Antibacterial and fungicidal activities of ethanol extracts from *Cotinus coggygria*, *Rhus typhina*, *R. trilobata*, *Toxicodendron orientale*, *Hedera helix*, *Aralia elata*, *Leptopus chinensis* and *Mahonia aquifolium*

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The search for promising plants with bactericidal and fungicidal activity is of great interest for practical and veterinary medicine. This article reveals the high antibacterial effect of the use of ethanol extracts from 8 species of plants of the families Anacardiaceae (*Cotinus coggygria* Scop., *Rhus typhina* L., *Rhus trilobata* Nutt. and *Toxicodendron orientale* Greene), Araliaceae (*Hedera helix* Linnaeus and *Aralia elata* (Michx.) Srnn.), Phyllanthaceae (*Leptopus chinensis* (Bunge) Pojark.), Berberidaceae (*Mahonia aquifolium* Pursh) against 23 strains of bacteria and one strain of fungi. The *in vitro* experiment revealed the zone of inhibition of growth of colonies exceeding 8 mm during the application of ethanol extracts of *C. coggygria* against twelve species of microorganisms (*Enterococcus faecalis*, *Escherichia coli*, *Staphylococcus aureus*, *S. epidermidis*, *Bacillus cereus*, *Listeria ivonii*, *Corynebacterium xerosis*, *Rhodococcus equi*, *Proteus vulgaris*, *P. mirabilis*, *Serratia marcescens* and *Candida albicans*), *Rhus typhina* – against twelve species (*E. faecalis*, *E. coli*, *S. aureus*, *S. epidermidis*, *L. ivonii*, *C. xerosis*, *R. equi*, *P. vulgaris*, *S. marcescens* and *C. albicans*), *Rhus trilobata* – against fourteen (*E. faecalis*, *E. coli*, *S. aureus*, *S. epidermidis*, *B. subtilis*, *B. cereus*, *L. ivonii*, *C. xerosis*, *R. equi*, *P. vulgaris*, *P. mirabilis*, *Pseudomonas aeruginosa*, *Yersinia enterocolitica* and *C. albicans*), *Toxicodendron orientale* – against eleven (*E. faecalis*, *S. aureus*, *L. innocua*, *C. xerosis*, *Corynebacterium jejunii*, *R. equi*, *P. vulgaris*, *P. mirabilis*, *P. aeruginosa* and *C. albicans*), *Hedera helix* – against seven (*S. aureus*, *S. epidermidis*, *L. monocytogenes*, *C. jejunii*, *R. equi*, *P. vulgaris* and *C. albicans*), *Aralia elata* – against nine (*E. coli*, *S. aureus*, *B. cereus*, *S. epidermidis*, *P. vulgaris*, *P. mirabilis*, *S. typhimurium*, *S. marcescens* and *C. albicans*), *Leptopus chinensis* – only against four (*E. coli*, *S. epidermidis*, *B. cereus* and *P. mirabilis*) and *Mahonia aquifolium* – against only three species (*S. epidermidis*, *C. jejunii* and *P. vulgaris*). As a result of the research, the most promising for studying in future regarding *in vivo* antibacterial activity were determined to be *C. coggygria*, *Rhus typhina*, *R. trilobata*, *Toxicodendron orientale* and *Aralia elata*.

Keywords: growth inhibition zone; bacterial colonies; poly-resistant strain; candidiasis.

Introduction

Recently, reports have appeared with increasing frequency about the potential possibilities of the search for effective antibacterial substances in plant extracts in the context of the spread of antibiotic poly-resistant strains which are hard to treat (Zazharskyi et al., 2019a; Palchykov et al., 2020). Natural products produced by Embryophyta as secondary metabolites are Abortive, with long pedicels, in indeterminate inflorescences. Some products of the species of the Anacardiaceae family, including mango (*Mangifera indica* L.) and rose pepper (*Pistacia vera* L.), are attractive because of their beautiful inflorescences, evergreen or bright-coloured autumn. Plants of the Anacardiaceae family are well-known for their cultivation edible fruits and seeds, dermatitis-causing taxa (for example, *Cnidoscolus* Mettenius, *Sorocarpus*, *Toxicodendron*), medical compounds, valuable timber and vanish-bearing plants (*Toxicodendron* and *Gutta*). Many species of Anacardiaceae are also valuable for their attractiveness in gardens. Specimens of *Rhus*, *Schinus*, *Searsia*, *Pistacia chinensis* Bunge, *P. mexicana* Kunth, *Smilax* and *Toxicodendron* are attractive because of their beautiful inflorescences, evergreen or bright-coloured autumn leaves. Some products of the species of the Anacardiaceae family, including mango (*Mangifera indica* L. and other species), pistachio (*Pistacia vera* L.), cashew (*Anacardium occidentale* L.) and rose pepper (*Schinus terebinthifolius*) are used in food all around the globe.

*Rhus typhina* L. is a fast-growing species which reproduces by rhizomes and seeds. Due to its biological advantages, this deciduous species of the Anacardiaceae family has been brought to urbanized landscapes of Ukraine from native areas in the East of North America. Zazharskyi et al.
(2018) analyzed the changes in morphometric and physiological parameters of 12-year-old plants of this species in artificial phytocenoses near the roads in Pavlograd (Ukraine). Compared with plants in relatively clean zone, the greatest decrease in the length of annual shoots of the trees was observed in those at the distance of 25–40 m from the highway. Leaves of *R. typhina* contain several galloyltransferases which catalyze β-glucosyl-
lin-dependent transformation of 1,2,3,4,6-pentagalloylglucose to gallotannins, have excellent thermostability and high tolerance to cold (Niemetz & Gross, 2001). Allopelopathy plays a role in the formation of resistance of *R. typhina* to invasion (Wei et al., 2017). Wang & Zhu (2017) suggest using *R. typhina* as an antioxidant in food, nutraceutical and cosmetic industries.

Methanol extract of leaves of *C. coggygria* was tested against seven strains of bacteria (*B. subtilis*, *S. aureus*, *E. coli*, *E. aerogenes*, *P. pneumotropica*, *P. vulgaris* and *P. aeroginosa*) using the method of disk diffusion. Extract from *C. coggygria* in the concentration of 10, 20 µg/mL and 1 mg/mL displayed moderate effect on all the named strains of bacteria (Singh et al., 2012).

Method of diffusion in agar was used to assess the activity of hexane, ethanolic and aqueous extracts from *C. coggygria* in the concentrations of 12.5, 25 and 50 mg/mL towards *Streptococcus mutans, S. sobrinus, Lactobacillus casei* and *Actinomyces viscosus*. Water and ethanolic extracts of *C. coggygria* demonstrated significant activity against all four indicated bacteria in all of the tested concentrations (Ferrazzano et al., 2013).

Essential oils from leaves with young shoots of *C. coggygria* in Serbia were tested for antibacterial and antifungal activities (Novakovic et al., 2007). Essential oil produced inhibition zones measuring 6–23 mm. The largest inhibition zones were observed against species of *Staphylococcus* and *Escherichia coli*, while the smallest were observed against *Proteus mirabilis*. Essential oil exerted higher antibacterial activity than streptomycin, which was used as positive control, except in the case of *P. mirabilis*. Bacteriostatic activity of the oil ranged within the concentrations of 2.5–5.0 µL/mL, while its bactericidal concentration – 2.5–10.0 µL/mL.

There are two major ways of action of antiviral agents: the first one is inhibiting infection, and the other is inhibition of replication of virus. The activity of the extract from *C. coggygria* against infection and replication was determined using the methods of local effect and disk method (Jing et al., 2012). Ethanol extract from leaves of *C. coggygria* exhibited especially strong inhibiting activity towards the infection with Tobacco mosaic virus (TMV – 93.5%), and significantly inhibited the replication of this virus (38.2%).

Ilczuk & Jacobgrad (2016) assessed the efficiency of aqueous extract from *C. coggygria* in an *in vitro* experiment against the tissue factor in the samples of saliva obtained from clinically healthy people. Extract from *C. coggygria* caused increase in the buffer ability of the saliva, decrease in the number of bacteria and prevented the aggregation of bacteria.

Rendeková et al. (2015) determined the anti-biofilm activity of extract from *C. coggygria* against two strains from the collection and ten clinical strains of *S. aureus*. The tested extract exerted bactericidal activity against all strains of *S. aureus*, particularly strains sensitive to meticillin (in the concentrations of 0.313–0.625 mg/mL). The concentrations of extract from *C. coggygria* which inhibited the formation of biofilm were 10–100 times higher (up to 32 mg/mL). Phytochemical analysis of *C. coggygria* detected quercetin, rhamnoside, methyl gallate and methyl trigalate as the main constituents of the extract. The results of the research revealed that *C. coggygria* is rich in tannins and flavonoids and is a promising local antibacterial preparation with anti-biofilm activity (Rendeková et al., 2015). *C. coggygria* is a commercial decorative plant with broad range of medical use. It is one of the most important species of trees used in ecological and landscape plantations in China, the main component of the landscape formed of red leaves in Beijing region in autumn (Wang et al., 2012; Fraternali & Ricchi, 2018).

Species of the *Hedera* genus are widely used in greenery. Researchers from Dresden University of Applied Sciences (Germany) are undertaking surveys on hydroponic facing of facades using *Hedera* (Koleva, 2015), as well as possibility of future optimization of these new ecosystems.

Hu & Wang (2008) demonstrated that anosolide A obtained from the seeds of *Aralia elata* (Miq.) Seem. has anti-inflammatory activity which inhibits the production of NO and anti-cancer activity against SNU-1, cancer cells of AGS and cancer cells of melanoma, despite its low antioxidant activity. Hu & Wang (2008) presume that triepene saponins from *A. elata* can play important role in displaying antibacterial and neuroprotective properties of tinctures of the plant.

Fadılıoğlu & Çoban (2019) state that alcohol extract of *Rhus trilobata* Nunt. may be used as a natural antioxidant, antibacterial agent and glaze material for slowing of the oxidation of lipids and inhibition of loss of quality of frozen fish.

Zhang & Shi (2020) presume that correct addition of *Leptopus chinensis* (Bunge) Pojak. could be one of the strategies of feeding which improve the digestion and digestion of dietary fibre and potentially reduce defecation in quality feed for ruminant animals, modeling the microbial community of scar.

Therefore, the species of plants we examine in this paper remain unstudied regarding their antimicrobial activity and could have a significant potential for human and veterinary medicine. The objective of this article was determining the antibacterial effect of ethanol extracts from *Cotinus coggygria*, *Rhus typhina*, *R. trilobata*, *Toxicodendron orientale*, *Hedera helix*, *Aralia elata*, *Leptopus chinensis* and *Mahonia aquifolium* on separate species of microorganisms in *in vitro* experiments.

### Materials and methods

The leaves and shoots of eight species of plants (Table 1) were collected in the territory of the Botanical Garden of Oles Honchar Dnipropetrovsk National University (Khromykh et al., 2018; Boyko & Brygadyrenko, 2019), dried at room temperature, fragmented, weighed and maintained for 10 days in 70% ethyl alcohol, and filtered.

Antibacterial activity of the plant tinctures were determined using disk diffusion in agar. From daily culture of ethanolic strains of microorganisms, we prepared weighed amounts according to the standard of opacity of material for slowing of the oxidation of lipids and inhibition of loss of quality of frozen fish.

The obtained weighted amount was inoculated to Muller-Hinton agar (Himedia) with subsequent cultivation in TCO-801 thermostat for 24 h at the temperature of 37 °C. On top of the inoculations, we put disks saturated with the tinctures of the extracted ethanol tinctures of four species of plants (Table 1).

### Table 1

| Family          | Species                     | Used part of the plant | Literature sources about the action of plants on bacteria |
|-----------------|-----------------------------|------------------------|---------------------------------------------------------|
| Anacardiaceae   | *Cotinus coggygria* Soop.   | shoots                 | Novakovic et al. (2007)                                  |
| *Rhus trilobata* Nunt. |                    | shoots                 | Pfeiffer & Drinnhagen (2010)                             |
| *R. typhina* L.  |                            | leaves                 | Kossai et al. (2011), Zhu et al. (2020)                  |
| *Toxicodendron orientale* Greene |          | leaves                 | Zhu & Zhu (2014), Krüger (2017)                          |
| *Aralia elata* (Miq.) Seem. |              | leaves                 | Pane et al. (2007), Pollet et al. (2009), Stradai et al. (2018) |
| *Leptopus chinensis* (Bunge) Pojak. |         | leaves                 | Zhang et al. (2018)                                     |
| *Mahonia aquifolium* (Pursh) Nunt. |             | leaves                 | Sochorova, R. (1998)                                    |

As positive control, we used disks with 15.0 µg of azithromycin – 9-decenoic-9a-aza-9a-methyl-9a-homochromyacin A – macrolide antibiotic of broad spectrum of action. Discs with 15.0 µg amphotericin were also used as a second control against *C. albicans* (Valle et al., 2015). After 24 h, the growth of the culture was assessed using antibiotic zone scale for measuring the growth inhibition zones of microorganisms (Antibiotic...
Zone Scale-C, model PW297, India) and software TpsDig2 (F. James Rohlf, 2016). The data in tables are presented as x ± SD (standard deviation).

Results

Prevention of growth of separate strains of microorganisms was seen under the influence of ethanol extracts from the studied plants (Table 2, 3). C. coggia exhibited the highest inhibiting activity, slowing the growth of E. faecalis (10.2 mm, hereafter the average radius of growth inhibition zone is indicated in mm), two strains of E. coli (F50 and 055 – 16.4 and 12.4 mm respectively), Proteus vulgaris (10.7), P. mirabilis (12.4), S. marcescens (13.7) during moderate slowing of growth for Y. enterocolitica (5.7). The extract from Rhus typhina competed with C. coggia for influence on E. faecalis (11.3), E. coli F50 (12.5), S. aureus and S. epidermidis (8.3 and 10.7), L. ivanovi (9.7), C. albicans (11.7), Rh. equi (10.3), P. vulgaris (9.6), S. pyrogenes and S. adhalcroc (10.2 and 10.6), S. marcescens (12.3) and C. albicans (9.3), and at the same time moderately slowed the growth of B. subtilis (3.5), P. mirabilis (7.8), P. aeruginosa ATCC 2799 (6.3) and Y. enterocolitica (4.5). Antibacterial effectiveness was determined for alcohol extract of R. triloba against E. faecalis (10.4), E. coli 055 (11.4), P. vulgaris and P. mirabilis (11.7 and 20.7), Y. enterocolitica (11.3), it also moderately slowed the growth of P. aeruginosa (4.2). Extract of T. orientale had notable inhibiting activity towards E. faecalis (12.7), P. vulgaris (10.5), moderate activity towards E. coli 055 (6.8) and P. mirabilis (8.7).

Table 2

The width of zone of growth inhibition (mm) for the ethanol extracts of Anacardiaceae families against 24 strains of microorganisms (n = 8)

| Strains of microorganisms | Cotinus coggyria | Rhus typhina | Rhus triloba | Toxicodendron orientale | Control* |
|---------------------------|-----------------|--------------|--------------|------------------------|----------|
| E. coli ATCC 19433        | 10.2 ± 0.32     | 11.3 ± 1.13  | 10.4 ± 0.78  | 12.7 ± 1.34            | 23.9 ± 2.45 |
| Escherichia coli F50      | 3.7 ± 0.19      | 1.6 ± 0.14   | 4.2 ± 0.42   | 2.6 ± 0.41             | 15.9 ± 1.67 |
| S. aureus ATCC 25923      | 12.4 ± 1.34     | 0 ± 0        | 11.4 ± 1.43  | 6.8 ± 0.55             | 15.6 ± 1.62 |
| P. vulgaris ATCC 14090    | 11.9 ± 1.54     | 10.7 ± 1.22  | 14.4 ± 0.78  | 0 ± 0                  | 10.3 ± 3.14 |
| Bacillus subtilis ATCC 663 | 0 ± 0          | 3.5 ± 0.86   | 12.8 ± 1.45  | 4.5 ± 0.77             | 30.3 ± 3.05 |
| B. cereus ATCC 10702      | 12.6 ± 1.43     | 2.3 ± 0.89   | 9.5 ± 1.76   | 4.2 ± 0.72             | 16.8 ± 1.86 |
| L. ivanovi ATCC 25923     | 15 ± 1.32       | 9.7 ± 0.87   | 9.9 ± 0.77   | 4.3 ± 0.32             | 14.7 ± 2.11 |
| S. marcescens ATCC 19112  | 0 ± 0          | 0 ± 0        | 10.7 ± 1.41  | 2.8 ± 0.25             | 0 ± 0      |
| C. albicans ATCC 1201      | 11.2 ± 1.38     | 9.3 ± 0.89   | 16.8 ± 1.78  | 17.8 ± 1.78            | 0 ± 0 / 24 ± 0.21*** |

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

Table 3

The width of growth inhibition zone (mm) produced by ethanol extracts of Hedera helix, Aralia elata, Leptopus chinensis and Mahonia aquifolium against 24 strains of microorganisms (n = 8)

| Strains of microorganisms | Hedera helix | Aralia elata | Leptopus chinensis | Mahonia aquifolium | Control* |
|---------------------------|-------------|-------------|-------------------|-------------------|----------|
| E. coli ATCC 19433        | 0 ± 0       | 0 ± 0       | 0 ± 0             | 3.2 ± 0.65        | 23.9 ± 2.45 |
| E. coli ATCC 10006        | 3.8 ± 0.34  | 11.9 ± 1.16 | 11.5 ± 0.78       | 1.5 ± 0.12        | 17.8 ± 1.87 |
| S. aureus ATCC 25923      | 0 ± 0       | 10.6 ± 0.98 | 3.6 ± 0.32        | 2.7 ± 0.43        | 15.6 ± 1.62 |
| P. vulgaris ATCC 14090    | 23.5 ± 2.78 | 9.7 ± 0.78  | 2.6 ± 0.21        | 2.8 ± 0.19        | 21.6 ± 2.45 |
| B. cereus ATCC 14153      | 26.7 ± 2.15 | 18.7 ± 1.78 | 21.6 ± 0.38       | 10.3 ± 3.4        | 21.6 ± 2.45 |
| B. cereus ATCC 10702      | 0 ± 0       | 15.8 ± 2.34 | 10.8 ± 0.09       | 4.7 ± 1.21        | 16.8 ± 1.86 |
| L. ivanovi ATCC 19112     | 0 ± 0       | 0 ± 0       | 1.6 ± 0.19        | 0 ± 0             | 14.7 ± 1.21 |
| L. monoxyantha ATCC 25923 | 9.3 ± 1.22  | 0 ± 0       | 0 ± 0             | 0 ± 0             | 25.1 ± 1.98 |
| C. albicans ATCC 1201     | 4.4 ± 0.19  | 8.4 ± 0.89  | 0 ± 0             | 3.6 ± 0.21        | 9.3 ± 1.34 |
| B. subtilis ATCC 13000    | 12.4 ± 1.26 | 0 ± 0       | 2.4 ± 0.32        | 17.5 ± 1.43       | 0 ± 0      |
| S. aureus ATCC 13015      | 11.8 ± 0.77 | 2.2 ± 0.18  | 1.3 ± 0.13        | 1.6 ± 0.21        | 19.1 ± 1.98 |
| M. aeruginosa ATCC 14028  | 10.8 ± 1.21 | 9.3 ± 0.11  | 4.2 ± 0.77        | 9.4 ± 0.77        | 0 ± 0      |
| B. cereus ATCC 14028      | 5.4 ± 0.77  | 9.7 ± 0.76  | 0 ± 0             | 1.4 ± 0.18        | 203.3 ± 1.54 |
| B. subtilis ATCC 13015    | 2.8 ± 0.54  | 4.4 ± 0.57  | 2.3 ± 0.22        | 7.2 ± 0.76        | 263.3 ± 2.76 |
| P. aeruginosa ATCC 2799   | 2.3 ± 0.45  | 0 ± 0       | 0 ± 0             | 2.2 ± 0.34        | 0 ± 0      |
| C. albicans ATCC 13000    | 2.8 ± 0.35  | 8.2 ± 0.78  | 3.5 ± 0.34        | 1.1 ± 0.36        | 0 ± 0      |
| C. albicans ATCC 2001     | 10.7 ± 1.03 | 13.6 ± 1.45 | 2.6 ± 0.32        | 5.7 ± 0.45        | 0 ± 0 / 24 ± 0.21*** |

Note: see Table 2.

Antibacterial effect was determined for the extracts of R. triloba and T. orientale on P. aeruginosa (10.1 and 17.4); T. orientale – against C. jejunii (12.7), both of which had antibacterial resistance to azithromycin (growth inhibition zone of 0 mm). Also, significant inhibiting effect of the tested alcohol extracts should be noted against S. aureus (15.8 and 10.8 mm, respectively). During the study on the influence of the extracts...
on the microorganisms of the Bacillaceae family, notable impact was observed for C. coggnygia on B. cereus (12.6 mm) and R. trilobata on B. subtilis and B. cereus (12.8 and 9.5). Moderate and high inhibitory effects on the microorganisms of the Listeriaceae family: C. coggnygia slowed the growth of L. ivanovi (9.8), T. orientale – L. innocua (10.7). Azithromycin was not effective against L. monocyogenes (0 mm). There was seen high inhibiting effect of the extracts from C. coggnygia, R. trilobata and T. orientale against C. xerosis (15.8, 11.5, 11.7), Rh. equi (11.7, 12.6, 10.2) and C. albicans (11.2, 16.8 and 17.8 mm, respectively). At the same time, the radius of the zone of inhibition of growth produced by amphotericin b exceeded only 2.4 mm.

Against the background of effective inhibition of microorganisms E. faecalis, E. coli 055 (except Rhys typhina), S. aureus, S. epidermidis (except T. orientale), L. ivanovi, C. xerosis, Rh. equi, P. vulgaris, P. mirabilis and C. albicans by ethanol extracts of plants of the Anacardiaceae family, we should note antibiotic-resistance of P. vulgaris, P. mirabilis, K. pneumoniae, S. marcescens to azithromycin (0 mm).

Extracts from H. helix, L. chinensis and M. aquifolium have high inhibitory effect on S. epidermidis (26.3, 18.7 and 21.6 mm), at the same time the growth inhibition zone exceeded the control by 16.0, 8.4 and 11.3 mm; H. helix and A. etala showed impact against S. aureus (23.5 and 9.7 mm), C. albicans (10.7 and 13.6 mm), H. helix, A. etala and M. aquifolium against P. vulgaris (10.8, 9.3 and 9.4 mm), A. etala and L. chinensis – E. coli F50 (11.9 and 11.5 mm), B. cereus (15.8 and 10.8 mm), P. mirabilis (14.7 and 10.6 mm), H. helix and M. aquifolium – C. jejuni (12.4 and 17.5 mm).

Furthermore, high antibacterial effect of H. helix was displayed against L. monocyogenes (9.3), A. etala – E. coli 055 (10.6), S. typhimurium (9.7), while M. aquifolium moderately inhibited S. adbraco and C. albicans (7.2 and 5.7 mm). Antibiotic resistance was determined for L. monocyogenes, C. jejuni, P. vulgaris, P. mirabilis, P. aeruginosa, K. pneumoniae, S. marcescens to the control group (azithromycin 0) and C. albicans to amphotericin b (2.4).

Discussion

Antimicrobial activity of ethanol extract of C. coggnygia was surveyed by Milošević et al. (2008). Extracts from leaves of C. coggnygia inhibited S. aureus and P. aeruginosa, producing growth inhibition zones of 13 and 10 mm. Despite the fact that C. albicans and E. coli were included in this study, Milošević et al. (2008) did not report about inhibition of these microorganisms.

Antibacterial activity of extracts from leaves of C. coggnygia growing mostly naturally in Turkey (Han et al., 2009), prepared using different solvents, was determined using disk diffusion method. The extract was found to be most efficient against E. faecalis (diameter of the inhibition zone of 20 mm) in distilled water, and methanol extract was most effective against S. aureus, S. epidermidis and E. faecalis (Han et al., 2009).

Antimicrobial activity expressed as minimum inhibitory concentration (MIC) of acetone extract and fractions obtained from young shoots of C. coggnygia ranged 3–200 mg/ml (Marčetić et al., 2012). Acetone extract inhibited the growth of Gram-positive bacteria S. epidermidis (MIC = 25 mg/ml) and S. aureus (MIC = 25 mg/ml), whereas the ethyl acetate fraction was active against B. subtilis (MIC = 25 mg/ml), K. pneumoniae (MIC = 50 mg/ml) and E. coli (MIC = 50 mg/ml). The greatest activity with chloroform fraction was seen towards C. albicans yeasts (MIC = 3.1 mg/ml), more efficiently than with the control antifungal preparation – nystatin (6.2 mg/ml).

Hooshyar et al. (2014) recommend further research on the use of the main constituents of H. helix, especially hederaesaponnin (saponin K10), to study the antiinflammatory activity towards L. major. Shchorkov et al. (2017) recommend using H. helix in the sphere of food chemistry, food technologies and nutraceutical studies (for diet-therapy and cosmetics).

García-Ramírez et al. (2016) studied in vitro anti-amoecic activity of extracts from fruits and stems of Rhus trilobata towards Entamoeba histo-lytica. Also, Varela-Rodríguez et al. (2019) report that flavonoids, phenol-lic and fatty acids, and also quercitin, methyl gallate, epigallocatechin 3-cinnamate, fisetin and marginal acid, included in the content of R. trilobata, can have anti-cancer properties.

Aschenbeck & Hylwa (2017) consider that Toxicodendron orientale has local antibacterial effect.

Ethanolic tunicate of Aralia elata (Brygadyrenko et al., 2019) exerted low immunosuppressive action, in the conditions of high fat diet, leading to increase in the quantity of typical Escherichia coli, decrease in Enterooccus spp. and Enterobacter spp. High concentrations of it (0.1% ethanolic tunicate of A. elata) killed bacteria of Clostridium and Klebsiella genera and various yeast fungi in the intestine. Male rats on a diet with excess of fat were observed to have no serious changes in the composition of the normal gut microbiota (Bifidobacterium spp., Lactobacillus spp., Proteus spp., Staphylococcus spp., Candida spp.), and no lactose-negative enterobacteria (Citrobacter genus) were detected.

R. typhina decreases the diversity of the soil bacterial community compared with other species of plants: soil was characterized by higher number of Actinobacteria and lower Proteobacteria and Acidobacteria (Zhu et al., 2020). A difference was found in the relative amount of Nos- cardioides and Streptomyces, which may be useful for the growth of R. typhina. Concentration of total carbon, potassium and nitrates are the main soil factors which affect the relative number of soil bacteria. Extract from R. typhina exhibited strong antimicrobial activity depending on the concentration and broad spectrum towards the tested bacteria of Bacillus cerevis and Helicobacter pylori with MIC equaling 0.10%. Yeasts displayed lower susceptibility with MIC of 0.60–0.75%. Furthermore, Zhang et al. (2018) surveyed the antioxidant activity of the extract, including the absorbing activity of radicals 2,2-diphenyl-1-picyrylhydrazyl (DPPH, MIC = 0.016 mg/ml) (Kossah et al., 2011). Extract of Mahonia aquifolium is recommended for the treatment of psoriasis in humans (Schorchorva, 1998; Na, 2006).

Conclusion

Thus, all the 8 surveyed species of plants have no notable antibacterial effect against multi-resistant strains Enterobacter aerogenes, Listeria innocua, P. aeruginosa ATCC 2799, K. pneumoniae. High inhibitory effect was determined for ethanol extracts from Cotinus coggnygia against 13 strains of microorganisms, Rhus typhina – against 12, Rhus trilobata – 14, Toxicodendron orientale – 10, Hedera helix – 7, Aralia elata – 10, Leptopus chinensis – 4 and Mahonia aquifolium – 3 of 24 surveyed polyresistant strains of bacteria and fungi. We think that it is possible to recommend the extracts from C. coggnygia, R. typhina, R. trilobata, T. orientale, H. helix, A. etala, L. chinensis and M. aquifolium to individu- al compounds they contain for further study of methods against polyresistant strains of the abovementioned microorganisms.

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