Comparison of phytochemical composition, antimicrobial, antifungal, and antioxidant activities of lipophilic and ethanolic green tea leaf extracts

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Infection diseases are a worldwide important problem for medicine and pharmacy. Today, there is a high interest in the evolution of new antimicrobial drugs due to the increasing percentage of resistant bacteria and fungi strains. Green tea leaf contains a variety of natural compounds that are possible to apply in the creation of new antimicrobial drugs.

The aim of the work was to compare phytochemical composition, antimicrobial, antifungal activities of lipophilic and ethanolic green tea leaf extracts.

Materials and methods. The object of the research was the lipophilic extract obtained using chloroform, along with two ethanolic extracts of green tea leaves. One of the ethanolic extracts had been previously processed with chloroform, while the other had not. Antioxidant activity was determined by the potentiometric method, while antimicrobial and antifungal activities were assessed by the “wells” method.

Results. The lipophilic extract of green tea leaves contains predominantly caffeine and organic acids, with the lowest amount of phenolic compounds. In contrast, the ethanolic extracts show the opposite pattern, with phenolic compounds predominating and caffeine present in lower quantities. The lipophilic extract exhibits greater inhibition of the growth of \( S. \) aureus, \( E. \) coli, \( P. \) vulgaris, \( B. \) subtilis, and \( C. \) albicans compared to the 96 % ethanolic extract processed with chloroform, with inhibition rates of 19 %, 18 %, 12 %, 12 %, 16 %, and 20 % respectively. When comparing antimicrobial activity to the 96 % ethanolic extract without chloroform treatment, the results remained consistent. The antioxidant activity of the lipophilic extract was 58.7 and 60.0 times lower than that of the 96 % ethanolic extract processed with chloroform and the 96 % ethanolic extract without treatment, respectively.

Conclusions. The study revealed that the lipophilic extract exhibited greater inhibition of the growth of both Gram-positive and Gram-negative bacteria as well as fungi compared to the ethanolic extracts. However, it showed a lower level of antioxidant activity. It is hypothesized that caffeine, organic acids, and catechins may interact synergistically to enhance the antimicrobial and antifungal activity of green tea leaf extracts. The lipophilic extract shows promise for further development in the production of antimicrobial and antifungal drugs.

Keywords: green tea, lipophilic extract, caffeine, organic acids, pharmacologic action.

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Bacteria and fungi are single-celled organisms and among the earliest forms of life on Earth. While many bacteria and fungi are harmless and even beneficial, aiding in processes such as food digestion in the human body [1]. Approximately 1% of these microorganisms are opportunistic or pathogenic, capable of causing infectious diseases [2].

According to literature data, every year 7.7 million people die from bacterial infections in the world, which is 13.6% of all deaths in the world. The main pathogens that cause half of all bacterial deaths are: Staphylococcus aureus, Escherichia coli, Streptococcus pneumoniae, and Pseudomonas aeruginosa [3]. Meanwhile, nearly a billion people suffer from fungal infections of the skin, nails, and hair, and more than 150 million people suffer from serious fungal diseases that can later be fatal [4]. Consequently, the search for new biologically active substances that can have a high level of antimicrobial and antifungal effects is still relevant today.

In infectious diseases, an excess of free radicals occurs as a result of pathophysiological and biochemical processes caused by the effects of pathogenic bacteria and fungi on human cells [5]. Thus, free radicals play a crucial role in the development of pathogenesis in infectious diseases.

In our opinion, green tea leaf (Camellia sinensis L.) are a promising plant that may have antimicrobial, antifungal and antioxidant effects. In our previous research, it was found that the chemical composition of C. sinensis leaf is represented by: flavonols (1.38%), flavones (0.25%), phenolic-carboxylic acids (1.34%), flavan-3-ols (20.56%), as well as organic acids (1.80%) and caffeine (2.56%) [6,7]. Due to the presence of flavan-3-ol derivatives, the extracts obtained have powerful antioxidant, anti-inflammatory, antiviral, and antimicrobial effects [8].

Today, scientists pay great attention to the study of the pharmacological activity of extracts obtained with alcohol-water and aqueous-alcohol extractants [9,10,11]. This is of great interest to the scientific community due to the presence of flavan-3-ol derivatives in raw materials, and primarily epigallocatechin-3-O-gallate [12,13,14]. But, at the same time, in the scientometric database Scopus and Web of Science there are no scientific works on the study of the quantitative content of biologically active substances and the pharmacological activity of the lipophilic extract of C. sinensis leaf.

**Aim**

The purpose of our work was to conduct phytochemical research to study the antimicrobial, antifungal and antioxidant effects of lipophilic and ethanolic C. sinensis leaf extracts.

**Materials and methods**

**Plant material.** Green tea (Camellia sinensis L.) leaf was collected in Anhui province, China (30.634140518993203, 116.33254121482477).

**Equipment.** The pH meter HANNA 2550 (Germany) with a combined platinum electrode EZDO 50 PO (Taiwan) was applied for potentiometric measurements. Quantitative analysis of biological active compounds was carried out on a UV-spectrophotometer UV – 1000 (China) with matched 1 cm quartz cells. Weighing was carried out using digital analytical balance AN100 (AXIS, Poland) with d = 0.0001 g.

**Extraction procedure.** Procedure for obtaining lipophilic extract: 25.0 g of crushed leaves were mixed with 500 mL of chloroform. The extraction was carried out for 1 hour in a water bath with a condenser, then repeated twice with a new portion of the solvent. The obtained extracts were then filtered and concentrated using a rotary evaporator to a volume of 50.0 mL.

**Procedure for obtaining 96 % ethanol extract after chloroform.** The obtained raw material after extraction of chloroform was dried at room temperature. Then the raw material was extracted twice with 96% ethanol for 1 hour in a water bath with a condenser, then repeated twice with a new portion of the solvent. The obtained extracts were then filtered and concentrated using a rotary evaporator to a volume of 50.0 mL.

**Qualitative analysis.** The total content of phenolic compounds was measured by the Folin–Ciocaltau assay, the optical density was measured at 760 nm [15]. The calibration curve was plotted with interval concentrations 1.0–5.0 μg/mL, the calibration equation \( Y = 0.1055X + 0.1745 \) (R² = 0.9951). Expressed as gallic acid and calculated according to the following equation:

\[
X(\%) = \frac{C_a \times K_{dl} \times 100}{V},
\]

where, \( C_a \) is the concentration of gallic acid according to the calibration curve, \( C \times 10^4 \) g/mL; \( V \) is the volume of extract, ml; \( K_{dl} \) is the coefficient of dilution.
The vanillin reagent assay was applied to find out the total catechins [16], the absorbance was measured at 505 nm. The calibration curve was plotted with interval concentrations 100–400 × 10⁻⁵ g/ml, the calibration equation was Y = 0.0025X – 0.0851 (R² = 0.9951). The total catechins content in the extract, expressed as epigallocatechin-3-O-gallate, was calculated according to the following equation:

\[ X(\%) = \frac{C \times K_{\text{dil}} \times 100}{V \times A} \times 100 \times 10^3 \times K \quad \text{(Eq. 2)} \]

where, \( C \) is the concentration of epigallocatechin-3-O-gallate according to calibration curve, \( C \times 10^{-5} \) g/ml; \( V \) is the volume of extract, ml; \( K_{\text{dil}} \) is the coefficient of dilution.

The total flavonoids were determined by assay of complex formation with \( \text{AlCl}_3 \), the absorbance was measured at 417 nm [17]. The total flavonoid content in the extract, expressed as rutin was calculated according to the following equation:

\[ X(\%) = \frac{C \times K_{\text{dil}} \times 100}{A_s \times V} \times 100 \times 10^3 \times K \quad \text{(Eq. 3)} \]

where, \( A \) is the absorbance of analyzed solution; \( A_s \) is the absorbance of standard solution of rutin; \( V \) is the volume of extract, ml; \( K_{\text{dil}} \) is the coefficient of dilution.

The total hydroxycinnamic acids derivatives content was measured by assay of complex formation with \( \text{NaNO}_2 – \text{NaMoO}_4 \), the absorbance was measured at 505 nm [18]. The total content of hydroxycinnamic acids derivatives in extract, expressed as chlorogenic acid was calculated according to the following equation:

\[ X(\%) = \frac{C \times K_{\text{dil}} \times 100}{A \times V} \times 100 \times 10^3 \times K \quad \text{(Eq. 4)} \]

where, \( A \) is the absorbance of analyzed solution; \( C \) is the specific adsorption coefficient of chlorogenic acid; \( V \) is the volume of extract, ml; \( K_{\text{dil}} \) is the coefficient of dilution.

The total organic acids content was determined by acid-base titration with the fixation end-point by potentiometric method [19]. The total content of organic acids in the extract, expressed as citric acid was calculated according to the following equation:

\[ X(\%) = \frac{(V_{\text{equiv}} - V_0) \times 0.0032 \times K_{\text{dil}} \times K \times 100}{V} \times \frac{100 \times 10^3 \times K \times 100}{A_s \times V} \quad \text{(Eq. 5)} \]

where, \( 0.0032 \) is the amount of citric acid, which is equivalent to 1 ml of sodium hydroxide solution (0.05 mol/l), g; \( V_{\text{equiv}} \) is the volume of sodium hydroxide solution (0.05 mol/l), which was used for titration, ml; \( V_0 \) is the volume of sodium hydroxide solution (0.05 mol/L), which was spent for titration in a blank experiment, ml; \( V \) is the volume of extract, ml; \( K_{\text{dil}} \) is the coefficient of dilution; \( K \) is the correction coefficient for 0.05 mol/l sodium hydroxide solution.

The content of caffeine was assessed by molecular adsorption analysis [19]. The total content of caffeine in the extract was calculated according to the following equation:

\[ X(\%) = \frac{A \times K_{\text{dil}} \times m_u \times 100 \times 10^3 \times K \times 100}{A_s \times V} \quad \text{(Eq. 6)} \]

where, \( A \) is the absorbance of analyzed solution; \( A_s \) is the absorbance of standard solution of caffeine; \( V \) is the volume of extract, ml; \( K_{\text{dil}} \) is the coefficient of dilution.

**Antioxidant activity assay.** The antioxidant activity of the extract was evaluated by the potentiometric method [20,21]. Antioxidant activity was calculated according to the following equation and expressed as mmol-equiv./mL:

\[ \text{AOA} = \frac{A_{\text{ox}} - \alpha \times A_{\text{red}}}{1 + \alpha} \times \text{Kdil} \times 103 \times \frac{m_1}{m_2} \quad \text{(Eq. 6)} \]

where, \( \alpha = C_{\text{eq}} / C_{\text{sol}} \times 10^6 \) mol/L = Ethanol/mol²/Faraday; \( C_{\text{eq}} \) is the concentration of \( \text{K[Fe(CN)]}_6 \), mol/l; \( C_{\text{sol}} \) is the concentration of \( \text{K[Fe(CN)]}_6 \), mol/l; \( E_{\text{thanol}} = 0.0546 \); \( C_{\text{eq}} \) is the concentration of ethanol; \( \Delta E \) is the change of potential; \( F = 96485.33 \) C/mol is Faraday constant; \( n = 1 \) is the number of electrons in electrode reaction; \( R = 8.314 \) J/molK is universal gas constant; \( T = 298 \) K; \( K_{\text{dil}} \) is the coefficient of dilution; \( m_1 \) is the mass of dry residue; \( m_2 \) is the mass of dry residue in 1 ml of extract.

Epigallocatechin-3-O-gallate, 60 % extract of C. sinensis leaf was used as the standard.

**Test organisms.** «Museum strains of Staphylococcus aureus ATCC 25923, Staphylococcus aureus ATCC 6538, Escherichia coli ATCC 25922, Proteus vulgaris NTCS 4636, Pseudomonas aeruginosa ATCC 27853 and Candida albicans ATCC 885/653 were used by the recommendations for the assessment of antimicrobial activity of drugs.

**Antimicrobial activity assay.** In our study, we used the extract solution, the solvent of which was 60 % ethanol. The method of diffusion of the drug into agar was carried out by the “wells” method [22]. Studies of antibacterial activity were performed by the “wells” method. Preparation of microorganisms suspensions with determined concentrations of microorganisms (optical density) was carried out by the standard of turbidity (0.5 units according to the scale of McFarland) with equipment of Densi-La-Meter (Czech, wavelength 540 nm). Suspensions were prepared according to the equipment and information list. The colony forming unit was 107 microorganisms at 1 ml of growth medium and determined by the standard of McFarland. On solidified agar, by a pipette under sterile conditions in Petri dishes 1 ml of a suspension of microorganisms was added. After incubation, the plates were incubated at room temperature for 15–20 minutes. Next, wells with a diameter of 6 mm were made in the cups, into which solutions of the test substances were introduced. The samples were incubated at 37 °C for 16–24 hours. After incubation, the plates were placed upside down on a dark matte surface so that light fell at an angle of 45° (accounting for reflected light). The diameter of the growth retardation zones was measured by the caliper [23].

Gentamicin and fluconazole were used as reference drugs for assessing antimicrobial and anti-fungal activity.
The content of organic acids expressed as citric acid in the extract after treatment with chloroform (0.10 ± 0.01 %).

Total phenolic in the extract after chloroform treatment was 0.51 ± 0.02, and was not found in the lipophilic extract. The quantitative content of the sum of cinnamic acids was found in the lipophilic extract.

The amount of catechins expressed as epigallocatechin-3-O-gallate was 8.40 ± 0.20 % in the 96 % extract, and 8.39 ± 0.20 % in the 96 % extract after treatment with chloroform, in turn, in the lipophilic no catechins were detected in the extract. The quantitative content of the sum of flavonoids expressed as rutin in the two ethanolic extracts shows that the content of the total hydroxycinnamic acids was 0.77 ± 0.02 %, corresponding to the content of organic acids in the lipophilic extract (Table 1).

The lipophilic extract of green tea leaves contains higher levels of caffeine and organic acids, while phenolic compounds are presented in lesser amounts. In contrast, the ethanolic extracts show the opposite trend, with phenolic compounds dominating but lower levels of caffeine.

Table 1. Results of determination of total content of phenolic compounds, catechins, flavonoids, hydroxycinnamic acids, organic acids, and caffeine in C. sinensis extracts

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total phenolic compounds, % ± SD</th>
<th>Total catechins, % ± SD</th>
<th>Total flavonoids, % ± SD</th>
<th>Total hydroxycinnamic acids, % ± SD</th>
<th>Caffeine, % ± SD</th>
<th>Total organic acids, % ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipophilic extract</td>
<td>0.43 ± 0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.21 ± 0.01</td>
<td>0.80 ± 0.01</td>
</tr>
<tr>
<td>96 % extract after chloroform</td>
<td>8.20 ± 0.20</td>
<td>8.39 ± 0.20</td>
<td>0.51 ± 0.02</td>
<td>0.77 ± 0.02</td>
<td>0.10 ± 0.01</td>
<td>0.53 ± 0.01</td>
</tr>
<tr>
<td>96 % extract</td>
<td>8.67 ± 0.20</td>
<td>8.40 ± 0.20</td>
<td>0.51 ± 0.02</td>
<td>0.78 ± 0.02</td>
<td>0.31 ± 0.01</td>
<td>1.32 ± 0.01</td>
</tr>
</tbody>
</table>

SD: standard deviation, n = 3.

Table 2. Results of antimicrobial and anti-fungi of C. sinensis extracts

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration m/mM/L, (expressed in total polyphenols as gallic acid)</th>
<th>Diameter of the growth retardation zone, mm ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gramm-positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Staphylococcus aureus</td>
</tr>
<tr>
<td>Lipophilic extract</td>
<td></td>
<td>32.33 ± 0.33</td>
</tr>
<tr>
<td>96 % extract after chloroform</td>
<td></td>
<td>26.33 ± 0.33</td>
</tr>
<tr>
<td>96 % extract</td>
<td></td>
<td>32.00 ± 0.20</td>
</tr>
<tr>
<td>96 % ethanol</td>
<td></td>
<td>14.00 ± 0.20</td>
</tr>
<tr>
<td>Gentamycin</td>
<td>0.003*</td>
<td>22.00 ± 0.20</td>
</tr>
<tr>
<td>Fluconazole</td>
<td>0.003*</td>
<td>18.00 ± 0.20</td>
</tr>
</tbody>
</table>

a: molar concentration of gentamycin; b: molar concentration of fluconazole; SD: standard deviation, n = 3.

Results

The lipophilic extract from C. sinensis leaf, as well as two ethanolic extracts, one with pre-treatment of the raw material with chloroform and the other without, were obtained. According to the results shown in Table 1, it was found that the content of phenolic compounds was 0.43 ± 0.02 % in the 96 % extract after treatment with chloroform and 8.20 ± 0.20 % in the 96 % extract without chloroform treatment. The difference in the content of phenolic compounds between the two 96 % extracts was 0.47 %, which practically corresponds to the content of phenolic compounds in the lipophilic extract.

The amount of catechins expressed as epigallocatechin-3-O-gallate was 8.40 ± 0.20 % in the 96 % extract, and 8.39 ± 0.20 % in the 96 % extract after treatment with chloroform, in turn, in the lipophilic no catechins were detected in the extract. The quantitative content of the sum of flavonoids expressed as rutin in the two ethanolic extracts was 0.51 ± 0.02 and was not found in the lipophilic extract (Table 1).

Table 1 shows that the content of the total hydroxycinnamic acids in the 96 % ethanolic extract without treatment with chloroform was 0.78 ± 0.02 %, and in the extract after treatment with chloroform it was 0.77 ± 0.02 %. No hydroxycinnamic acids were found in the lipophilic extract.

The highest caffeine content was determined in the lipophilic extract (1.21 ± 0.02 %), and the lowest in the 96 % extract after treatment with chloroform (0.10 ± 0.01 %). The content of organic acids expressed as citric acid in the lipophilic extract of C. sinensis was 0.80 ± 0.01 %, in the 96 % ethanolic extract it was 1.32 ± 0.01 %, and in the 96 % extract after treatment with chloroform, it was 0.53 ± 0.01 %. The difference between the two ethanolic extracts was 0.79 ± 0.01 %, corresponding to the content of organic acids in the lipophilic extract (Table 1).

The lipophilic extract of green tea leaves contains higher levels of caffeine and organic acids, while phenolic compounds are presented in lesser amounts. In contrast, the ethanolic extracts show the opposite trend, with phenolic compounds dominating but lower levels of caffeine.

Table 2 illustrates the significant antimicrobial and antifungal activity exhibited by all the extracts obtained. The lipophilic extract demonstrates superior inhibition of growth compared to the 96 % ethanolic extract treated with chloroform, with respective improvements of 19 %, 18 %, 12 %, 12 %, 16 %, and 20 % against S. aureus, E. coli, P. vulgaris, B. subtilis, and C. albicans. Furthermore, the antimicrobial activity remains unchanged compared to the 96 % extract without chloroform treatment.

Comparing the obtained results with the reference standard gentamicin, it was observed that S. aureus, B. subtilis, and E. coli exhibited less sensitivity to gentamicin compared to the lipophilic extract, the 96 % extract after chloroform treatment, and the 96 % ethanolic extract of C. sinensis leaf. Conversely, P. vulgaris and P. aeruginosa were more sensitive to gentamicin. In terms of antifungal activity against C. albicans, it was found that the lipophilic extract, the 96 %
Table 3. Results of antioxidant activity of C. sinensis extracts

<table>
<thead>
<tr>
<th>Samples</th>
<th>Antioxidant activity, mmol-eqv./m_{dry res.}</th>
<th>Conditional term of antioxidant activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipophilic extract</td>
<td>10.30 ± 0.10</td>
<td>Lower Medium</td>
</tr>
<tr>
<td>96 % extract after chloroform</td>
<td>605.00 ± 6.00</td>
<td>Very high</td>
</tr>
<tr>
<td>96 % extract</td>
<td>617.29 ± 6.00</td>
<td>Very high</td>
</tr>
</tbody>
</table>

Table 4. Level of antioxidant activity of C. sinensis leaf extracts and standard: epigallocatechin-3-O-gallate at concentration 0.03 mol/L

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration, mol/L</th>
<th>Antioxidant activity, mmol-eqv./m_{dry res.} ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipophilic extract</td>
<td>0.03</td>
<td>10.30 ± 0.10</td>
</tr>
<tr>
<td>96 % extract after chloroform</td>
<td></td>
<td>37.81 ± 2.00</td>
</tr>
<tr>
<td>96 % extract</td>
<td></td>
<td>37.80 ± 2.00</td>
</tr>
<tr>
<td>Epigallocatechin-3-O-gallate</td>
<td></td>
<td>30.78 ± 2.00</td>
</tr>
</tbody>
</table>

extract after chloroform treatment, and the 96 % ethanolic extract of C. sinensis leaf were more effective at inhibiting fungal growth than fluconazole (Table 2).

The level of antioxidant activity of the obtained extracts was studied by the potentiometric method. According to the research results, it was found that the level of antioxidant activity of the lipophilic extract was 58.7 and 60.0 times less than the 96 % extract after treatment with chloroform and 96 % extract without treatment, respectively. Although, according to the developed classification of the “strength” of antioxidant activity according to Maslov, the lipophilic extract has a level of antioxidant activity that is below average, 96 % extract after treatment with chloroform is very high, and 96 % extract without treatment is very high (Table 3).

Further, it was prepared solutions (in terms of the amount of polyphenols expressed as gallic acid) of extracts with 0.03 M concentration of C. sinensis leaf extracts and epigallocatechin-3-O-gallate. As a result of the study, it was found that the level of antioxidant activity of 96 % extract, 96 % extract after chloroform C. sinensis leaf were higher of standard epigallocatechin-3-O-gallate, whereas the level of antioxidant activity of lipophilic extract was lower (Table 4).

Discussion

The analyzed extracts from C. sinensis leaves exhibited high antimicrobial and antifungal activity against strains of S. aureus, P. aeruginosa, P. vulgaris, B. subtilis, and C. albicans. While the concentration of polyphenols in the extracts was three times lower than that of gentamicin and fluconazole, it might initially appear that the antimicrobial and antifungal activity of the C. sinensis leaf extracts is significantly inferior to that of gentamicin and fluconazole. However, it is important to note that gentamicin carries serious toxicity risks to the auditory nerve, kidneys, and liver, potentially leading to severe complications. In contrast, despite the lower concentration, fluconazole and C. sinensis leaf extracts exhibited comparable antifungal effects. Fluconazole is recognized as a leading antifungal agent, albeit with weaker activity against gram-negative and gram-positive bacteria. In contrast, C. si-
Conclusions

1. We conducted a study to quantify the content of phenolic compounds, catechins, flavonoids, hydroxycinnamic and organic acids, and caffeine in lipophilic and two ethanolic extracts of green tea leaves.

2. The lipophilic extract demonstrated potent inhibition of Gram-positive and Gram-negative bacteria as well as fungi, albeit with a low level of antioxidant activity.

3. Our findings suggest that caffeine and organic acids act as catechin agonists, enhancing the antimicrobial and antifungal effects of C. sinensis leaf extracts. Therefore, the lipophilic extract holds promise for the development of future antimicrobial and antifungal drugs.

Conflicts of interest: authors have no conflict of interest to declare.

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References


6. Jian H, Engelhardt LH, Thrane C, Maiwald B, Stark J. Determination of flavonol glycosides in green tea, oolong tea and black tea by UHPLC compared to HPLC. Food Chem. 2015;183:30-5. doi: 10.1016/j.foodchem.2015.03.024


14. Maslov O, Komisarenko M, Kolisnyk S, Derymedvid L. Evaluation of antioxidant activity from green tea leaves [dissertation on the realization of flavonol glycosides in green tea, oolong tea and black tea by UHPLC compared to HPLC]. Food Chem. 2015;183:30-5. doi: 10.1016/j.foodchem.2015.03.024


16. Maslov O, Komisarenko M, Kolisnyk S, Derymedvid L. Evaluation of antioxidant activity from green tea leaves [dissertation on the realization of flavonol glycosides in green tea, oolong tea and black tea by UHPLC compared to HPLC]. Food Chem. 2015;183:30-5. doi: 10.1016/j.foodchem.2015.03.024
Original research

extract (Punica granatum L.). News of Pharmacy. 2023;106(2):5-12. doi: 10.24959/nphj.23.119

22. Volianskyi YL, Hrytsenko IS, Shyrobokov VP, et al. Vyvchennia spet-
syfichnoi aktyvnosti protymikrobnykh ilkarskykh zasobv [Study of the

23. Volianskyi YL, Myronenko LH, Kalinichenko SV, Skliar NI, Kolokolova
OB, Tkach LV et al. [Standardization of the preparation of microbial

24. Maslov OY, Komisarenko MA, Ponomarenko SV, Kolisnyk SV, Osoled-
chenko TP, Kostina TA, et al. Antioxidant, antimicrobial and antifungal
activity of the obtained “Cachisept” tablets for resorption in the oral
cavity for the treatment and prevention of dental caries. Current issues
doi: 10.14739/2409-2932.2023.3.285425