

**BIOLOGICALLY ACTIVE SUBSTANCES OF *MALVA SYLVESTRIS* L.
EXTRACTS AS SOURCES OF SAFE PHYTOTHERAPEUTIC AGENTS****Olha Fedoryshyn^{1,✉}, Olena Yaremkevych¹, Iryna Rusyn¹, Ananiy Kohut¹**¹ Lviv Polytechnic National University, 12, S. Bandery str., Lviv, 79013, Ukraine✉ olha.m.fedoryshyn@lpnu.ua

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Abstract. This study examines the content of major groups of biologically active substances (BAS) in extracts of *Malva sylvestris* L., a wild medicinal plant widely distributed across temperate ecosystems. Using established chemical analysis methods, reliable data were obtained for 40 % and 70 % aqueous-ethanol extracts regarding their BAS composition. The total phenolic content was determined spectrophotometrically using the Folin–Ciocalteu method, while the total flavonoid content was quantified by the aluminum chloride colorimetric assay. Comparative analysis revealed that the 40 % extract contained higher levels of phenolic compounds (1.28 ± 0.02 mg/mL), flavonoids (0.77 ± 0.03 mg/mL), and amino acids (10.7 ± 0.01 mg/mL) than the 70 % extract (0.88 ± 0.03 mg/mL, 0.35 ± 0.02 mg/mL, and 6.8 ± 0.01 mg/mL, respectively). Thin-layer chromatography additionally confirmed the presence of polysaccharides, quercetin, ascorbic acid, and anthocyanins in the analyzed samples. It was found that a 40 % ethanol solution is a more effective extractant for polar compounds, whereas increasing the ethanol concentration to 70 % reduces their solubility. The results confirm the potential of *M. sylvestris* L. extracts as a promising source of BAS for the development of safe phytotherapeutic agents.

Keywords: *Malva sylvestris* L. extracts, bioactive compounds, antioxidants, phenolic compounds, flavonoids, amino acids.

1. Introduction

The current environmental challenges associated with industrialization, agriculture, and urbanization necessitate a reconsideration of approaches to the sustainable use of natural resources,¹ particularly in the medical, pharmaceutical, and biotechnological sectors. In

this context, the search for environmentally safe phytotherapeutic agents derived from wild medicinal plants, which adapt to natural conditions without substantial anthropogenic influence, has become increasingly relevant.² Particular attention is given to the standardization of natural preparations, the optimization of analytical methods, and the isolation of a broad spectrum of biologically active substances (BAS) with anti-inflammatory, antioxidant, antimicrobial, and other pharmacological activities.

Herbal medicine represents one of the oldest healing practices of humankind and continues to attract growing scientific interest. BAS play a dual role: they are essential not only for human health but also for plants themselves, protecting them from adverse environmental conditions. Factors such as soil type, climate, altitude, and anthropogenic influences can alter the quantitative and qualitative composition of secondary metabolites, which are largely responsible for biological activity. Ecological studies have demonstrated that variations in BAS levels can serve as indicators of both plant habitat and environmental quality.^{3,4} Thus, the therapeutic efficacy of herbal remedies depends not only on plant species but also on their geographical origin.

The investigation of valuable plant metabolites with biological activity is therefore of interest to both scientific research and biodiversity conservation. One such plant is *Malva sylvestris* L. (mallow), a representative of the native flora that has long been used in traditional medicine. This species exhibits high ecological adaptability, ensuring its wide distribution and its potential as a reliable source of BAS. Importantly, it thrives under natural conditions without requiring special agrotechnical measures, making it a potentially inexhaustible and environmentally sustainable source of bioactive compounds.⁵ Its cultivation and use also support soil conservation and biodiversity, contributing to sustainable ecosystem management.

According to previous studies, mallow leaves are rich in vitamins that promote recovery and provide analgesic effects.⁶ Traditionally, *M. sylvestris* infusions have been employed in the treatment of colds, coughs, tonsillitis, bronchitis, burns, digestive disorders, eczema, and wounds.⁷ Owing to its emollient properties, the plant was used in Roman and Greek medicine.^{8,9} Its leaves and flowers have shown diverse therapeutic effects, and their extracts are used to treat inflammatory conditions of mucous membranes, cystitis, and diarrhea. In addition, the young leaves, shoots, flowers, and fruits are consumed as food in salads and soups, while the roots are cooked. In India, *M. sylvestris* is prescribed for respiratory and gastrointestinal ailments,¹⁰ while in Brazil it is used against bronchitis, wounds, colitis, and hemorrhoids.¹¹ In Ukraine, preparations derived from dried inflorescences are available as expectorants for respiratory diseases (bronchitis, dry cough, hoarseness, *etc.*), as well as for gastrointestinal inflammation and diarrhea.

Phytochemical studies have confirmed that *M. sylvestris* extracts contain phenolic compounds and their derivatives, such as flavonoids, terpenoids, catalase, sulfate oxidase, fatty acids (including omega-3 and omega-6), and certain steroids, along with β -carotene and vitamins C and E, which demonstrate anti-inflammatory and antioxidant effects.^{12–15} Other investigations indicate that mallow infusions can mitigate liver damage caused by carbon tetrachloride and protect renal tissues from cisplatin- and vanadium-induced toxicity.¹⁶ The presence of tannins, flavonoids, phenolic compounds, and ascorbic acid further underscores its potential in cancer prevention and wound healing.^{4,10,17,18} It is well known that phenolic compounds, flavonoids, tannins, coumarins, and other phytochemicals exhibit strong antioxidant properties.^{19–21}

Given the medicinal significance of *M. sylvestris* as a wild plant resource, the present study aims to determine the content of key groups of biologically active substances in its aqueous – ethanolic extracts.

2. Experimental

The object of the study was aqueous–ethanolic extracts (40 % and 70 %) of *Malva sylvestris* L., collected under natural conditions in the Lviv region of Ukraine during the flowering period (June – July 2024). The plant material was harvested manually from ecologically clean areas, away from roads and industrial zones. The collected flowers were air-dried in the shade at room temperature (20–25°C) to constant weight, ground to a particle size of 1–2 mm, and stored in paper bags until extraction.

To determine the composition of biologically active substances, standard reagents and solutions were employed in accordance with the State Pharmacopoeia of

Ukraine.²² Analyses were performed using an ULab 108UV spectrophotometer (cell thickness 10 mm) and a CM-3.01 centrifuge.

The following methods were applied: thin-layer chromatography (TLC) for the detection of ascorbic acid, mucilages, anthocyanins, and flavonoids; standard qualitative chemical reactions; and mathematical and statistical methods for data processing.

2.1. Preparation of Aqueous – Ethanolic Extracts

Mallow extracts were prepared as follows: dried plant material (5.0 g) was placed in a flask, and either 40 % or 70 % aqueous – ethanolic solution was added at a solid-to-liquid ratio of 1:20. Extraction was carried out for 10 days at room temperature in the dark. The resulting extracts were filtered and centrifuged at 6000 rpm for 10 minutes.

2.2. Determination of Biologically Active Compounds by Thin-Layer Chromatography

The qualitative composition of BAS in the aqueous – ethanolic extracts of *M. sylvestris* L. was assessed by TLC on Silufol UV-254 plates.^{23–25}

2.2.1. Ascorbic Acid Determination

The solvent system used was *n*-butanol – acetic acid – water (4:1:5, upper phase) or *n*-butanol – ethanol – water (4:1:5, upper phase after settling). Extract samples were applied spot-wise to the marked positions. For detection, plates were treated with a 0.2 % solution of 2,6-dichlorophenolindophenol (a redox indicator, where the ascorbic acid spot is decolorized) or examined under UV light at 254 nm, where ascorbic acid absorbs radiation.

2.2.2. Determination of Mucilages, Anthocyanins, and Flavonoids

Extract samples (5–10 μ l) were applied to the plate using a micropipette, with the starting line marked 1.5 cm from the lower edge.

Flavonoids and anthocyanins: mobile phase – *n*-butanol – acetic acid – water (4:1:5, upper phase). Detection was performed by exposure to ammonia vapors or treatment with a 1 % ethanolic solution of $AlCl_3$, followed by observation under UV light at 365 nm. Flavonoids fluoresced yellow, green, or blue. Anthocyanins were observed directly in daylight as pink-red spots.

Mucilaginous substances (polysaccharides): mobile phase – *n*-butanol – ethanol – water (4:1:2). Detection was

carried out by treating plates with 1 % α -naphthol in ethanol, followed by 20 % sulfuric acid. After heating, polysaccharides appeared as violet or purple zones.

All compounds were identified by their R_f values, spot colors, and characteristic reactions with reagents, in comparison with appropriate standards (quercetin, ascorbic acid, cyanidin, and polysaccharides).

2.3. Determination of Biologically Active Substances by Qualitative Reactions

Standard qualitative reactions were employed to identify groups of BAS that contribute significantly to the biological activity of the extracts.^{22, 26}

2.3.1. Detection of Phenolic Compounds

Reaction with FeCl₃: addition of a 1 % iron (III) chloride solution yields a blue, purple, or green coloration, indicating phenolic groups.

Reaction with NaOH: treatment with 10 % sodium hydroxide produces an intense yellow or reddish color.

Reaction with vanillin / conc. HCl: a red coloration indicates the presence of phenolic compounds.

2.3.2. Detection of Flavonoids

Reaction with AlCl₃: treatment with a 2 % aluminum chloride solution in alcohol produces a yellow fluorescence, enhanced under UV light.

Reaction with Pb(CH₃COO)₂: addition of several drops of lead (II) acetate produces a light-yellow to yellow or orange precipitation.

Shinoda reaction: addition of magnesium turnings and concentrated hydrochloric acid results in a red, pink, or orange color in the presence of flavonoids.

2.3.3. Detection of Tannins

Ferric ammonium reaction: addition of a 1 % solution of iron (III) ammonium sulfate (FeNH₄(SO₄)₂) yields a blue-black coloration for hydrolyzed tannins and green for condensed tannins.

Gelatin test: addition of gelatin solution in the presence of sodium chloride produces a precipitate, confirming tannins.

2.3.4. Detection of Ascorbic Acid

Treatment with FeCl₃ and potassium ferrocyanide (K₃[Fe(CN)₆]) gives a blue coloration, indicating the presence of ascorbic acid.

2.3.5. Detection of Barium (Ba²⁺)

Under normal conditions, extracts of *M. sylvestris* L. do not contain barium ions; however, their presence is

possible in environmentally contaminated areas, since barium salts may accumulate in polluted environments.

The following qualitative reactions were performed:

Reaction with sulfuric acid or sulfates: the addition of sulfuric acid solution or sodium sulfate solution to the extract produces a white crystalline precipitate of barium sulfate (BaSO₄), which is insoluble in acids.

Flame test: barium ions impart a pale green (apple green) color to the flame.

2.4. Quantitative Analysis of Total Phenolic Content

The total phenolic content was determined spectrophotometrically using a modified Folin – Ciocalteu method. To 0.1 mL of the test solution (pre-diluted at a ratio of 1:10), 0.1 mL of Folin – Ciocalteu reagent, 1.5 mL of distilled water, and 0.3 mL of a concentrated Na₂CO₃ solution were added. The mixture was incubated in the dark for 150 minutes. The absorbance of the resulting solution was measured at 760 nm using a ULab 108UV spectrophotometer. The total phenolic content was calculated as gallic acid equivalent based on a calibration curve constructed under identical conditions, using gallic acid as the standard. All measurements were performed in triplicate to ensure data reliability.^{27, 28}

2.5. Quantitative Analysis of Total Flavonoid Content

The total flavonoid content was determined using a modified spectrophotometric method based on the complexation reaction between flavonoids and AlCl₃. For this purpose, a 5 % sodium nitrite (NaNO₂) solution, a 0.1 M sodium hydroxide (NaOH) solution, and a 10 % aluminum chloride (AlCl₃) solution were prepared.

An aliquot of 0.2 mL of the mallow extract was placed in a test tube and mixed with 0.8 mL of ethanol. Then, 0.06 mL of the 5 % NaNO₂ solution was added, and the mixture was allowed to stand for 5 minutes. Subsequently, 0.06 mL of the 10 % AlCl₃ solution was added, and the reaction was allowed to proceed for another 5 minutes. Next, 0.4 mL of the 0.1 M NaOH solution and 0.480 mL of ethanol were added. The resulting mixture was incubated in the dark for 5 minutes. The absorbance of the final solution was measured at 510 nm using a ULab 108UV spectrophotometer. The total flavonoid content was calculated as quercetin equivalent using a calibration curve prepared under identical conditions with quercetin as the standard. All measurements were performed in triplicate to ensure data accuracy and reproducibility.²⁹

2.6. Quantitative Analysis of Amino Acids

The quantitative determination of amino acids was performed using a spectrophotometric method based on the well-established reaction between amino acids and ninhydrin, which yields a colored complex. The optical density (absorbance) of the resulting compound was measured at a wavelength of 570 nm. Simultaneously, the absorbance of the ninhydrin-alanine reaction product was measured and used as a reference, as alanine is the predominant amino acid in the *M. sylvestris* L. samples under investigation.

The amino acid content in the mallow extracts was calculated by the comparison of the absorbance of the sample solution with the absorbance of the standard alanine solution:^{30, 31}

$$X(\%) = \frac{A_x \cdot m_0}{A_0 \cdot m} \cdot 100,$$

where A_x is the absorbance of the sample solution; A_0 is the absorbance of the standard alanine solution; m_0 is the mass of the standard alanine sample, g; and m is the mass of the extract used for analysis, g.

3. Results and Discussion

The qualitative analysis of *M. sylvestris* L. extracts demonstrated the presence of key groups of biologically active substances in all aqueous – ethanolic samples. As summarized in Table 1, phenolic compounds, flavonoids, tannins, and ascorbic acid were consistently identified across the tested extracts. These results indicate that *M. sylvestris* L. possesses phytotherapeutic potential.

Additionally, an analysis was performed to detect the presence of barium ions (Ba^{2+}), which may accumulate in plant raw materials when grown on contaminated soils. No barium was detected in the tested samples, confirming the ecological safety of the raw materials.

Table 1. Qualitative identification of biologically active substances in aqueous – ethanolic (40 % and 70 %) extracts of *M. sylvestris* L.

| Group of substances / Qualitative reaction | Characteristic color / precipitate | 40 % extract | 70 % extract |
|---|---|--------------|--------------|
| Phenolic compounds reaction with $FeCl_3$ (10 %) reaction with NaOH reaction with vanillin in conc. HCl | blue / purple change from yellow to red red | + + + | + + + |
| Flavonoids $AlCl_3$ (in alcohol) reaction with $Pb(CH_3COO)_2$ Shinoda reaction (Mg + HCl) | yellow fluorescence, enhanced under UV light precipitate red-orange | + + + | + + + |
| Tannins reaction with $FeNH_4(SO_4)_2$ gelatin test | deep-blue precipitate of tannins | + + | ± + |
| Ascorbic acid reaction with $FeCl_3 + K_3[Fe(CN)_6]$ | blue | + | + |
| Barium ions (Ba^{2+}) reaction with H_2SO_4 flame test | white crystalline precipitate $BaSO_4$ pale green flame | - - | - - |

+ Is positive qualitative reaction and appearance of characteristic color; ± is weak color of qualitative reaction

As a result of TLC analysis, compounds were identified based on their R_f values, spot coloration, and characteristic reactions with reagents, in comparison with appropriate standards (quercetin, ascorbic acid, anthocyanins, and polysaccharides). For the determination of ascorbic acid, mucilages, anthocyanins, and flavonoids, concentrated extracts (5–10 μ L) were applied to the plates using a micropipette, with the starting line marked 1.5 cm from the lower edge.

Ascorbic acid was determined using the solvent system *n*-butanol – acetic acid – water (4:1:5, upper phase). Extract samples were applied by the spot (capillary) method. After chromatography, ascorbic acid appeared as white spots under UV light, due to its ability to absorb UV radiation.

Flavonoids were detected under the following conditions:

1) mobile phase: ethyl acetate – formic acid – water (5:4:11). Detection: spraying with 1 % ethanolic $AlCl_3$ solution and observation under UV light at 365 nm, which revealed yellow-green fluorescent spots.

2) mobile phase: *n*-butanol – acetic acid – water (4:1:5, upper layer). Detection: anthocyanins were visible in daylight without additional treatment, appearing as pink-red spots.

3) polysaccharides: mobile phase – *n*-butanol – ethanol – water (4:1:2). Detection: plates were treated with 1 % α -naphthol in ethanol followed by 20 % sulfuric acid. After heating, polysaccharides appeared as violet or purple zones.

The solvent systems applied provided effective separation of compounds in the *M. sylvestris* L. extracts by R_f values. Detection was carried out using suitable developers and UV light at 254 nm. The results of TLC analysis of aqueous – ethanolic extracts of *M. sylvestris* L. are summarized in Table 2.

In the analyzed 40 % and 70 % aqueous – ethanolic extracts of *M. sylvestris* L., several compounds were

identified by TLC, distinguished by their characteristic colors under visible light, after treatment with specific developers, and under UV illumination. Specifically: (1) quercetin (yellow-green) was detected in the 40 % extract ($R_f = 0.49$) and in the 70 % extract ($R_f = 0.50$); (2) mucilage (purple) was observed in both the 40 % ($R_f = 0.30$) and the 70 % extract ($R_f = 0.34$); (3) anthocyanins (pink-red) were identified in the 40 % ($R_f = 0.29$) and 70 % extract ($R_f = 0.35$).

Hence, the results of qualitative analysis also confirmed the presence of phenolic compounds and flavonoids in all *M. sylvestris* L. samples. This finding is supported by spectrophotometric analysis (Fig. 1), which revealed the highest concentration of phenolic compounds in the 40 % aqueous – ethanolic extract (1.28 ± 0.02 mg/mL) compared to the 70 % extract (0.88 ± 0.03 mg/mL).

Similarly, the concentration of flavonoids in the extracts (Fig. 2) was substantial. In the 40 % extract, the flavonoid content reached 0.77 ± 0.03 mg/mL, whereas in the 70 % extract it was 0.35 ± 0.02 mg/mL, indicating a decline in concentration with increasing ethanol content.

Table 2. TLC results of aqueous – ethanolic extracts of *Malva sylvestris* L.

| Aqueous – ethanolic extracts | Identified compound, R_f | | | |
|------------------------------|---------------------------------|------------------|----------------------|---------------------|
| | <i>Polysaccharides (mucous)</i> | <i>Quercetin</i> | <i>Ascorbic acid</i> | <i>Anthocyanins</i> |
| <i>M. sylvestris</i> L. 40 % | 0.30 | 0.49 | 0.38 | 0.29 |
| <i>M. sylvestris</i> L. 70 % | 0.25 | 0.50 | 0.40 | 0.35 |

R_f is the retardation factor; average values are given.

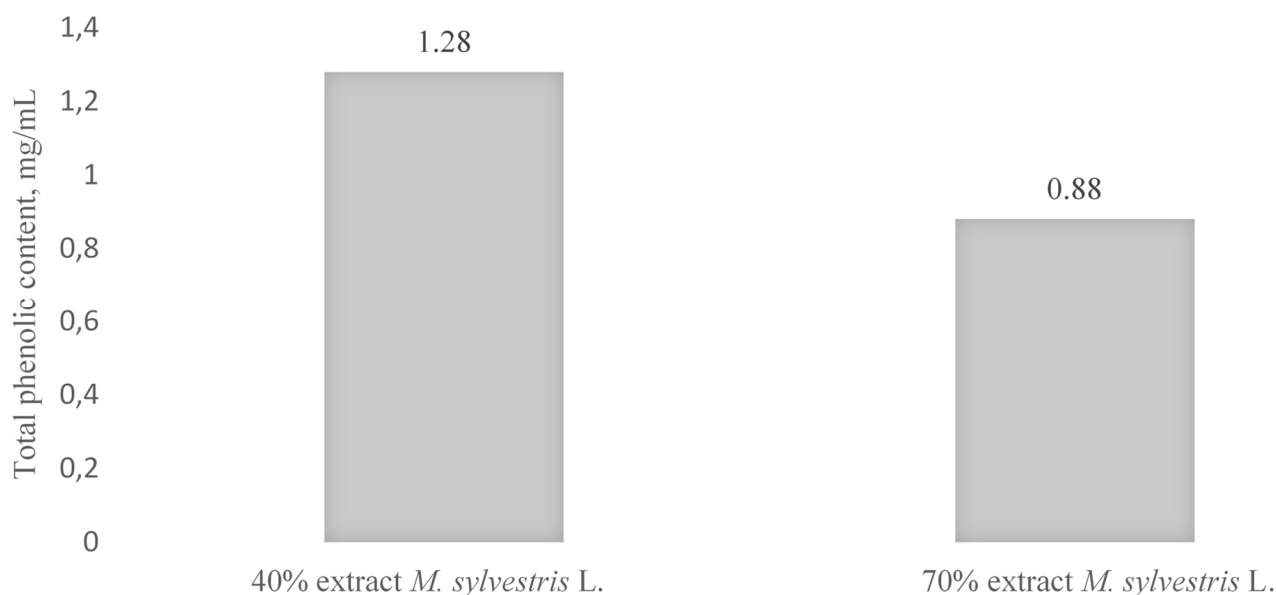


Fig. 1. Total phenolic content in the *M. sylvestris* L. extracts

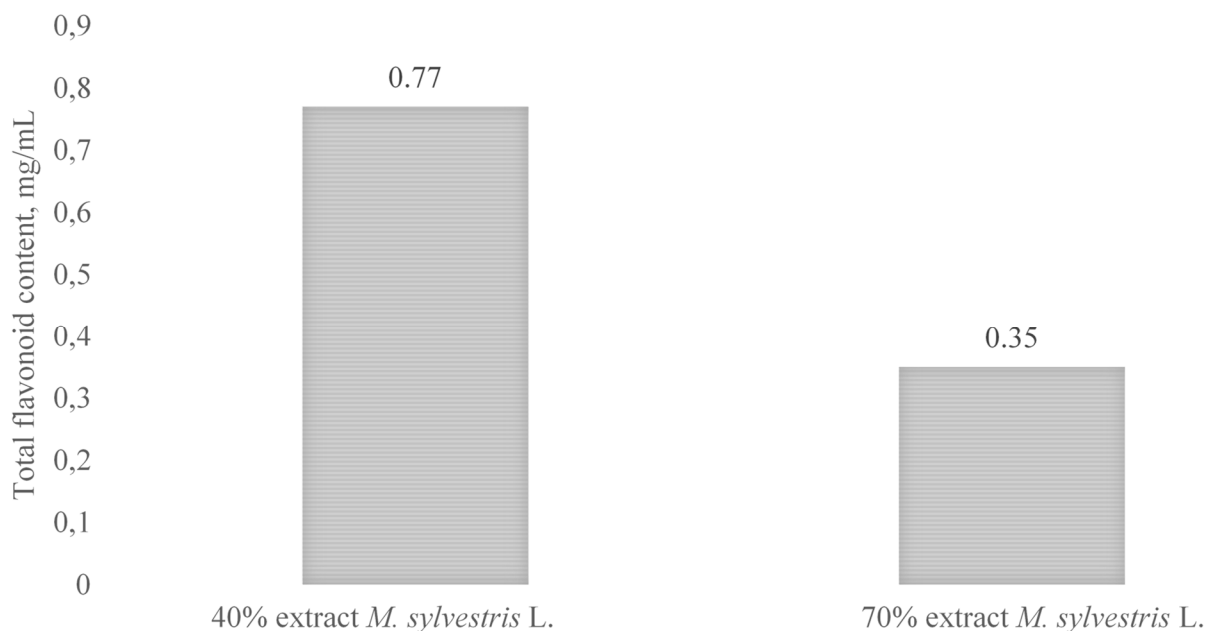


Fig. 2. Total flavonoid content in the *M. sylvestris* L. extracts

The total phenolic content was determined spectrophotometrically at 760 nm and expressed as gallic acid equivalents. Each measurement was performed in triplicate to ensure data reliability, and calculations were based on the standard calibration curve ($y = 0.2893x + 0.5067$).

The total flavonoid content was quantified by a modified spectrophotometric method at 510 nm, employing the complexation reaction of flavonoids with aluminum chloride. Measurements were likewise conducted in triplicate, and the results were expressed as milligrams of quercetin equivalents per milliliter of extract. Calculations were made using the calibration curve for freshly prepared quercetin solutions ($y = 0.1758x + 0.3168$). The results for total phenolic and flavonoid contents are summarized in Table 3.

Table 3. Total phenolic content expressed as gallic acid equivalent and total flavonoid content expressed as quercetin equivalent in aqueous – ethanolic extracts of *M. sylvestris* L.

| Aqueous – ethanolic extracts | Total phenolic content, mg/mL ($\bar{x} \pm \Delta\bar{x}$, $n = 3$) | Total flavonoid content, mg/mL ($\bar{x} \pm \Delta\bar{x}$, $n = 3$) |
|------------------------------|---|--|
| <i>M. sylvestris</i> L. 40 % | 1.28 ± 0.02 | 0.77 ± 0.03 |
| <i>M. sylvestris</i> L. 70 % | 0.88 ± 0.03 | 0.35 ± 0.02 |

The findings of quantitative determination of amino acids demonstrated a higher concentration of these compounds in the 40 % aqueous – ethanolic extract compared with the 70 % extract, indicating superior solubility of proteinaceous components in the less concentrated alcohol (Table 4).

Table 4. Total amino acid content expressed as alanine equivalent in aqueous – ethanolic extracts of *M. sylvestris* L.

| Aqueous – ethanolic extracts | Total amino acid content, mg/mL ($\bar{x} \pm \Delta\bar{x}$, $n = 3$) |
|------------------------------|---|
| <i>M. sylvestris</i> L. 40 % | 10.7 ± 0.01 |
| <i>M. sylvestris</i> L. 70 % | 6.8 ± 0.01 |

Based on the data in Table 4, it can be concluded that increasing the ethanol concentration in the extractant (from 40 % to 70 %) significantly reduces the efficiency of amino acid extraction from the dried plant material of *M. sylvestris* L., with the yield decreasing by more than one and a half times. This finding indicates that lower ethanol concentrations are more favorable for extracting protein components, highlighting the importance of optimizing solvent composition to maximize the recovery of biologically active substances.

4. Conclusions

In this study, extracts of *M. sylvestris* L. were shown to contain substantial amounts of phenolic compounds, flavonoids, ascorbic acid, mucilage, anthocyanins, and amino acids. The 40 % aqueous – ethanolic extract exhibited the highest concentrations of these biologically active substances (BAS), highlighting its potential as a valuable source of natural antioxidants. Quantitative analysis of amino acids revealed their content to be 1.07 ± 0.001 % in the 40 % extract and 0.68 ± 0.001 % in the 70 % extract. Spectrophotometric studies further confirmed the higher phenolic content in the 40 % extract (1.28 ± 0.002 mg/mL) compared to the 70 % extract (0.88 ± 0.03 mg/mL).

The elevated BAS content supports the feasibility of using *M. sylvestris* L. as a source of natural antioxidants in the production of environmentally friendly herbal medicines. The species' ability to thrive in urban, polluted, and disturbed ecosystems demonstrates its ecological plasticity and capacity to accumulate BAS under diverse environmental conditions. This makes its utilization particularly relevant in the context of sustainable development and eco-friendly phytotherapy. Moreover, the variability in BAS content can serve as an indicator in environmental monitoring, reflecting the degree of anthropogenic pressure.

When combined with evidence from contemporary literature, these findings emphasize that plants not requiring irrigation or fertilization contribute positively to soil and water conservation. Thus, the cultivation or rational harvesting of *M. sylvestris* L. could become an integral component of environmentally sustainable strategies in medicine. Future studies should focus on exploring the relationship between ecological growth conditions and biological activity, thereby enabling the rational selection of raw materials for the development of phytomedicines with predictable therapeutic effects.

References

[1] Dyachok, V.; Ivankiv, O.; Diachok, I. Production of Bioelectricity for the Aqueous Extracts of Some Plants. *Environmental Problems*. **2024**, *9*, 89–95. <https://doi.org/10.23939/ep2024.02.089>

[2] Dyachok, V.; Venher, L.; Ivankiv, O.; Diachok, I. Development of Environmentally Safe Technologies for the Extraction of Plant Raw Materials. *Environmental Problems*. **2023**, *8*, 31–36. <https://doi.org/10.23939/ep2024.02.089>

[3] Cardoso, A. M. R.; Cavalcanti, Y. W.; de Almeida, L. F. D.; de Lima Pérez, A. L. A.; Padilha, W. W. N. Antifungal Activity of Plant-Based Tinctures on *Candida*. *Revista Sul-Brasileira de Odontologia*. **2012**, *9*, 25–30. <https://doi.org/10.21726/rsbo.v9i1.961>

[4] Barros, L.; Carvalho, A. M.; Ferreira, I. C. F. R. Leaves, Flowers, Immature Fruits and Leafy Flowered Stems of *Malva sylvestris*: A Comparative Study of the Nutraceutical Potential and Composition. *Food Chem. Toxicol.* **2010**, *48*, 1466–1472. <https://doi.org/10.1016/j.fct.2010.03.012>

[5] Irfan, A.; Imran, M.; Khalid, M.; Ullah, M. S.; Khalid, N.; Assiri, M. A.; Thomas, R.; Muthu, S.; Basra, M. A. R.; Hussein, M.; *et al.* Phenolic and Flavonoid Contents in *Malva sylvestris* and Exploration of Active Drugs as Antioxidant and Anti-COVID 19 by Quantum Chemical and Molecular Docking Studies. *J. Saudi Chem. Soc.* **2021**, *25*, 101277. <https://doi.org/10.1016/j.jscs.2021.101277>

[6] Memdueva, N.; Tzanova, M.; Yaneva, Z.; Rusenova, N.; Grozeva, N.; Dinev, T. Natural Deep Eutectic Solvent-Based Extraction of *Malva sylvestris* L.: Phytochemical Content, Antioxidant and Antimicrobial Potential. *Separations*. **2025**, *12*, 187. <https://doi.org/10.3390/sep202512070187>

[7] Batiha, G. E.; Tene, S. T.; Teibo, J. O.; Shaheen, H. M.; Oluwatoba, O. S.; Teibo, T. K. A.; Al-Kuraishy, H. M.; Al-Garbee, A. L.; Alexiou, A.; Papadakis, M. The Phytochemical Profiling, Pharmacological Activities, and Safety of *Malva sylvestris*: A Review. *Naunyn-Schmiedeberg Arch. Pharmacol.* **2023**, *396*, 421–440. <https://doi.org/10.1007/s00210-022-02329-w>

[8] Guarrera, P. M. Traditional Phytotherapy in Central Italy (Marche, Abruzzo, and Latium). *Fitoterapia*. **2005**, *76*, 1–25. <https://doi.org/10.1016/j.fitote.2004.09.006>

[9] Guarrera, P. M.; Savo, V. Wild Food Plants Used in Traditional Vegetable Mixtures in Italy. *J. Ethnopharmacol.* **2016**, *185*, 202–234. <https://doi.org/10.1016/j.jep.2016.02.050>

[10] Yeole, N. B.; Sandhya, P.; Chaudhari, P. S.; Bhujbal, P. S. Evaluation of *Malva sylvestris* and *Pedalium Murex* Mucilage as Suspending Agent. *Int. J. PharmTech. Res.* **2010**, *2*, 385–389. https://sphinxnsai.com/sphinxnsaiVol_2No.1/PharmTech_Vol_2No.1/PharmTech_Vol_2No.1_7.htm

[11] Esteves, P. F.; Sato, A.; Esquibel, M. A.; De Campos-Buzzi, F.; Meira, A. V.; Cechinel-Filho, V. Antinociceptive Activity of *Malva sylvestris* L. *Lat. Am. J. Pharm.* **2009**, *28*, 454–456.

[12] Benso, B.; Franchin, M.; Massarioli, A. P.; Paschoal, J. A. R.; Alencar, S. M.; Franco, G. C. N.; Rosalen, P. L. Anti-Inflammatory, Anti-Osteoclastogenic and Antioxidant Effects of *Malva sylvestris* Extract and Fractions: *In Vitro* and *In Vivo* Studies. *PLoS One*. **2016**, *11*, e0162728. <https://doi.org/10.1371/journal.pone.0162728>

[13] Martins, C. A. F.; Campos, M. L.; Irioda, A. C.; Stremel, D. P.; Trindade, A. C. L. B.; Pontarolo, R. Anti-Inflammatory Effect of *Malva sylvestris*, *Sida cordifolia*, and *Pelargonium graveolens* Is Related to Inhibition of Prostanoid Production. *Molecules*. **2017**, *22*, 1883. <https://doi.org/10.3390/molecules22111883>

[14] Arabaci, G.; Usluoglu, A. Catalytic Properties and Immobilization Studies of Catalase from *Malva sylvestris* L. *J. Chem.* **2013**, *2013*, 686185. <https://doi.org/10.1155/2013/686185>

[15] Areesanan, A.; Nicolay, S.; Keller, M.; Zimmermann-Klemd, A. M.; Poterat, O.; Gründemann, C. Potential Benefits of *Malva sylvestris* in Dry-Eye Disease Pathology *in vitro* Based on Antioxidant, Wound-Healing and Anti-Inflammatory Properties. *Biomed. Pharmacother.* **2023**, *168*, 115782. <https://doi.org/10.1016/j.biopha.2023.115782>

[16] Paul, Z. A.; Malla, A. T.; Dar, M. A.; Masoodi, M. H. Phytochemistry and Pharmacological Activity of *Malva sylvestris* L: A Detailed Insight. *Comb. Chem. High Throughput Screening* **2024**, *27*, 2309–2322. <https://doi.org/10.2174/0113862073269336231009110313>

- [17] Gasparetto, J. C.; Martins, C. A.; Hayashi, S. S.; Otuky, M. F.; Pontarolo, R. Ethnobotanical and Scientific Aspects of *Malva sylvestris* L.: A Millennial Herbal Medicine. *J. Pharm. Pharmacol.* **2012**, *64*, 172–189. <https://doi.org/10.1111/j.2042-7158.2011.01383.x>
- [18] Wichtl, M. *Herbal Drugs and Phytopharmaceuticals: A Handbook for Practice on a Scientific Basis*; CRC Press, 1994.
- [19] Elhaty, I. A.; Zeyoudi, S. A. A Comparative Study of the Phenolic and Flavonoids Contents, and Antioxidant Activity of *Ziziphus Mauritiana*'s Leaves, Ripe and Unripe Fruit Extracts from UAE. *Chem. Chem. Technol.* **2024**, *18*, 363–371. <https://doi.org/10.23939/chcht18.03.363>
- [20] Asma, F.; Salah Eddine, H.; Yassmine, C.; Hanane, Z. Phytochemical Screening, Antibacterial and Antioxidant Activities of *Ocimum basilicum* L. Cultivated in Biskra, Algeria. *Chem. Chem. Technol.* **2023**, *17*, 397–406. <https://doi.org/10.23939/chcht17.02.397>
- [21] Wijesooriya, S. S.; Pandithavidana, D. R. Investigation and Comparison of Antioxidant Potential of Catechins Present in Green Tea: DFT Study. *Chem. Chem. Technol.* **2022**, *16*, 591–599. <https://doi.org/10.23939/chcht16.04.591>
- [22] *Farmakopeia Ukrainy [State Pharmacopoeia of Ukraine]*, 2nd ed., Supplement 2; Ukrainian Scientific Pharmacopoeial Center for Quality of Medicines, 2015.
- [23] Sherma, J. Thin-Layer Chromatography in Food and Agricultural Analysis. *J. Chromatogr. A* **2000**, *880*, 129–147. [https://doi.org/10.1016/S0021-9673\(99\)01132-2](https://doi.org/10.1016/S0021-9673(99)01132-2)
- [24] Sherma, J.; Fried, B. *Handbook of Thin-Layer Chromatography*, 3rd ed.; Marcel Dekker, 2003.
- [25] Hussein M. A.; Hameed, R. M.; Hnewa, R. A. A. Qualitative Analysis of Standard Amino Acid by Thin Layer Chromatography in Examination of Inborn Errors of Metabolism. *Sci. J. Med. Res.* **2021**, *5*, 73–77. <https://sjomr.org.in/index.php/SJOMR/article/view/191/149>
- [26] Vitalini, S.; Beretta, G.; Iriti, M.; Orsenigo, S.; Basilio, N.; Dall'Acqua, S.; Iorizzi, M.; Fico, G. Phenolic Compounds from *Achillea millefolium* L. and Their Bioactivity. *Acta Biochim. Pol.* **2011**, *58*, 203–219. https://doi.org/10.18388/abp.2011_2266
- [27] Hamada, V.; Krvavych, A.; Konechna, R.; Mylyanych, A.; Buchkevych, I.; Holubieva, T.; Lubenets, V. Development of Technology for Obtaining Herbal Extracts of Adonis Vernalis. *Lett. Appl. NanoBioSci.* **2023**, *12*, 78. <https://doi.org/10.33263/LIANBS123.078>
- [28] Pavlyuk, I.; Stadnytska, N.; Jasicka-Misiak, I.; Gorka, B.; Wieczorek, P. P.; Novikov, V. A Study of the Chemical Composition and Biological Activity of Extracts from Wild Carrot (*Daucus carota* L.) Seeds Waste. *Res. J. Pharm. Biol. Chem. Sci.* **2015**, *6*, 603–611. https://www.rjpbcs.com/2015_6.2.html
- [29] Karpiuk, V.; Konechnyi, Y.; Yaremkevych, O.; Karpiuk, I.; Mylyanych, A.; Krvavych, A.; Konechna, R. Study of the Content of Phenolic Compounds, Antimicrobial and Antioxidant Properties of the Herb *Caltha palustris*. *Res. J. Pharm. Technol.* **2024**, *17*, 5673–5679. <https://doi.org/10.52711/0974-360X.2024.00864>
- [30] Zarivna, N. O.; Horlachuk, N. V. Vyznachennia killisnoho vmistu aminokyslot u ridkomu ekstrakti chebretsia povzuchoho, vybir kryteriiv pryiniatnosti. *Medychna ta klinichna khimia.* **2022**, *1*, 77–80. <https://doi.org/10.11603/mcch.2410-681X.2022.i1.13041>
- [31] Fedoryshyn, O.; Yaremkevych, O.; Konechna, R.; Oliynyk, L.; Kohut, A. Study on Wheat and Oat Bran Extracts and Their Antioxidant Properties. *Chem. Chem. Technol.* **2025**, *19*, 529–537. <https://doi.org/10.23939/chcht19.03.529>

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ДОСЛІДЖЕННЯ БІОЛОГІЧНО АКТИВНИХ РЕЧОВИН ЕКСТРАКТІВ *MALVA SYLVESTRIS* L. ЯК ДЖЕРЕЛА БЕЗПЕЧНИХ ФІТОТЕРАПЕВТИЧНИХ ЗАСОБІВ

Анотація. У статті досліджено вміст основних груп біологічно активних речовин (БАР) в екстрактах *Malva sylvestris* L., дикорослої лікарської рослини, поширеної в екосистемах помірного клімату. Використовуючи відомі методи хімічного аналізу, отримали достовірні дані для 40 % та 70 % водно-етанольних екстрактів щодо їхнього складу БАР. Загальний вміст фенолів оцінювали спектрофотометрично за методом Фоліна – Чокальтеу, а загальний вміст флавоноїдів визначали колориметричним аналізом із хлоридом алюмінію. Порівняльний аналіз показав, що 40 % екстракт характеризується вищим вмістом фенольних сполук ($1,28 \pm 0,02$ мг/мл), флавоноїдів ($0,77 \pm 0,03$ мг/мл) й амінокислот ($10,7 \pm 0,01$ мг/мл) порівняно із 70 % екстрактом ($0,88 \pm 0,03$ мг/мл, $0,35 \pm 0,02$ мг/мл і $6,8 \pm 0,01$ мг/мл, відповідно). Методом тонкошарової хроматографії в досліджуваних зразках також ідентифіковано полісахариди, кверцетин, аскорбінову кислоту й антоціани. Встановлено, що 40 % етанольний розчин є ефективнішим екстрагентом для полярних сполук, тоді як підвищення концентрації етанолу до 70 % знижує їхню розчинність. Отримані результати підтверджують перспективність використання екстрактів *M. sylvestris* як джерела БАР для створення безпечних фітотерапевтичних засобів.

Ключові слова: екстракти *Malva sylvestris* L., біологічно активні сполуки, біологічна активність, тонкошарова хроматографія (ТШХ).