Annals of Phytomedicine 14(1): 1022-1027, 2025

DOI: http://dx.doi.org/10.54085/ap.2025.14.1.102

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885

Original Article : Open Access

Determination of vitamins, flavonoids, macro and micronutrients of *Mentha arvensis* L. in the territory of the Chatkal State Biosphere Reserve

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Article Info

Article history
Received 4 March 2025
Revised 22 April 2025
Accepted 23 April 2025
Published Online 30 June 2025

Keywords
Mentha arvensis L.
Apigenin
Rutin
Hyperoside
Gallic acid
Vitamins
Macro and Microelements

Abstract

Mentha arvensis L. is a highly valued medicinal plant due to its broad range of pharmacological activities, particularly its digestive, respiratory, anti-inflammatory, and antimicrobial effects. Its active phytochemicals, such as menthol, menthone, and rosmarinic acid, are primarily responsible for its therapeutic potential. Whether consumed as a tea, applied topically as an essential oil, or used in aromatherapy, *M. arvensis* continues to be a versatile plant in both traditional and modern medicine. The main active ingredient in *M. arvensis* is menthol, a compound responsible for its cooling sensation and many therapeutic benefits. In addition to menthol, *M. arvensis* also contains flavonoids, tannins, and essential oils, which contribute to its antioxidant, anti-inflammatory, and antimicrobial properties. In this study, vitamins, flavonoids and macro and microelements of *M. arvensis* in the territory of the Chatkal State Biosphere Reserve were investigated. The outlined results showed the presence of five vitamins (B1, B9, C, B2, and B12) known compounds, which were identified for the first time from *M. arvensis* in the territory of the Chatkal State Biosphere Reserve. It was also found to contain 5 flavonoids, such as kaempferol, hypolaetin, gallic acid, luteolin and rutin, which ranged from 1.869 to 341.241 mg/100 g, and six macroelements, such as sodium (Na), magnesium (Mg), sulphur (S) and calcium (Ca), phosphorus (P), and potassium (K), which ranged from 0.751 to 64.874 mg/g; microelements such as chromium (Cr), molybdenum (Mo), manganese (Mn), zinc (Zn), boron (B), and iron (Fe) ranged from 0.054 to 0.751mg/g. *M. arvensis* can be considered a beneficial herbal plant that has the potential to become a food source, herbal formulation, cosmetic and pharmaceutical.

1. Introduction

Mentha arvensis L., a perennial herbaceous plant of the Lamiaceae family, is sometimes referred to as field mint or wild mint. It is found in many temperate and subtropical areas, including the Chatkal State Biosphere Reserve's special ecological zone. This plant's square stems, serrated leaves, and unique, fragrant scent, which comes from essential oils including menthol, menthone, and limonene, are its defining features. The therapeutic qualities of *M. arvensis*, such as its anti-inflammatory, antibacterial, antioxidant, and digestive advantages, have been well investigated. In many cultures, it has long been used to treat illnesses, including skin conditions, gastrointestinal problems, and respiratory difficulties (Sharifi-Rad *et al.,* 2021; Kumar *et al.,* 2022). In addition to its pharmacological and nutritional benefits, recent studies have demonstrated its potential as a rich source of bioactive components, such as vitamins, flavonoids, and micro-micronutrients (Ghasemzadeh *et al.,* 2020; Pandey *et al.,* 2021). The plant is a useful topic for phytochemical research because of its resilience to a variety of environmental circumstances, especially in areas with distinct ecosystems like the Chatkal State Biosphere Reserve. The chemical makeup and health advantages of *M. arvensis* have also been studied in response to the growing interest in natural products and plant-based therapies, making it a viable option for the creation of functional foods and nutraceuticals (Tiwari *et al.,* 2020; Zhang *et al.,* 2023).

Vitamins are vital organic substances that enhance immunological function, act as cofactors in enzyme activities, and offer antioxidant protection, all of which are vital to preserving human health. *M. arvensis* has been shown to be a good source of B-complex vitamins including thiamine (B1), riboflavin (B2), and niacin (B3), as well as vitamins C (ascorbic acid) and A (retinol). *M. arvensis* possesses a high concentration of vitamin C, a powerful antioxidant that helps the plant fight oxidative stress and strengthen immunity (Ghasemzadeh *et al.,* 2020). The plant is a great food source for treating vitamin A insufficiency since it contains significant levels of vitamin A, which is known for its involvement in skin and visual health (Pandey *et al.,* 2021). *M. arvensis* contains B-complex vitamins, which are also necessary for nerve function, cellular repair, and energy metabolism. Recent research has shown that environmental variables such as soil composition, solar exposure,

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and cultivation methods might affect the vitamin content of *M. arvensis* (Tiwari *et al.,* 2020; Kumar *et al.,* 2022). Plants cultivated in soils rich in nutrients and receiving enough sunshine, for example, typically have greater vitamin concentrations. *M. arvensis* contains several vitamins, which not only increase the plant's nutritional value but also support its antibacterial and anti-inflammatory medicinal qualities.

The plant kingdom has a vast range of polyphenolic chemicals called flavonoids, which are distinguished by their important pharmacological and biological characteristics (Sivakumar *et al*., 2022; Duraisami *et al*., 2021). Flavonoids are structurally composed of a 15-carbon skeleton with two aromatic rings joined by a three-carbon bridge in the C6-C3-C6 arrangement. According to Panche *et al.* (2016), flavonoids' distinct structure enables them to display a variety of biological actions, such as cardioprotective, anti-inflammatory, anticancer, and antioxidant properties. Each of the several subclasses of flavonoids - flavones, flavonols, flavanones, isoflavones, and anthocyanins - has unique chemical characteristics and health advantages. Flavonoids are especially noteworthy for their antioxidant action since they may chelate metal ions, scavenge free radicals, and prevent oxidative stress, all of which shield cells from harm (Sri Bhuvaneswari *et al*., 2023; Kumar and Pandey, 2013). Flavonoids can alter cellular signalling pathways, including MAPK and NF-κB, which are important for inflammation and the development of cancer (Tang *et al.,* 2020). Diets high in flavonoids have been associated in epidemiological studies with a lower chance of developing chronic illnesses, such as diabetes, cardiovascular disease, and neurological diseases (Wang *et al.,* 2018). However, flavonoids' chemical structure, dietary matrix, and individual metabolism all affect how bioavailable they are. Flavonoids are important nutraceuticals with potential for creating medicinal agents and functional meals, according to a recent study (Górniak *et al.,* 2019). Utilising flavonoids' full potential to improve human health and prevent illness requires an understanding of their mechanisms of action and health benefits.

Micro-micronutrients, sometimes referred to as trace elements, are vital minerals that the body needs in tiny amounts to sustain healthy physiological processes. These comprise metals including zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), selenium (Se), and iodine (I), which are essential for cellular metabolism, hormone synthesis, enzyme activation, and immunological response (Prasad, 2013). Micro-micronutrients are essential for functions including oxygen transport, DNA synthesis, and antioxidant defence even though the body has very little of them. For example, zinc is essential for wound healing and immunological function, and iron is a crucial part of haemoglobin, which helps carry oxygen in the blood (Cengiz *et al.,* 2020). Selenium protects cells from oxidative damage by acting as a cofactor for antioxidant enzymes such as glutathione peroxidase, whereas iodine is necessary for the manufacture of thyroid hormones, which control development and metabolism (Rayman, 2020). Severe health problems, such as anaemia, decreased immunity, and cognitive impairment, can result from deficiencies in certain micronutrients. It is crucial to maintain a balanced consumption because, on the other hand, excessive intake can also be detrimental. The importance of micronutrients in avoiding chronic illnesses, including diabetes, cardiovascular disease, and neurological diseases, has been highlighted by recent studies (Gupta and Gupta, 2014). In order to treat micronutrient deficiencies and improve public health outcomes, it is essential to understand the physiological functions, dietary sources, and bioavailability of micro-micronutrients.

2. Materials and Methods

2.1 Collection of *M. arvensis*

Mentha arvensis L. was authenticated by Professor Orzimat Turginov, National Herbarium of Uzbekistan (TASH), Tashkent, Uzbekistan. A Voucher Specimen, No. 18042025, was placed in the herbarium unit. *M. arvensis*, which were at fresh vegetative stages, have been collected from the territory of the Chatkal State Biosphere Reserve. Chatkal State Biosphere Reserve is located on the western and northern slopes of the Chatkal Range of the Western Tien Shan. The reserve is situated in the Tashkent Region in Uzbekistan at an altitude ranging from 1500 to 3900 metres above sea level.

Figure 1: Fresh *Mentha arvensis*.

2.2 Determination of flavonoids and vitamins

M. arvensis plant samples were dried at room temperature. The analysis was performed using HPLC with gradient elution mode and diode array detector (DAD). Acetonitrile and buffer solution were used as the mobile phase. Spectral data were analysed in the spectral range from 200 to 400 nm. Chromatography conditions: Chromatograph - Agilent Technologies 1260. Mobile phase (gradient mode) – acetonitrile – buffer solution pH = 2.92 (4%:96%) 0-6 min. (10%: 90%) 6-9 min. (20%: 80%) 9-15, (4%:96%) 15-20 min. Injection volume – 10 µl. Mobile phase flow rate – 0.75 ml/min. Column – Eclipse XDB – C 18. 5.0 µm, 4.6 × 250 mm. Detector – diode-matrix detector, wavelengths 254, 320 nm. Water-soluble vitamins were also analysed using HPLC with gradient elution and a diode array detector (DAD), employing acetonitrile and a buffer solution as the mobile phase. Spectral data for these vitamins were collected in the 200 to 400 nm range (Shelemetyeva, 2009).

2.3 Determination of plant nutrients

For six hours, plant samples were disintegrated using hydrogen peroxide and nitric acid in a special microwave oven until they were reduced to their atomic elements for examination. Accurate volumetric measurements were made for the samples before being subjected to the nitric acid solution. The analysis was carried out using an optical emission spectrometer with an inductively coupled argon plasma (2100DV Santa Clara, CA, USA) (Jabborova *et al.,* 2021).

2.4 Statistical analysis

ANOVA was used to examine experimental data with the IBM SPSS Statistics 20.

3. Results

3.1 Flavonoids content of *M. arvensis*

M. arvensis samples obtained from the Chatkal State Biosphere Reserve were subjected to a detailed study of their phytochemical and nutritional content. The flavonoid analysis isolated five major compounds: rutin, hypolaetin, gallic acid, luteolin, and kaempferol. Rutin was found at the highest rate of 341.241 mg/100 g, which confirms its major importance as a high antioxidant, one that is best known for resisting oxidative stress and maintaining cardiovascular function. However, hypolaetin and gallic acid levels were found to be 6.186 mg/100 g and 58.098 mg/100 g, respectively, and they add to the plant's anti-inflammatory and antimicrobial properties. Luteolin was found to be at 3.451 mg/100 g and kaempferol at 1.869 mg/100 g, which adds to antidiabetic activity and is important to combat inflammation as well as keep cells healthy (Figure 2).

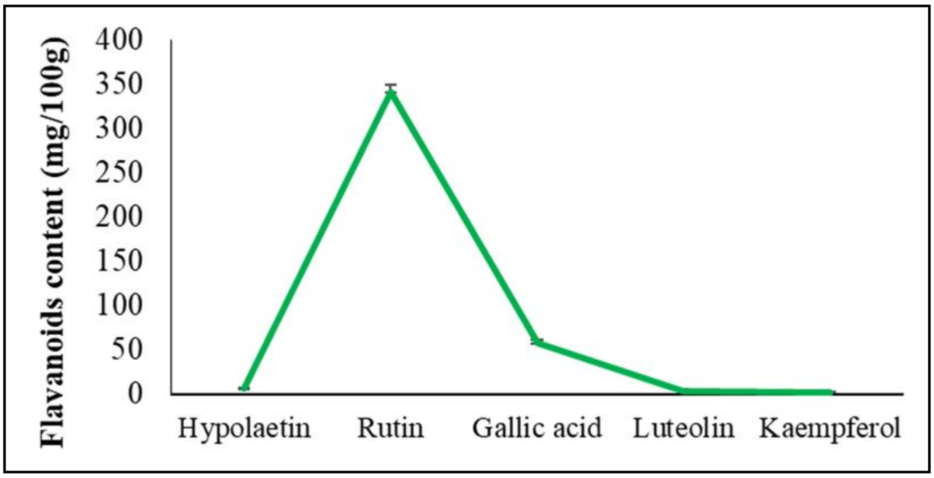

Figure 2: Flavonoids content of *M. arvensis*.

3.2 Vitamins content of *M. arvensis*

The vitamin content also highlighted the nutritional value of the plant. Out of the five water-soluble vitamins found, vitamin C was found to be the highest at 43.478 mg/100 g, increasing for its antioxidant properties and role in immune health. Vitamin B9 (folic acid) was at 24.414 mg/100 g, and vitamin B12 (cobalamin), essential for red blood cell formation and neurological function, was at 13.251 mg/100 g. Vitamin B1 (thiamine) and B2 (riboflavin), essential for energy metabolism and enzymatic activity, were found to be at 2.321 mg/100 g and 0.874 mg/100 g, respectively (Figure 3).

Vitamins content (mg/100g)

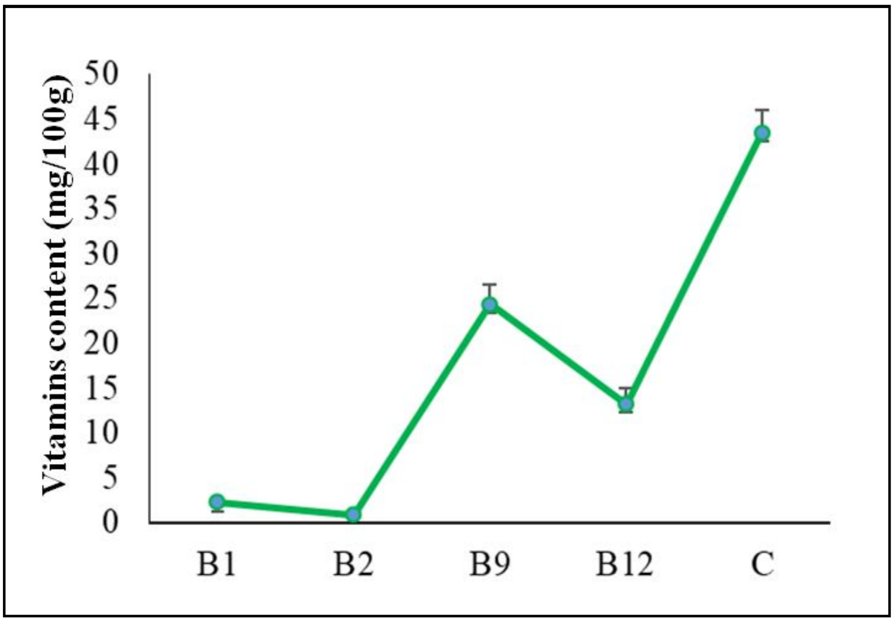

Figure 3: Vitamins content of *M. arvensis*.

3.3 Macro and microelements content of *M. arvensis*

The macroelements analysis revealed the highest level of potassium (K) at 64.874 mg/g, important for electrolyte balance, nerve transmission, and muscle contractions. Other macro elements, such as calcium (Ca), important for bone development, were found to be at 5.421 mg/g, and phosphorus (P), important for energy production and DNA synthesis, was in small amounts at 11.791 mg/g. Magnesium (Mg), aiding enzymatic activity, was found at 2.185 mg/g, and sodium (Na) and sulphur (S), both responsible for fluid balance and protein structure, at 0.751 mg/g and 2.501 mg/g, respectively (Figure 4).

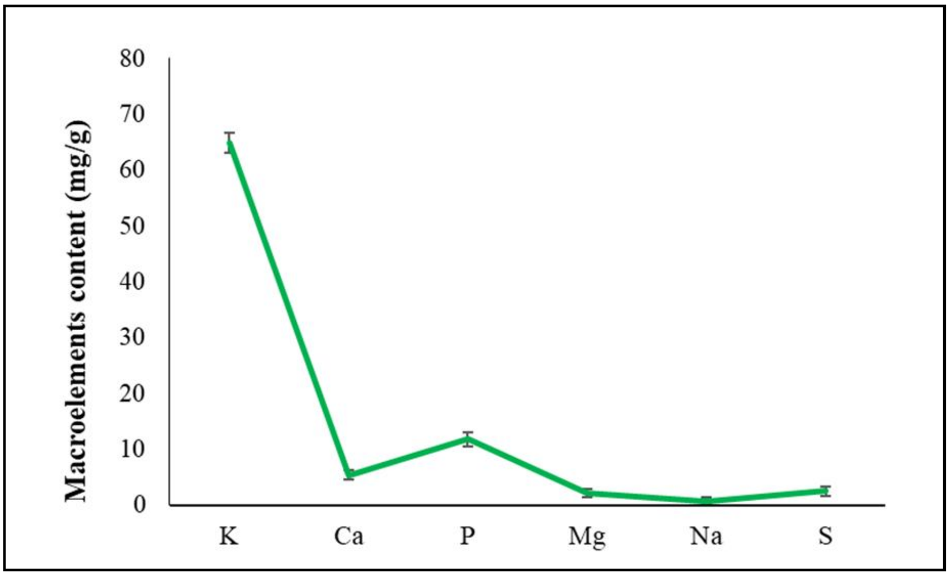

Figure 4: Macroelements content of *M. arvensis*.

Among microelements, iron (Fe) was the most prominent, at 0.751 mg/g, and plays a significant role in oxygen transport and energy metabolism. Boron (B), which is required for plant cell wall stability and bone integrity in humans, was measured at 0.465 mg/g, while zinc (Zn), vital for immune function and enzyme activity, was measured at 0.284 mg/g. Manganese (Mn), essential for metabolic processes, was measured at 0.148 mg/g, while chromium (Cr), essential for the regulation of blood sugar, and molybdenum (Mo), involved in enzymatic processes, were measured at 0.054 mg/g and 0.086 mg/g, respectively (Figure 5).

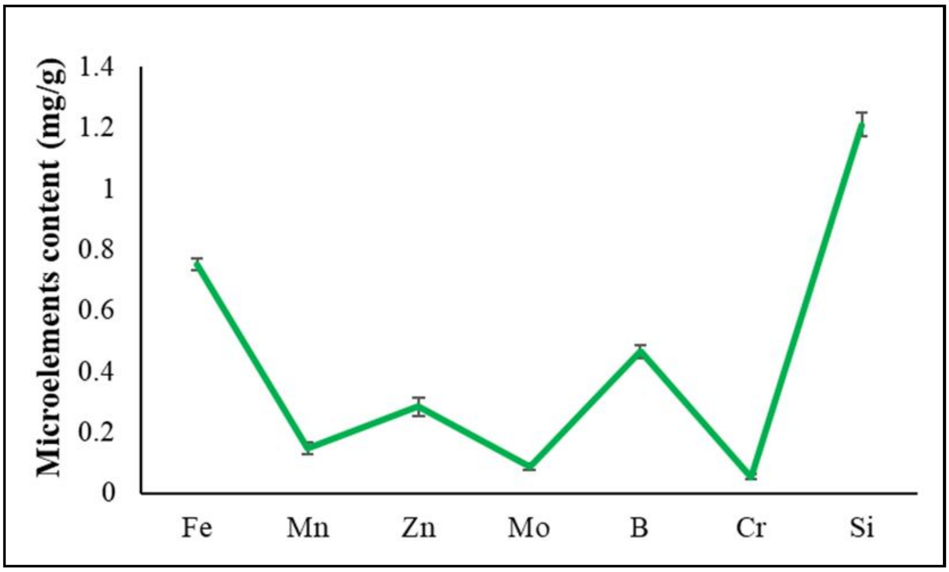

Figure 5: Microelements content of *M. arvensis*.

Strontium (Sr) was the most abundant element in the ultra-microelements, with 0.588 mg/g. Lithium (Li), vanadium (V), and nickel (Ni) were the least abundant, with 0.086, 0.077, and 0.073 mg/g, respectively (Figure 6). Despite being present in small amounts, the elements are notable for their roles in preserving healthy bones, regulating enzymes, and supporting metabolic processes.

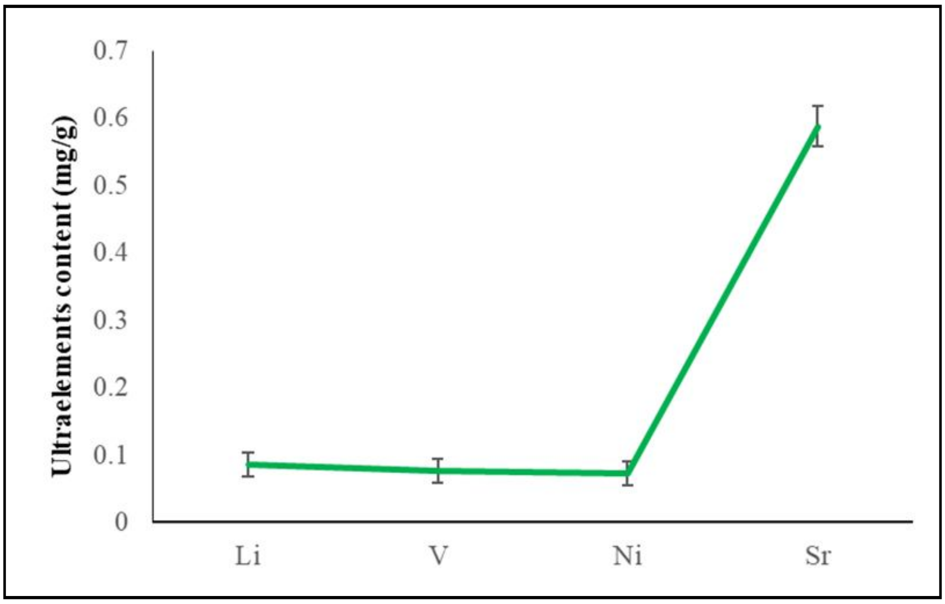

Figure 6: Ultramicroelements content of *M. arvensis*.

4. Discussion

The findings revealed that *M. arvensis* shows its good potential in various industries, as supported by existing research and data from the Chatkal State Biosphere Reserve. Flavonoids like rutin, luteolin, and kaempferol are consistent with recent research on the importance of their antioxidant, anti-inflammatory, and antidiabetic activity. The luteolin has been found to be a powerful inhibitor of α-glucosidase and α-amylase that attests to its inhibitory effect on blood sugar control (Wei *et al.,* 2023). The high rutin value attests to its antioxidant and cardiovascular effects. Nutritional characterisation of *M. arvensis* in addition reinforces its role as an affluent repository of critical vitamins. Abundant vitamin C supply, a competent antioxidant, is helpful in the immune-enforcing process and maintaining healthy skin. The presence of B-complex vitamins, *i.e.*, B1, B2, B9, and B12, helps in energy metabolism, cell repairing, and neuromuscular activity (Anjum *et al*., 2022). Existing research studies have demonstrated that environmental constituents, *i.e.*, sunlight and soil, contribute to shaping the quantity of vitamins found in medicinal plants. All these findings support the nutritional value of the plant and its applicability in functional foods and nutraceuticals.

Macro- and microelement analysis verified the presence of potassium and iron, which are required for electrolyte balance and oxygen transportation. Zinc and manganese are trace elements that have essential functions in enzymatic activities and immune responses (Faisal *et al.,* 2023). Ultramicroelements like strontium and lithium present in minor quantities take part in bone structure and metabolic balance. All these results add new evidence pointing to the essential role of micronutrients in chronic disease prevention and overall health. Pharmacologically, *M. arvensis* is of highly therapeutic importance with its bioactive constituents like menthol and rosmarinic acid. The constituents have been associated with antimicrobial, antidiabetic, and anticancer activity in new *in silico* and *in vitro* research. Plant essential oils with high menthol content are applied intensively in medications and cosmetics due to their cooling and calming nature. Researchers have also evaluated the application of *M. arvensis* in the sustenance of soil fertility and nutrient cycling, hence qualifying it as a candidate for phytoremediation and sustainable agriculture.

5. Conclusion

The findings revealed the diverse and impactful role of *M. arvensis* as a nutritionally abundant and therapeutically valuable herb crop. Its antioxidant, antibacterial, and anti-inflammatory effects are clearly demonstrated through the detailed evaluation of its phytochemical, vitamin, and mineral profile. Key bioactive compounds like rutin, luteolin, and vitamin C underline its significance in promoting cardiovascular health, boosting immunity, and combating oxidative stress. In addition to verifying its nutritional value, the presence of macroelements such as potassium, calcium, and magnesium, along with microelements like zinc, iron, and manganese, reinforces its importance in addressing deficiencies and supporting overall physiological health. Future research should try to ascertain the bioavailability and synergistic activity of the phytoconstituents in *M. arvensis* to maximize their therapeutic applications. *M. arvensis* holds vast potential for environmental sustainability, particularly if deployed in the improvement of soil health and phytoremediation to a greener and healthier world.

Acknowledgements

The authors would like to acknowledge the support provided by the Innovation Development Agency of the Ministry of Higher Education, Science and Innovation of Uzbekistan. Project Number FL-8323102106.

Conflict of interest

The author declares no conflicts of interest relevant to this article.

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Citation **Maftuna Chorieva, Monika Chaudhary, Alimjan Matchanov, Abdulahat Azimov, Anora Matkarimova and Dilfuza Jabborova (2025). Determination of vitamins, flavonoids, macro and micronutrients of *Mentha arvensis* L. in the territory of the Chatkal State Biosphere Reserve. Ann. Phytomed., 14(1):1022-1027. http://dx.doi.org/10.54085/ap.2025.14.1.102.**