The aim of the study was to determine the degree of antimicrobial activity of the anthocyanin complexes of Aronia melanocarpa (Aronia melanocarpa), black currant (Ribes nigrum), elderberry (Sambucus nigra) with reference culture Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, Bacillus subtilis ATCC 6633, Pseudomonas aeruginosa ATCC 27853, Candida albicans NCTC 885-653. The highest degree of microbiological sensitivity of bacterial cultures Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa was observed in the native form of anthocyanin complexes derived from black currant (Ribes nigrum), Escherichia coli and Bacillus subtilis – to the anthocyanins in native form, derived from elder black (Sambucus nigra), which indicates their high antimicrobial activity against the microorganisms mentioned above. Reducing the concentration of anthocyanins in alcoholic extract at dilution in the ratio of 1:1 and 1:2 significantly decreased the microbiological sensitivity of microorganisms to them Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa. When surveying the effects of anthocyanin complexes from Aronia melanocarpa, Ribes nigrum, Sambucus nigra on Candida albicans fungi culture, no sensitivity was established, which indicates the absence of antymycotic activity of the above complexes in laboratory conditions in vitro.

**Keywords:** anthocyanin complexes, antimicrobial activity, Aronia melanocarpa, Ribes nigrum, Sambucus nigra, Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Candida albicans

**Introduction.** The evaluation of the effectiveness of use of plant extracts in medicine as natural antioxidants and immunomodulators for the treatment of human diseases is a very relevant area of research [1–4]. Some recent studies of elongated herbs have indicated high levels of polyphenols, anthocyanins, quercetin and vitamin C that can exhibit antioxidant action. It is also known that anthocyanins have pronounced anticarcinogenic, antimicrobial and anti-inflammatory effects and antidiabetic properties [5]. Plants of Ukrainian flora today are widely used in the treatment of various diseases, due to the high biological activity of their active substances, the absence of side effects and contraindications, which makes them irreplaceable in the treatment of cardiovascular, endocrine, cancer and other human pathologies [6–8]. Researchers are significantly interested in antimicrobial properties of flavonoids. Today mechanisms of influence of quercetin on gram-positive bacteria, flavonoids – on bacteria of the genus Staphylococcus, the antimicrobial action also have anthocyanins are well known [9, 10]. However, it should be noted that the antimicrobial properties of berry extracts (aronia, currants and elderberry) and their influence on specific microorganisms – human pathogens have not been sufficiently studied today. Also, the issues of the influence of antimicrobial substances, in particular, the anthocyanins of individual berries on the microflora of the gastrointestinal tract, on the growth and development of the organism, antioxidant properties, as well as the possibility of their use in the treatment of inflammatory processes, which determines the relevance of our research, remain unclear.

**The Aim of the Study** was to determine the degree of antimicrobial activity of the anthocyanin complexes of Aronia melanocarpa (Aronia melanocarpa), black currant (Ribes nigrum), elderberry (Sambucus nigra) with reference culture Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, Bacillus subtilis ATCC 6633, Pseudomonas aeruginosa ATCC 27853, Candida albicans NCTC 885-653.

**Materials and Methods.** The research was conducted at the Department of Microbiology, Virology and Immunology at the National University of...
of reference crops around the wells; zones of growth retardation of microorganisms up to 11 mm indicated the insensitivity of microorganisms to the drug introduced into the well; The growth retardation zones of reference cultures with a diameter of 11–15 mm indicated a low sensitivity of culture; zones with a diameter of 15–25 mm were evaluated as an indicator of the average microorganism sensitivity to the drug; areas of growth inhibition of reference crops, which exceeded 25 mm – high sensitivity of microorganisms to ACC. The statistical analysis of the data was carried out with the help of the computer program Statsoft Statistica v. 10.0. The comparison of the obtained results of microbiological research was carried out according to the non-parametric Wilcoxon criterion with the definition of the median (Me) and percentile (25%–75%), p<0,05 [11]. An estimation of the integral value of the antioxidant activity of the experimental ACC was carried out by the potentiometric method: an electrochemical cell with platinum and chloride-silver electrodes, a differential voltmeter B2-34, a mediator system K3 [Fe (CN)]6 / K4 [Fe (CN)]6, the analytical signal is the current in the oxidation of the molecules required for the recovery of Fe3+ → Fe2+ ions by the extract of the anthocyanine complex. According to the results of the analysis of anthocyanins by the method of high-performance liquid chromatography and chromatographic mass spectrometry, the main components of the extracts are various anthocyanic glycosides [12–15]. Standard samples – solutions of gallic acid, analysed the changes in the potential of Men+/Me n+ red from the galacic acid concentration as function f (mV) = C.

**Results and Discussion.** When examining antibacterial properties of anthocyanin complexes derived from black currants, black elder and aronia, it was found that in the native form ACC from black currant had the best antibacterial properties – the highest sensitivity was observed in all tested microorganisms. *Escherichia coli* and *Bacillus subtilis* had a high sensitivity to the ACC of the elderberry of the black and blue-green aronia, and *Staphylococcus aureus* and *Pseudomonas aeruginosa* – a moderate sensitivity (Table).

In the dilution of 1:1, a high sensitivity of black currant to ACC was observed only in *Bacillus subtilis*, the rest microorganisms had a moderate sensitivity. *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus subtilis* had a medium sensitivity to ACC from elderberry black, E. coli had low-sensitivity. *Bacillus subtilis* infectious culture had an average sensitivity to the ACC from aronia, a culture of *Staphylococcus aureus* was insensitive. In the dilution 1:2, the average sensitivity to ACC of black currant and elderberry black was observed only in B. subtilis. The
mechanism of action of ACC on microorganisms, obviously, is aimed at the destruction of cell walls and inhibition of nutrition of microbial cells. When investigating sensitivity to ACC from Candida albicans fungi, their antymycotic effect in vitro was not established. The mechanisms underlying the anthocyanin activity include both the membrane and intracellular interactions of these compounds. The antimicrobial activity of anthocyanins contained in fruits is most likely due to multiple mechanisms and synergies, since they contain various compounds, including anthocyanins, weak organic acids, phenolic acids and mixtures of different chemical forms. Today the antimicrobial activity of crude extracts of phenolic compounds of various fruits (mainly berries) against human pathogens is extensively studied, however, there is lack of information about the antimicrobial activity of pure anthocyanins. As a rule, anthocyanins are active against their antimycotic effect in vitro was not established. The effect of the extract of bilberry (Vaccinium macrocarpon) on two major etiological components periodontitis, multifactorial disorders affecting the supporting structure of the teeth was studied. Phenolic acids, flavonoids (flavonols, anthocyanins) and proanthocyanidins accounted for 16.6 and 12.9% of blueberry extract, respectively. Bilberry extract showed its antibacterial activity (minimal inhibitory concentration – 1 mg/ml) against the parodontopathogenic bacterium Fusobacterium nucleatum (Gram-negative anaerobic non-spore-forming bacteria). Also, the blueberry extract at 62.5 μg/ml inhibited the formation of Fusobacterium nucleatum biofilm by 87.5 ± 2.3%. Also, it has been found by the authors that there is an inflammatory action bilberry extract. This double antibacterial and anti-inflammatory effect of bilberry polyphenols suggests that it can be a promising candidate for new therapeutic agents [17].

A number of authors noted that blueberry contains a significant amount of flavonoids, with which a number of beneficial effects for human health are associated. The effect of the extracts of bilberry (Vaccinium angustifolium) on two major etiological components periodontitis, multifactorial disorders affecting the supporting structure of the teeth was studied. Phenolic acids, flavonoids (flavonols, anthocyanins) and proanthocyanidins accounted for 16.6 and 12.9% of blueberry extract, respectively. Bilberry extract showed its antibacterial activity (minimal inhibitory concentration – 1 mg/ml) against the parodontopathogenic bacterium Fusobacterium nucleatum (Gram-negative anaerobic non-spore-forming bacteria). Also, the blueberry extract at 62.5 μg/ml inhibited the formation of Fusobacterium nucleatum biofilm by 87.5 ± 2.3%. Also, it has been found by the authors that there is an inflammatory action bilberry extract. This double antibacterial and anti-inflammatory effect of bilberry polyphenols suggests that it can be a promising candidate for new therapeutic agents [17].

Often, urinary tract infection is a major problem for elderly people, and the basis for treatment is antibiotics.

**Table – Results of study of antimicrobial and antioxidant activity plant’s anthocyanin complexes (Me, 25%–75%)**

<table>
<thead>
<tr>
<th>Anthocyanin complexes</th>
<th>Concentration</th>
<th>Staphylococcus aureus</th>
<th>Escherichia coli</th>
<th>Pseudomonas aeruginosa</th>
<th>Bacillus subtilis</th>
<th>Antioxidant activity, mg/g</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ribes nigrum</strong></td>
<td>Native form</td>
<td>27.00*</td>
<td>36.00*</td>
<td>27.00*</td>
<td>31.00*</td>
<td>4.42</td>
</tr>
<tr>
<td></td>
<td>1:1</td>
<td>20.00**</td>
<td>17.00**</td>
<td>23.00**</td>
<td>25.00*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21.00**</td>
<td></td>
</tr>
<tr>
<td><strong>Sambucus nigra</strong></td>
<td>Native form</td>
<td>21.00**</td>
<td>32.00*</td>
<td>24.00**</td>
<td>31.00*</td>
<td>4.21</td>
</tr>
<tr>
<td></td>
<td>1:1</td>
<td>17.00**</td>
<td>14.00***</td>
<td>18.00**</td>
<td>23.00**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18.00**</td>
<td></td>
</tr>
<tr>
<td><strong>Aronia melanocarpa</strong></td>
<td>Native form</td>
<td>22.00**</td>
<td>34.00*</td>
<td>17.00**</td>
<td>29.00*</td>
<td>4.36</td>
</tr>
<tr>
<td></td>
<td>1:1</td>
<td>14.00***</td>
<td>0</td>
<td>0</td>
<td>20.00**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * – high sensitivity (>25 mm); ** – average sensitivity (15–25 mm); *** – low sensitivity (11–15 mm); 0 – no sensitivity.
The increasing prevalence of bacteria that cause urological disorders, resistant to antimicrobial agents, has stimulated interest in specific nutrients, such as cranberries, to prevent recurrence of urinary tract infections. chokeberry (Aronia melanocarpa) is a rich source of phenolic substances, and thus, the dietary intake of black juice of black chokeberry can reduce the number of urinary tract infections requiring treatment. The authors have suggested daily use of juice of black chokeberry with a high content of total phenols (715 mg of gallic acid equivalent, 100 ml (-1)), including B-type procyanidins, anthocyanins and chlorogenic acids. The results have not revealed an immediate decrease in the incidence of urinary tract infections or the general use of antibiotics. However, during the subsequent 3-month period of administration of juice in the groups, a decrease in the doses of antibiotics to 55% in relation to pathogens of the urinary tract was observed [18]. It is known that species of wild berries exhibit a wide range of pharmacological actions. They have long been traditionally used for antiseptic, antimicrobial, cardioprotective and antioxidant properties. The authors have also investigated the potential of selective antiviral activity of common methanol extracts, as well as anthocyanins and nonanthocyanins from certain berries: strawberries (Fragaria vesca) and raspberries (Rubus idaeus) of Rosaceae family, bilberry (Vaccinium myrtillus) and cowberry (Vaccinium vitis-idaea) Ericaceae. The antiviral effect was tested against viruses of families Picornaviridae, Paramyxoviridae, Orthomyxoviridae, pathogenic for humans, in which chemotherapy and chemoprophylaxis is indicated. The results have shown that the extracts tested for all berries inhibit the replication of the virus CV-B1 (Picornaviridae) and influenza A (Orthomyxoviridae). CV-B1 is most inhibited by both blueberries and strawberries, and also extracts of magnolia vine, and influenza A – by extracts of blueberries and strawberries. The anthocyanin fractions of all wild berries significantly inhibit the replication of the A / H3N2 influenza virus, therefore some wild berries can be a valuable resource of antiviral substances [19]. A number of authors studied the antimicrobial properties of anthocyanins of blueberry (Vaccinium angustifolium) against Escherichia coli O157: H7, Listeria monocytogenes, Salmonella Typhi-

References
Біологічні науки


УДК 579.61:58.072-082
Антиоксидантина крива антоцианів активність
Антоцианових комплексів деяких видів ЯГД в Україні
Філімонова Н. І., Глебова К. В., Шакун О. А., Тіщенко І. Ю.,
Босенко О. Л., Домарьов А. П., Кричковська Л. В., Горбач Т. В.
Резюме. У дослідженні розглянуто питання визначення ступеня антиоксидантов активності антоцианових комплексів Aronia melanocarpa (Aronia melanocarpa), чорної смородини (Ribes nigrum), бузини (Sambucus nigra) з етапами культурами Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, Bacillus

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изделия, виделена з Sambucus nigra, що свідчить про високу антимікробну активність проти згаданих вище мікробіологічних. зниження концентрації абоціанов в спиртовому экстракті при разведені у співвідношенні 1:1 та 1:2 значно зничило мікробіологічну критику мікроорганізмів до Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa. При визначенні ефекту абоціанових комплексів з Aronia melanocarpa, Ribes nigrum, Sambucus nigra на культурах грибів Candida albicans не встановлено чутливості, що свідчить про відсутність антимікробної активності абоціанов в лабораторних умовах in vitro.

Ключові слова: абоціанові комплекси, антимікробна активність, Aronia melanocarpa, Ribes nigrum, Sambucus nigra, Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Candida albicans.

УДК 579.61: 58.072-082

АНТИМИКРОБНАЯ И АНТИОКСИДАНТНАЯ АКТИВНОСТЬ АНТОЦИАНОВЫХ КОМПЛЕКСОВ НЕКОТОРЫХ ВИДОВ ЯГОД В УКРАИНЕ

Филимонова Н. И., Глебова Е. В., Шакун Е. А., Тищенко И. Ю., Босенко О. Л., Домарее А. П., Крчковская Л. В., Горбач Т. В.

Резюме. В исследовании рассмотрен вопрос определения степени антимикробной активности антоциановых комплексов Aronia melanocarpa (Aronia melanocarpa), черной смородины (Ribes nigrum), бузины (Sambucus nigra) с зелеными культурами Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, Bacillus subtilis ATCC 6633, Pseudomonas aeruginosa ATCC 27853, Candida albicans NCTC 885-653. Высшая степень мікробиологичной чувствительности бактериальных культур Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa наблюдалась в нативной форме антоциановых комплексов, полученных из черной смородины (Ribes nigrum), Escherichia coli и Bacillus subtilis – к антицианам в натуральном виде, выделенная из Sambucus nigra, что свидетельствует о высокой антимикробной активностью против упомянутых выше мікроорганізмов. Снижение концентрации антоцианов в спиртовом экстракте при разведении в соотношении 1: 1 и 2 значительно снизило микробиологическую чувствительность микроорганизмов к Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa. При исследовании эффекта антоциановых комплексов из Aronia melanocarpa, Ribes nigrum, Sambucus nigra на культуре грибов Candida albicans не установлено чувствительности, что свидетельствует об отсутствии антимикотической активности антоцианов в лабораторных условиях in vitro.

Ключевые слова: антоциановые комплексы, антимикробная активность, Aronia melanocarpa, Ribes nigrum, Sambucus nigra, Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Candida albicans.

The authors of this study confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of coauthors of the article.

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