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Antimicrobial activity of European plum fruits (*Prunus domestica* L.) depending on altitude

Svetlana M. Paunović[1]*, Pavle Mašković[2], Žaklina Karaklajić-Stajić[1], Jelena Tomić[1], Boris Rilak[1]

[1]*Fruit Research Institute, Kralja Petra I 9, 32000 Čačak, Republic of Serbia*
**E-mail: svetlana23869@gmail.com*
[2]*University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, 32000 Čačak, Republic of Serbia*

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Abstract. The research aimed to establish the antimicrobial activity of plum fruits in inhibiting the development of selected bacteria and fungi strains. Eight plum cultivars (‘Čačanska Rana’, ‘Čačanska Lepotica’, ‘Timočanka’, ‘Čačanska Najbolja’, ‘Mildora’, ‘Krina’, ‘Čačanska Rodna’, and ‘Stanley’) from two different growing locations (300 and 550 m altitudes) were included in the study. Antimicrobial activity of the plum extract was determined using the microdilution method (minimum inhibitory concentration – *MIC*). The antimicrobial activity significantly varied among the tested cultivars and altitudes. The cultivars showed different antibacterial activity, with *MIC* values ranging from 21.97 to 195.31 µg ml^{-1} and antifungal activity ranging from 21.97 to 63.49 µg ml^{-1}. Depending on the altitude, antibacterial activity in the plum fruits ranged from 19.53 to 260.41 µg ml^{-1}, and antifungal activity varied from 19.53 to 97.67 µg ml^{-1}. In general, plum fruits showed the highest activity against *Escherichia coli and Aspergillus niger*. The obtained results suggested that plum fruits have significant antimicrobial activity, which can contribute to the global acceptance of plums as a functional food.

Key words: *Prunus domestica* L, cultivar, altitude, antibacterial activity, antifungal activity

Introduction

The use of different fruit species for primary healthcare and other purposes has progressively increased worldwide in recent years. Many consumers prefer natural compounds from fruits compared to synthetic additives because foodborne pathogens pose a threat to public health. Infections caused by bacteria and fungi are associated with a wide range of clinical manifestations, including diarrhea, hemorrhagic colitis, hemolytic uremic syndrome, and death (Boyce et al., 1995; Bender et al., 1997; Vogt & Dippold, 2005). However, the various extracts in fruits, including plum, produce a diverse range of primary and secondary metabolites, that have antimicrobial properties, making fruit and fruit products successful in the treatment of fungal, bacterial, and viral infections (Rauha et al., 2000; Cavanagh et al., 2003; Puupponen-Pimiä et. al, 2005). Different authors (Gottschling et al., 2001; Zhou & Duan, 2005; Kotzekidou et al., 2008) reported that many natural compounds found in plants possess antimicrobial functions and could serve as a source of antimicrobial agents against Gram-positive and Gram-negative bacteria and various fungi. Namely, the different parts of fruit (root, leaf, flower, fruit, stem, and bark) are effectively used to treat many diseases, considering that their antimicrobial properties affect a range of physiological processes in the human body, protecting against both free radicals and the growth of undesirable microorganisms. Also, polyphenols, including flavonoids and phenolic acids have a wide range of pharmaceutical activities, including antioxidant, anti-inflammatory, antiviral, and anti-bacterial activities (Iqbal et al., 2005).

Therefore, the objective of this study was to evaluate and compare the antimicrobial activity of fruit extracts from nine plum cultivars growing at two different altitudes, and to assess the potential use of the fruit as new healthy food ingredients, medical compounds, and pharmaceuticals highly beneficial for human health.

Materials and Methods

Plant material. The research was conducted at the Fruit Research Institute, Čačak, Republic of Serbia, during 2017–2019, at two locations differing in altitude: Location 1: Preljinsko Brdo (43°54’ 33’’ N latitude, 20°24’32’’ E longitude, 300 m altitude), and Location 2: Jelica (43°47’34’’ N latitude, 20°21’36’’ E longitude, 550 m altitude). The analysis involved eight plum cultivars (‘Čačanska Rana’, ‘Čačanska Lepotica’, ‘Timočanka’, ‘Čačanska Najbolja’, ‘Mildora’, ‘Krina’, ‘Čačanska Rodna’, and ‘Stanley’). Each cultivar was represented by five trees. Plum fruits were sampled at full ripeness, selected visually, and at the same stage of development.

Test microorganisms. Antimicrobial activity was tested in vitro against six bacteria: *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumoniae* ATCC 13883, *Escherichia coli* ATCC 25922, *Proteus vulgaris* ATCC 13315, *Proteus mirabilis* ATCC 14153 and *Bacillus subtilis* ATCC 6633, and two fungi: *Candida albicans* ATCC 10231 and *Aspergillus niger* ATCC 16404. Pure cultures were generated by subculturing four times on the same media for seven days.

Minimum inhibitory concentration (MIC). Minimum inhibitory concentrations of the extracts and cirsimarin against the test bacteria were determined by the microdilution method in 96-multi-well microtiter plates (Satyajit et al., 2007). All tests were performed in Muller-Hinton broth except for the yeast, in which case Sabouraud dextrose broth was used. A volume of 100 µl stock solutions of oil (in methanol, 200 µl ml^{-1}) and cirsimarin (in 10% DMSO, 2 mg ml^{-1}) were pipetted into the first row of the plate. Fifty microliters of Mueller Hinton or Sabouraud dextrose broth (supplemented with Tween 80 to a final concentration of 0.5% (v/v)) were added to the other wells. A volume of 50 µl from the first test wells was pipetted into the second well of each microtiter line, and then 50 microliters of scalar dilution were transferred from the second to the twelfth well. Ten microliters of resazurin indicator solution (prepared by dissolving of a 270 mg tablet in 40 ml of sterile distilled water) and 30 µl of nutrient broth were added to each well. Finally, 10 µl of bacterial suspension (10^6 CFU ml^{-1}) and yeast spore suspension (3×10^4 CFU ml^{-1}) were added to each well. The growth conditions and the sterility of the medium were checked for each strain. A standard antibiotic, Amracin, was used to control the sensitivity of the tested bacteria, whereas Nystatin was used as a control against the tested yeast. The plates were wrapped loosely with cling film to prevent dehydration and prepared in triplicate. They were then placed in an incubator at 37°C for 24 h for the bacteria and at 28°C for 48 h for the yeast. Subsequently, the color change was assessed visually, and any color change from purple to pink or colorless was recorded as positive. The lowest concentration at which color change occurred was taken as the *MIC* value. Results were expressed as IC_{50} values.

Statistical analysis. The experimental data obtained during the three-year research period were subjected to statistical analysis using Fisher’s three-factor analysis of variance – ANOVA. The significance of differences between the mean values of the tested factors and the interaction means was determined by the LSD test at $P \leq 0.05$ significance levels.

Results and Discussion

The antimicrobial activity of plants has been intensively studied, and, in addition to controlling the invasion and growth of plant pathogens, their activity against human pathogens has been investigated to characterize and develop new healthy food ingredients, medical compounds, and pharmaceuticals. Many plant species possess antioxidant and antibacterial capabilities that enhance resistance to various diseases, they are being exploited as sources of nutritional supplements (Rauha et al., 2000; Cavanagh et al., 2003; Pupponen-Pimiä et al., 2005). The results of the analysis of antibacterial and antifungal activity in plum fruits obtained through the dilution method are given in Tables 1a and 1b.

Minimum inhibitory concentrations (*MICs*) were determined for eight selected indicator strains. Amracin and nystatin were used as standard antimycotics. Plum fruits were evaluated for their antibacterial activity against two Gram-positive (*Staphylococcus aureus, Bacillus subtilis*) and four Gram-negative (*Escherichia coli, Klebsiella pneumonia, Proteus vulgaris, Proteus mirabilis*) bacterial strains. Also, the antifungal ability of plums was determined against two fungi (Candida albicans and Aspergillus niger). The results of the present investigation indicate that the antibacterial and antifungal activity varied with the cultivars

Table 1a. Antibacterial activity in plum fruits depending on altitude
Tabela. 1a. Antibakterijska aktivnost u plodovima šljive u zavisnosti od nadmorske visine

Cultivar *Sorta*	Location *Lokacija*	*Staphylococcus aureus*	*Klebsiella pneumonia*	*Escherichia coli*	*Proteus vulgaris*
‘Čačanska Rana’		122.08 ± 30.6 bc*	78.13 ± 13.1 d	36.65 ± 3.08 bc	112.31 ± 13.9 bc
‘Čačanska lepotica’		107.43 ± 15.3 c	102.55 ± 16.5 c	21.97 ± 1.75 e	117.19 ± 27.6 abc
‘Timočanka’		136.72 ± 33.5 ab	130.21 ± 32.0 b	31.76 ± 2.91 cd	91.14 ± 12.7 cd
‘Čačanska najbolja’		149.74 ± 40.8 a	188.80 ± 54.9 a	30.95 ± 2.73 d	110.68 ± 22.5 bc
‘Mildora’		117.19 ± 28.8 bc	195.31 ± 70.7 a	48.86 ± 5.09 a	164.84 ± 62.2 a
‘Krina’		73.25 ± 11.8 d	74.89 ± 11.2 d	52.11 ± 5.54 a	71.63 ± 8.78 d
‘Čačanska rodna’		56.97 ± 5.80 d	81.39 ± 9.61 cd	37.44 ± 3.39 b	133.47 ± 32.4 ab
‘Stanley’		68.37 ± 8.32 d	144.86 ± 42.1 b	24.42 ± 2.85 e	152.99 ± 49.8 b
‘Čačanska Rana’	Location 1	68.37 ± 6.67 d	97.66 ± 13.3 de	34.21 ± 4.34 cd	68.37 ± 8.94 fg
	Location 2	175.80 ± 31.3 ab	58.61 ± 8.37 f	39.10 ± 4.73 c	156.25 ± 51.9bcd
‘Čačanska Lepotica’	Location 1	58.61 ± 8.73 d	156.25 ± 20.1 c	19.53 ± 2.32 g	78.12 ± 13.2 fg
	Location 2	156.25 ± 26.2 b	48.86 ± 6.67 f	24.42 ± 3.34 fg	156.25 ± 53.9bcd
‘Timočanka’	Location 1	78.12 ± 11.4 d	195.31 ± 52.4 b	24.42 ± 3.18 fg	78.12 ± 13.2 fg
	Location 2	195.31 ± 52.4 a	65.12 ± 10.6 ef	39.10 ± 4.73 c	104.17 ± 21.2 ef
‘Čačanska Najbolja’	Location 1	117.19 ± 17.5 c	260.41 ± 85.6 a	29.31 ± 4.17 def	78.12 ± 13.2 fg
	Location 2	182.29 ± 43.6 ab	117.19 ± 17.5 d	32.58 ± 4.37 cde	143.24 ± 40.3 cde
‘Mildora’	Location 1	78.12 ± 13.1 d	234.37 ± 80.1 a	39.10 ± 4.73 c	117.19 ± 34.6 def
	Location 2	156.25 ± 21.4 b	156.25 ± 21.4 c	58.61 ± 6.73 a	212.50 ± 98.8 a
‘Krina’	Location 1	68.37 ± 12.2 d	110.68 ± 15.7 d	39.10 ± 4.73 c	39.10 ± 6.67 g
	Location 2	78.14 ± 17.5 d	39.10 ± 4.69 f	65.12 ± 8.22 a	104.17 ± 20.9 ef
‘Čačanska Rodna’	Location 1	48.83 ± 15.9 d	104.17 ± 16.4 d	26.05 ± 4.12 efg	91.14 ± 16.4 f
	Location 2	65.12 ± 10.1 d	58.61 ± 8.73 f	48.83 ± 5.31 b	175.80 ± 61.1 bc
‘Stanley’	Location 1	58.61 ± 8.23 d	234.78 ± 80.7 a	19.53 ± 4.37 def	110.68 ± 26.7 def
	Location 2	78.14 ± 17.5 d	55.35 ± 8.22 f	29.31 ± 4.37 def	195.31 ± 72.5 b
ANOVA					
Cultivar/*Sorta* (A)		**	**	**	**
Treatment/*Tretman* (B)		**	**	**	**
A × B		**	**	**	**

*Means followed by different letters within the cultivar and treatment columns are significantly different at $P \leq 0.05$ according to LSD test and ANOVA (F-test) results/*Srednje vrednosti u kolonama za sorte, tretmane i godine označene različitim slovima značajno se razlikuju na nivou $P \leq 0,05$ na osnovu LSD-testa i rezultata ANOVA (F-test)* and altitude. Cultivars showed different antibacterial activity, with *MIC* values ranging from 21.98 to 195.31 µg ml^{-1} and antifungal activity ranging from 21.97 to 94.40 µg ml^{-1}. The most sensitive was *Escherichia coli* with a *MIC* of 21.98 µg ml^{-1} in 'Čačanska Lepotica', followed by the bacteria *Aspergillus niger* with a *MIC* of 21.97 µg ml^{-1} in 'Krina' and *Candida albicans* with a *MIC* of 34.21 µg ml^{-1} in 'Čačanska Rana'. Also, cultivar 'Krina' had higher antibacterial activity against *Klebsiella pneumonia* and *Proteus vulgaris* (74.89 and 71.63 µg ml^{-1}, respectively), and 'Mildora' and 'Čačanska Lepotica' against *Proteus mirabilis* and *Bacillus subtilis* (58.61 and 78.13 µg ml^{-1}, respectively), while higher antimicrobial activity on the *Staphylococcus aureus* was obtained in cultivar 'Čačanska Rodna' (56.97 µg ml^{-1}). In contrast, 'Čačanska Najbolja' showed the lowest antimicrobial activity toward Staphylococcus aureus (149.74 µg ml^{-1}), *Candida albicans* (63.49 µg ml^{-1}) and *Aspergillus niger* (48.73 µg ml^{-1}), while 'Mildora' exposed weaker antimicrobial activity against *Klebsiella pneumonia* (195.31 µg ml^{-1}), *Proteus vulgaris* (164.84 µg ml^{-1}) and *Bacillus subtilis* (143.31 µg ml^{-1}). Additionally, 'Krina' expressed the lowest susceptibility against *Escherichia coli*, with *MIC* values of 52.11 µg ml^{-1}, and 'Timočanka' toward *Proteus mirabilis*, with *MIC* values of 158.33 µg ml^{-1}.

Table 1b. Antibacterial and antifungal activity in plum fruits depending on altitude
Tabela 1b. Antibakterijska i antifungalna aktivnost u plodovima šljive u zavisnosti od nadmorske visine

Cultivar *Sorta*	Location *Lokacija*	*Staphylococcus aureus*	*Klebsiella pneumonia*	*Escherichia coli*	*Proteus vulgaris*
'Čačanska Rana'		146.48 ± 21.6 bc*	107.42 ± 10.9 cd	34.21 ± 2.69 c	36.65 ± 6.08 b
'Čačanska Lepotica'		126.95 ± 27.3 a	78.13 ± 7.01 d	48.85 ± 4.49 bc	31.76 ± 2.95 b
'Timočanka'		158.33 ± 22.2 bc	129.04 ± 35.8 b	58.61 ± 5.88 bc	32.58 ± 2.98 b
'Čačanska Najbolja'		130.21 ± 8.78 cd	106.25 ± 33.3 bc	63.49 ± 26.3 a	48.73 ± 7.38 b
'Mildora'		58.61 ± 5.88 d	143.31 ± 58.9 a	48.85 ± 5.09 bc	25.31 ± 1.75 b
'Krina'		133.46 ± 25.7 bc	117.18 ± 28.4 bc	58.61 ± 22.3 b	21.97 ± 1.58 b
'Čačanska Rodna'		91.14 ± 29.5 b	104.16 ± 13.9 d	46.40 ± 15.6 bc	40.92 ± 16.9 a
'Stanley'		107.43 ± 10.9 bc	87.90 ± 23.2 d	54.53 ± 16.4 b	32.58 ± 2.98 a
'Čačanska Rana'	Location 1	97.65 ± 13.3 cde	97.65 ± 13.3 cde	39.10 ± 2.37 d	39.10 ± 3.79 b
	Location 2	195.31 ± 52.4 b	117.19 ± 17.5 cd	29.31 ± 2.57 d	34.21 ± 3.43 b
'Čačanska Lepotica'	Location 1	97.65 ± 13.3 cde	58.61 ± 8.63 e	58.61 ± 7.12 cd	39.10 ± 4.78 b
	Location 2	156.25 ± 32.9 bc	97.65 ± 13.3 cde	39.10 ± 4.37 d	24.42 ± 3.34 b
'Timočanka'	Location 1	156.25 ± 32.9 bc	91.16 ± 12.4 cde	78.12 ± 10.9 bcd	39.10 ± 5.08 b
	Location 2	160.42 ± 60.7 a	166.93 ± 71.8 a	39.10 ± 3.76 d	26.05 ± 4.12 b
'Čačanska Najbolja'	Location 1	117.19 ± 17.5 cd	78.12 ± 9.42 de	97.67 ± 29.4 a	58.36 ± 56.6 a
	Location 2	143.24 ± 23.9 bc	134.37 ± 59.5 a	29.31 ± 10.7 bcd	39.10 ± 4.98 b
'Mildora'	Location 1	39.10 ± 4.08 e	117.19 ± 54.9 a	58.61 ± 8.73 cd	31.10 ± 4.25 b
	Location 2	78.12 ± 10.5 de	173.44 ± 61.5 a	39.10 ± 3.95 d	19.53 ± 3.12 b
'Krina'	Location 1	78.12 ± 10.1 de	78.12 ± 25.6 bc	78.12 ± 20.9 ab	24.42 ± 3.34 b
	Location 2	188.80 ± 40.9 b	156.25 ± 23.2 b	39.10 ± 4.18 d	19.53 ± 3.08 b
'Čačanska Rodna'	Location 1	78.12 ± 10.2 de	74.87 ± 18.7 e	63.49 ± 16.2 bc	55.80 ± 61.1 a
	Location 2	104.17 ± 16.4 cd	133.46 ± 32.3 cd	29.31 ± 2.67 d	26.05 ± 3.12 b
'Stanley'	Location 1	58.61 ± 8.73 de	58.61 ± 8.63 e	63.49 ± 17.1 bc	39.10 ± 4.70 b
	Location 2	156.25 ± 30.1 bc	117.19 ± 26.9 cd	45.58 ± 5.94 d	26.05 ± 4.13 b
ANOVA					
Cultivar/*Sorta* (A)		**	**	**	**
Treatment/*Tretman* (B)		**	**	**	**
A × B		**	**	**	**

*Means followed by different letters within the cultivar and treatment columns are significantly different at P ≤ 0.05 according to LSD test and ANOVA (F-test) results/*Srednje vrednosti u kolonama za sorte, tretmane i godine označene različitim slovima značajno se razlikuju na nivou P ≤ 0,05 na osnovu LSD-testa i rezultata ANOVA (F-test)*

In terms of altitude, the fruits of all tested cultivars harvested at lower altitude showed higher antimicrobial activity against strains such as *Staphylococcus aureus* with a *MIC* of 72.03 µg ml^{-1}, *Escherichia coli* with a *MIC* of 28.91 µg ml^{-1}, *Proteus vulgaris* with a *MIC* of 82.60 µg ml^{-1}, *Proteus mirabilis* with a *MIC* of 90.34 µg $ml^{-1}$and *Bacillus subtilis* with a *MIC* of 81.83 µg ml^{-1}. In contrast, at higher altitude, lower antimicrobial activity was observed against *Aspergillus niger* with a *MIC* of 26.87 µg ml^{-1}, followed by *Candida albicans* with a *MIC* of 36.24 µg ml^{-1} and *Klebsiella pneumoniae* with a *MIC* value of 74.89 µg ml^{-1}. The highest difference between the growing locations in antimicrobial activity was recorded against *Klebsiella pneumonia* (2.33-fold). The variation in *Escherichia coli* and *Aspergillus niger* between two altitudes was less evident (1.46-fold and 1.52-fold, respectively), as well as variation against *Proteus vulgaris* and *Bacillus subtilis* (1.64-fold and 1.67-fold, respectively), whereas *Staphylococcus aureus* (1.87-fold), *Proteus mirabilis* (1.89-fold) and *Candida albicans* (1.85-fold) had similar variations. Depending on the altitudes, the highest variations within cultivars were determined in 'Stanley' against *Klebsiella pneumonia* (4.24-fold), and the lowest variations were recorded in cultivar 'Timočanka' against *Proteus mirabilis* (1.03-fold). Also, a high variation was recorded in 'Čačanska Najbolja' toward *Candida albicans* (3.34-fold), and a low variation against *Escherichia coli* (1.12-fold). The present results are in agreement with the findings of Miljić et al. (2016), who observed that wines from the plum cultivars 'Čačanska Rana' and 'Čačanska Lepotica' commonly grown in Serbia showed considerable antimicrobial activity against the Gram-negative and Gram-positive bacteria (*Escherichia coli* and *Staphylococcus aureus*), while strain yeast *Candida albicans* was more resistant than the bacteria to the activity of the tested samples. Heo et al. (2008) reported that the antimicrobial activity of different extracts varied depending on the type of extract and the bacterial strains tested. Similarly, Saraswathi et al. (2020) found that cherry plum (*Prunus cerasifera* Ehrh.) fruits showed an antibacterial effect against *Staphylococcus aureus, Bacillus subtilis, Proteus vulgaris* and *Escherichia coli*, while El-Beltagi et al. (2019) indicated positive results against both Gram-negative and Gram-positive bacteria with European plum fruits. Belhadj & Marzouki (2014) showed that fresh plums have an antibacterial effect against *Staphylococcus aureus* and *Escherichia coli*, while Sójka et al. (2015) noted the antimicrobial effects against Gram-negative bacteria *Escherichia coli*. According to Silvan et al. (2020), plum extract powders gained after freeze-drying, vacuum-drying, and spray-drying methods have promising antibacterial properties that have been tested in different biological models, which influence the different levels of growth inhibition against pathogens. Other parts of the plum also have significant antibacterial and antifungal activity. Albarakaty (2022) reported that plum peel is a natural source of antibacterial agents and has great antibacterial (*Escherichia coli, Bacillus cereus, Staphylococcus aureus*), as well as antifungal action against *Candida albicans*. Furthermore, Savić et al. (2016) observed that the plum seed extract primarily inhibits the growth of Gram-negative bacteria (*Escherichia coli*), while Yurdugül & Bozoglu (2009) confirmed the inhibitory activity of lyophilized fruits of wild plums against strains of *Klebsiella pneumonia* and *Escherichia coli*. Additionally, Murathan et al. (2020) recorded that all tested plum extracts exhibited antibacterial activity against *Staphylococcus aureus, Escherichia coli* and *Bacillus cereus*, as well as an antimutagenic effect.

Conclusion

The antimicrobial properties of plum fruits are of great importance both in fundamental science and the food industry. Their potential use as natural additives has emerged from a growing tendency to replace synthetic antioxidants with natural alternatives. The obtained results suggest that plum extracts show good antibacterial activity against the Gram-positive and Gram-negative bacterial strains and the fungi. Plum fruits indicated the highest activity against Gram-negative bacterium *Escherichia coli* and fungus *Aspergillus niger* compared to other selected indicator strains. Also, the altitude at which plums are grown significantly affected their antibacterial and antifungal properties. Specifically, at lower altitude plum fruits exhibited higher antimicrobial activity against strains of *Staphylococcus aureus, Escherichia coli, Proteus vulgaris, Proteus mirabilis* and *Bacillus subtilis*, while at higher altitude, the most sensitive strains were Aspergillus niger, *Candida albicans* and *Klebsiella pneumo-*

niae. In general, the significant antimicrobial activity of plum fruit extracts may have important applications in the future as natural antimicrobial agents for health-promoting plum products, as well as in the pharmaceutical and food industries. Furthermore, the research can be a useful determinant for selecting an appropriate altitude for plum growing to obtain fruits with high antimicrobial activity.

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ANTIMIKROBNA AKTIVNOST PLODOVA EVROPSKE ŠLJIVE (*Prunus domestica* L.) U ZAVISNOSTI OD NADMORSKE VISINE

Svetlana M. Paunović[1], Pavle Mašković[2], Žaklina Karaklajić-Stajić[1], Jelena Tomić[1], Boris Rilak[1]

[1]*Institut za voćarstvo, Kralja Petra I 9, 32000 Čačak, Republika Srbija*
E-mail: svetlana23869@gmail.com
[2]*Univerzitet u Kragujevcu, Agronomski fakultet, Cara Dušana 34, 32000 Čačak, Republika Srbija*

Rezime

Cilj istraživanja je bio da se utvrdi antimikrobna aktivnost plodova šljive na inhibiciju razvoja odabranih sojeva bakterija i gljivica. Eksperimentom je obuhvaćeno osam sorti šljiva (Čačanska rana, Čačanska lepotica, Timočanka, Čačanska najbolja, Mildora, Krina, Čačanska rodna i Stanley) i dve različite lokacije gajenja sa različitom nadmorskom visinom (300 i 550 m). Antimikrobna aktivnost ekstrakta šljive određena je primenom mikrodilucione metode (minimalna inhibitorna koncentracija – *MIC*). Antimikrobna aktivnost je varirala između ispitivanih sorti i nadmorskih visina. Sorte su pokazale različitu antibakterijsku aktivnost, sa vrednostima *MIC* u rasponu od 21,97 do 195,31 µg ml^{-1} i antifungalnu aktivnost u rasponu od 21,97 do 63,49 µg ml^{-1}. U zavisnosti od nadmorske visine, antibakterijska aktivnost u plodovima šljive kretala se od 19,53 do 260,41 µg ml^{-1}, dok je antifungalna aktivnost varirala od 19,53 do 97,67 µg ml^{-1}. Generalno, plodovi šljive su pokazali najveću aktivnost protiv *Escherichia coli* i *Aspergillus niger*. Dobijeni rezultati pokazuju da plodovi šljive imaju značajnu antimikrobnu aktivnost, što može doprineti globalnom prihvatanju šljive kao funkcionalno zdrave hrane.

Ključne reči: *Prunus domestica* L, sorta, nadmorska visina, antibakterijska aktivnost, antifungalna aktivnost