*; *Lavandula angustifolia* against *P. vulgaris*, *K. pneumonia* and *S. typhimurium*; *Echinacea purpurea* against *C. albicans*, *E. coli*, *P. vulgaris*, *K. pneumonia*; *Bergenia crassifolia* against *P. vulgaris*, *K. pneumonia* and *S. typhimurium*. The obtained results allow food additives to be developed for veterinary and medical use for people and animals, affected by heightened risk of infection with bacterial and fungal infections, on the basis of phytopreparations.

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