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STUDY OF THE ELEMENTAL COMPOSITION OF *PARTHENOCISSUS QUINQUEFOLIA* AND *PARTHENOCISSUS TRICUSPIDATA* RAW MATERIALS IN COMPARISON WITH THE SOIL ELEMENTAL COMPOSITION

Actuality. *Considering the significance of macro- and microelements in maintaining the vital functions of a human body, it is important to determine their qualitative and quantitative composition in medicinal plant raw materials. Promising objects of study include species of the genus Parthenocissus Planch. – P. quinquefolia and P. tricuspidata, which are widespread in Ukraine and possess both decorative and pharmacological value. However, modern professional literature lacks data on the mineral element content in the raw materials of P. quinquefolia and P. tricuspidata. The raw materials of these species contain a wide range of biologically active substances, such as stilbenes, flavonoids, phenolic acids, and other substances that have antimicrobial, antioxidant, anti-inflammatory, anticancer, and senolytic activities.*

The aim of the work *– to investigate the elemental composition of P. quinquefolia and P. tricuspidata raw materials in comparison with the elemental composition of the soil.*

Materials and methods. *Leaves and shoots of P. quinquefolia and P. tricuspidata were collected during the flowering phase (July), and fruits during full ripeness (September–October) in 2023 in Lisnyky village and Skvyra town, Kyiv Oblast (Ukraine).*

The study of the qualitative composition and quantitative content of mineral elements was carried out by the X-ray fluorescence method on the energy dispersive spectrometer "ElvaX-med" (Elvatech Ltd., Ukraine) in the Scientific and Technical centre "Viria Ltd." (Kyiv, Ukraine).

Research results. *The leaves and shoots of both species of Parthenocissus accumulated a higher total content of mineral elements compared to the fruits. The mineral content in the leaves and shoots of P. quinquefolia (2297.23 mg/100 g) was slightly higher than in P. tricuspidata (2112.52 mg/100 g) collected in Lisnyky village, and in P. tricuspidata (1650.78 mg/100 g) collected in Skvyra town, significantly exceeded the content in the leaves and shoots of P. quinquefolia (524.88 mg/100 g) collected in Skvyra town. In the fruits of P. quinquefolia (1371.17 mg/100 g) and P. tricuspidata (1332.20 mg/100 g) collected in Lisnyky village, the total mineral content was almost identical and somewhat lower than in the fruits of P. tricuspidata (1818.23 mg/100 g), and 2.2 times lower than in the fruits of P. quinquefolia (3097.57 mg/100 g) collected in Skvyra town.*

The raw material of P. quinquefolia exhibited a slightly higher total content of mineral elements compared to P. tricuspidata. At the same time, P. tricuspidata was characterized by a higher sulfur content, particularly in the leaves and shoots, which may represent a species-specific feature of this raw material.

Both species of Parthenocissus showed a similar elemental composition, with sulfur, potassium, and calcium prevailing regardless of the growing conditions. Neither species accumulated heavy metals (titanium, cobalt, zirconium) even in cases of significant soil concentrations, indicating the environmental safety of the raw materials.

Conclusions. *The results of the study of the mineral composition of P. quinquefolia and P. tricuspidata raw materials confirm the potential for further phytochemical and pharmacological studies of these raw materials to develop and implement phytomedicines with hypoglycemic, neuroprotective, anti-inflammatory, and antioxidant properties.*

Key words: *Virginia creeper, Parthenocissus quinquefolia, Japanese creeper, Parthenocissus tricuspidata, X-ray fluorescence method, macroelements, microelements, soil elemental composition.*

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ДОСЛІДЖЕННЯ ЕЛЕМЕНТНОГО СКЛАДУ СИРОВИНИ ДІВОЧОГО ВИНОГРАДУ П'ЯТИЛИСТОГО ТА ДІВОЧОГО ВИНОГРАДУ ТРИГОСТРОКІНЦЕВОГО В ПОРІВНЯННІ З ЕЛЕМЕНТНИМ СКЛАДОМ ҐРУНТУ

Актуальність. *Зважаючи на важливість макро- та мікроелементів у забезпеченні життєдіяльності організму, актуальним є встановлення їхнього якісного складу та кількісного вмісту в лікарській рослинній сировині. Перспективними об'єктами дослідження є представники роду Parthenocissus Planch. (дівочий виноград) – P. quinquefolia та P. tricuspidata, які поширені на території України і мають декоративну та фармакологічну цінність, адже в сучасній фаховій літературі відсутні дані щодо вмісту мінеральних елементів у сировині P. quinquefolia та P. tricuspidata. Сировина цих видів містить широкий спектр БАР, зокрема стильбени, флавоноїди, гідроксикоричні та фенольні кислоти, а також інші сполуки, що проявляють антимікробну, антиоксидантну, протизапальну, антиканцерогенну, сенолітичну активність.*

Мета дослідження *– вивчити елементний склад сировини дівочого винограду п'ятилистого (P. quinquefolia) та дівочого винограду тригострокінцевого (P. tricuspidata) в порівнянні з елементним складом ґрунту, взятому з-під рослин.*

Матеріали та методи дослідження. *Листя й пагони P. quinquefolia та P. tricuspidata були заготовлені у фазу квітування (липень), плоди – під час повної стиглості (вересень – жовтень) у 2023 році в с. Лісники та в м. Сквира Київської області (Україна).*

Дослідження якісного складу та кількісного вмісту мінеральних елементів проводили рентген-флуоресцентним методом (РФА) на енергодисперсійному спектрометрі ElvaX.

Результати дослідження. *Листя з пагонами обох видів дівочого винограду характеризується накопиченням більшої загальної кількості мінеральних елементів, ніж плоди. Вміст мінеральних елементів у листі з пагонами **P. quinquefolia** (2297,23 мг/100 г) дещо вищий, ніж у **P. tricuspidata** (2112,52 мг/100 г), зібраних у с. Лісники, і у **P. tricuspidata** (1650,78 мг/100 г), зібраних у м. Сквира, та значно перевищує їх вміст у листі з пагонами **P. quinquefolia** (524,88 мг/100 г), зібраних у м. Сквира. У плодах **P. quinquefolia** (1371,17 мг/100 г) та **P. tricuspidata** (1332,20 мг/100 г), зібраних у с. Лісники, загальний вміст елементів майже не відрізняється та є дещо меншим, ніж у плодах **P. tricuspidata (1818,23 мг/100 г)** та у 2,2 раза менший, ніж у плодах **P. quinquefolia** (3097,57 мг/100 г), зібраних у м. Сквира.*

Сировина P. quinquefolia *має дещо вищий загальний вміст мінеральних елементів порівняно з **P. tricuspidata**. Тоді як для сировини **P. tricuspidata** характерним є накопичення більшої кількості сульфуру, особливо в листі з пагонами, що може бути видовою особливістю цієї сировини.*

Обидва види дівочого винограду мають подібний елементний склад із переважанням сульфуру, калію та кальцію, незалежно від умов зростання, та не накопичують важкі метали (титан, кобальт, цирконій) навіть за їх значного вмісту в ґрунті, що свідчить про екологічну безпечність сировини.

Висновки. *Результати дослідження мінерального складу сировини **P. quinquefolia** та **P. tricuspidata** підтверджують перспективність подальших фітохімічних і фармакологічних досліджень цієї сировини з метою розробки та впровадження фітозасобів із гіпоглікемічною, нейропротекторною, протизапальною та антиоксидантною дією.*

Ключові слова: *дівочий виноград п'ятилистий, Parthenocissus quinquefolia, дівочий виноград тригострокінцевий, Parthenocissus tricuspidata, рентген-флуоресцентний метод, макроелементи, мікроелементи, елементний склад ґрунту.*

Introduction. The centuries-long use of medicinal plants as a source of biologically active substances (BAS) with specific therapeutic effects has become the basis for the search for new promising plants. Of particular interest in this regard are representatives of the genus Parthenocissus Planch. (family Vitaceae), especially Virginia creeper (P. quinquefolia (L.) Planch.) and Japanese creeper (P. tricuspidata (Siebold et Zucc.) Planch.), which are widespread in both cultivated and wild states across Ukraine as ornamental plants for vertical gardening (Nie, 2010). Moreover, these perennial lianas are used in traditional medicine in North America and Asia to treat gastrointestinal diseases and for their anti-inflammatory, antioxidant, anticancer, antiviral, hemostatic, antidiabetic, and anti-aging properties (Faisal, 2018; Liang, 2018; Abood, 2024).

The raw materials of P. tricuspidata contain a variety of BAS that exhibit a broad spectrum of pharmacological activities, including antimicrobial, antioxidant, anti-inflammatory, and anticancer effects, which may reduce the risk of degenerative diseases by alleviating oxidative stress. Specifically, the shoots contain the stilbenoid resveratrol and flavonoids (catechin, aromadendrin-3-O-β-D-glucopyranoside, and engelitin) (Jeon, 2013); the stems contain phenolic compounds such as protocatechuic, benzoic, caffeic, and caffeoylglycolic acids, acacetin, and catechin (Nguyen, 2014); while the leaves contain derivatives of caffeic acid, flavonoids (quercetin and kaempferol), and phytosterols (β-sitosterol glucoside, 2α-hydroxyursolic, and 2,24-dihydroxyursolic acids) (Hwang, 2004).

Similarly, P. quinquefolia shoots are known to contain valuable BAS such as stilbenes (trans-resveratrol, piceatannol, resveratrol 2-O-β-glucopyranoside, parthenocissins A and B, ε-viniferin, pallidol, cyphostemins A and B, miyabenol C) (Yang, 2014). All parts of the plant contain hydroxycinnamic acids (coumaric, caffeic, and chlorogenic acids) and derivatives of benzoic acid (gallic acid) (Abood, 2024); numerous flavonoids (quercetin, kaempferol, isorhamnetin, luteolin, quercetin-3-O-α-L-rhamnoside, myricetin-3-O-α-L-rhamnoside, naringin, quercitrin, rutin), including catechins (epicatechin, catechin, gallocatechin, epicatechingallate) (Yang, 2010; Ismail, 2021; Konovalova, 2023).

However, no data on the mineral element content in the raw materials of *P. quinquefolia* and *P. tricuspidata* have been found in the available scientific literature. Considering the significant raw material base and the prospects for systematic pharmacognostic and pharmacological studies, it is relevant to establish the qualitative composition and quantitative content of mineral elements in these raw materials. Macro- and microelements have a critical role in maintaining life processes. They are directly involved in processes such as hematopoiesis, respiration, neuromuscular conduction, and other intracellular processes. Since the mineral composition of plants can be influenced by the geochemical characteristics of the soil and the selective accumulation ability of plants, it is advisable to study the mineral composition of medicinal plant raw materials in comparison with the soil in which they grow (Prakash, 2011; Makovetskaya, 1999; Kyslychenko, 2008).

The aim of the work was to investigate the elemental composition of the raw materials of ***P. quinquefolia*** and ***P. tricuspidata*** in comparison with the elemental composition of the soil.

Materials and methods. Leaves and shoots of P. quinquefolia and P. tricuspidata were harvested during the flowering phase (July), and fruits during full ripening (September-October) in 2023 in Lisnyky village (Obukhiv district) and Skvyra town (Bila Tserkva district), Kyiv Oblast, Ukraine.

The study of the qualitative composition and quantitative content of mineral elements was carried out by the X-ray fluorescence (XRF) method on the energy dispersive spectrometer "ElvaX-med" (Elvatech Ltd., Ukraine) in the Scientific and Technical centre "Viria Ltd." (Kyiv, Ukraine) (Szczerbowska-Boruchowska, 2008; Korotkov, 2009).

For analysis, an average sample of crushed raw material weighing 50 mg was taken, mixed with an organic binder free of metal impurities. The mixture was dried and pressed into a tablet with a diameter of 10 mm, a thickness of approximately 2 mm, and a weight of 50 mg. The resulting tablet was analyzed on the device for 10 minutes. The energy range of the X-ray fluorescence analyzer was 1–40 keV, with a sensitivity of 1 ppm (1 μg/g).

The composition of clean filter paper (State Standard GOST 12026-76) was measured, considering its spectrum as a background during the analysis of working samples.

The analyzer was calibrated to determine the mass fraction of individual elements using standard solutions of metal ions according to Ukrainian STAR solutions (1.0 mg/dm3; State Standard Samples of Ukraine DSZU 022.86-98), which are used for calibration, certification, and verification of analytical instruments (Konovalova, 2010; Konovalova, 2024).

Statistical data processing was carried out based on five consecutive measurements using the Student's t-test according to the monograph of the State Pharmacopoeia of Ukraine (SPU) 5.3.N.1 (SPU, 2018).

Results and discussion. In the samples of P. quinquefolia raw materials collected in Lisnyky village (Obukhiv district), 11 mineral elements were identified in the fruits, 12 in the leaves and shoots, and 20 in the soil beneath the plants. Similarly, in the samples collected in Skvyra town (Bila Tserkva district), 11 elements were found in the fruits, 13 in the leaves and shoots, and 21 in the soil samples.

In the samples of P. tricuspidata raw materials collected in Lisnyky village, 12 mineral elements were identified in the fruits, 13 in the leaves and shoots, and 18 in the soil beneath the plants. In Skvyra town, the samples revealed 11 elements in the fruits, 13 in the leaves and shoots, and 21 in the soil.

The results are presented in Fig. 1, 2 and Table 1, 2.

According to the obtained data, the raw material of P. quinquefolia harvested in Lisnyky village is dominated by macroelements such as sulfur, potassium, and calcium, with a total content of 2282.85 mg/100 g in fruits and 1366.01 mg/100 g in leaves with shoots. Notably, the leaves with shoots of P. quinquefolia accumulate higher amounts of calcium, while the fruits are rich in potassium. Among microelements, iron (2.8 times higher in leaves with shoots) and strontium (4 times higher in leaves with shoots) predominate in both leaves with shoots and fruits. The total microelement content in leaves with shoots of P. quinquefolia is 13.93 mg/100 g, while in fruits it is 4.85 mg/100 g. The ultramicroelement content is negligible, at 0.45 mg/100 g and 0.31 mg/100 g, respectively.

Overall, the elemental composition of leaves with shoots and fruits of P. quinquefolia (Lisnyky) is similar, with minor differences: manganese, zirconium, and bromine are absent in fruits but present in small amounts in leaves and shoots, whereas chlorine and chromium are found in fruits but not in leaves and shoots.

It is noteworthy that leaves with shoots of P. quinquefolia (Lisnyky) contain 1.7 times more mineral elements (2297.23 mg/100 g) than fruits (1371.17 mg/100 g). The ranking of mineral element content in leaves with shoots is as follows: Ca > S > K > Fe > Sr > Mn > Zn > Zr > Ni > Cu > Br > Rb. For fruits, the order is: K > S > Ca > Cl > Fe > Sr > Zn > Cu > Ni > Cr > Rb.

The soil sample collected in Lisnyky is predominantly contains iron, calcium, potassium, sulfur, tita-

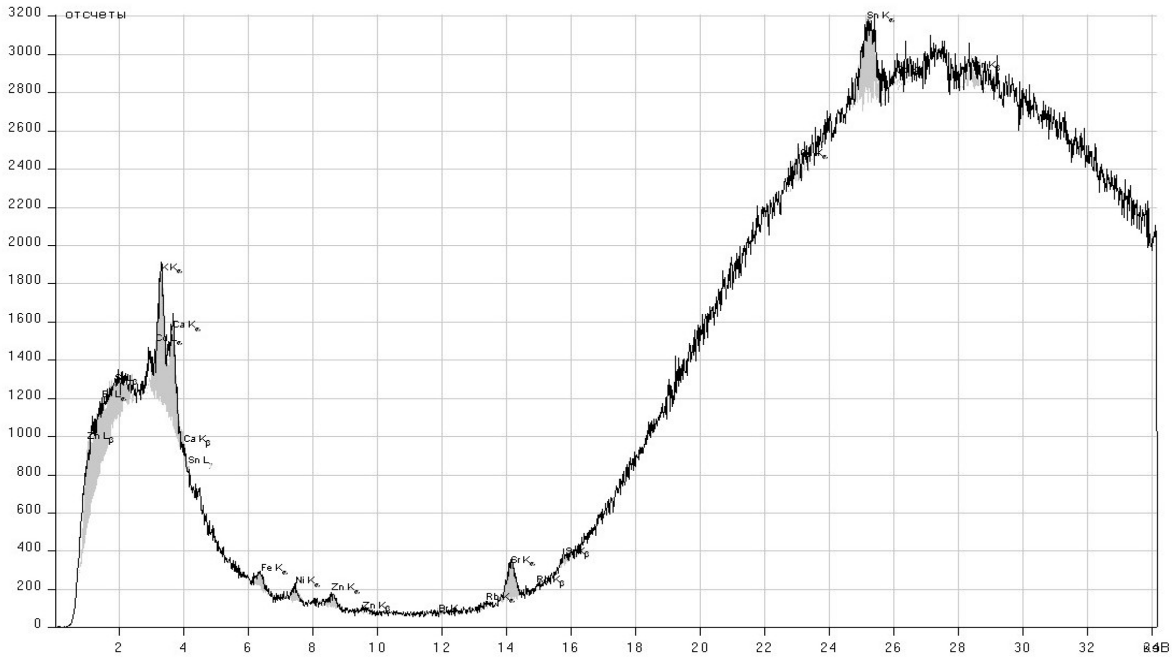

Fig. 1. Spectrogram of the mineral element content in P. quinquefolia fruits (Lisnyky village)

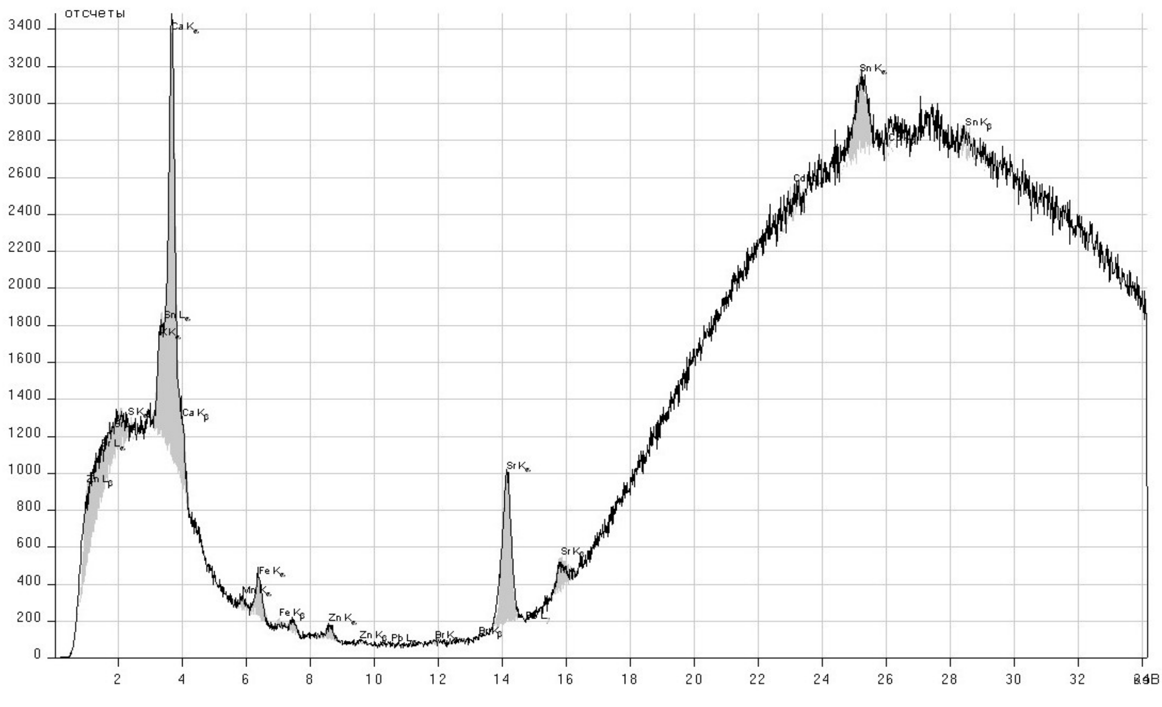

Fig. 2. Spectrogram of the mineral element content in the leaves and shoots of P. quinquefolia (Lisnyky village)

nium, barium, manganese, cobalt, and zirconium. The total mineral element content (mg/100 g) is 6334.83, including 3703.74 macroelements, 2011.5 microelements, and 619.59 ultramicroelements.

The high content of calcium, potassium, and sulfur in the soil correlates with their high content in the raw material of *P. quinquefolia* obtained from plants growing on it. Regarding other elements that are abundant

Table 1

Mineral element content in *P. quinquefolia* raw material compared to the mineral composition of the soil

Element	The element content, mg/100 g of absolutely dry raw material					
	Fruits (Lisnyky)	Leaves with shoots (Lisnyky)	Soil (Lisnyky)	Fruits (Skvyra)	Leaves with shoots (Skvyra)	Soil (Skvyra)
S	421.25	724.26	634.10	1958.98	48.22	229.72
Cl	24.81	0	50.51	0	0	33.34
K	669.38	581.10	1269.16	742.21	220.85	1301.85
Ca	250.57	977.49	1749.97	390.51	246.58	1601.89
Mn	0	1.27	97.99	0.42	0.49	89.99
Fe	2.09	5.93	1889.93	2.89	4.32	2297.38
Cu	0.33	0.18	0.92	0.17	0.20	1.02
Zn	1.02	1.06	6.42	0.80	0.73	8.08
Se	0	0	0	0	0	0.52
Rb	0.12	0.10	7.46	0.13	0.12	7.39
Sr	1.29	5.26	7.16	0.75	2.51	6.77
Br	0	0.13	0.81	0	0.11	1.05
Pb	0	0	0.81	0	0	2.35
Cr	0.13	0	3.99	0.39	0.25	5.18
Co	0	0	96.11	0	0.18	115.74
Ni	0.18	0.21	4.90	0.32	0.32	11.78
Ti	0	0	247.15	0	0	271.51
Zr	0	0.24	57.24	0	0	45.17
Sn	0	0	23.09	0	0	25.37
Y	0	0	1.53	0	0	2.26
Ba	0	0	185.58	0	0	134.78

in the soil sample, their content does not influence the accumulation of these elements in the plant; for instance, titanium, barium, and cobalt were not detected at all in the studied raw material samples.

It is worth noting that the leaves with shoots of P. quinquefolia contain slightly more sulfur (90 mg/100 g) than the soil sample, which may be a characteristic of the plant itself.

In the raw material of *P. quinquefolia* collected in Skvyra, the predominant accumulation of macroelements is also observed, particularly in the fruits, which contain significantly more sulfur (almost 8 times more than in the leaves with shoots), while calcium is higher in the leaves with shoots. Additionally, the total content of mineral elements (mg/100 g) in the fruits is significantly higher (3097.57), of which 3091.7 are macroelements, 5.16 microelements, and 0.71 ultramicroelements. In the leaves with shoots, the total content is 524.88 mg/100 g, including 515.65 macroelements, 8.48 microelements, and 0.75 ultramicroelements.

The ranking of mineral element content in leaves with shoots of P. quinquefolia (Skvyra) is as follows: Ca > K > S > Fe > Sr > Zn > Mn > Ni > Cr > Cu > Co > Rb > Br. For fruits, the order is: S > K > Ca > Fe > Zn > Sr > Mn > Cr > Ni > Cu > Rb.

The soil sample from Skvyra town is characterized by predominant levels of iron, calcium, potassium, titanium, sulfur, barium, cobalt, and manganese. The total mineral element content (mg/100 g) is 6193.14, including 3166.80 macroelements, 2414.55 microelements, and 611.79 ultramicroelements.

Comparing the mineral composition of P. quinquefolia raw material and soil (Skvyra), it can be concluded that the accumulation of potassium and calcium in this plant is due to the abundance of these elements in the soil. In contrast, the sulfur content, particularly in fruits, is characteristic of the plant itself, being 8.5 times higher than in the soil.

The absence or low content of iron, titanium, barium, cobalt, and manganese in *P. quinquefolia* raw materials, compared to their significant presence in the soil, confirms that *P. quinquefolia* does not accumulate heavy metals from the soil.

As shown in the presented results (Table 2), all analyzed samples of P. tricuspidata raw materials are predominantly composed of macroelements such as sulfur, potassium, and calcium. Among the microelements, iron is prevalent, while the content of other elements is significantly lower or negligible.

Leaves and shoots of P. tricuspidata (Lisnyky) accumulate more mineral elements compared to fruits,

Table 2

Mineral element content in the raw material of *P. tricuspidata* compared to the mineral composition of the soil

Element	The element content, mg/100 g of absolutely dry raw material					
	Fruits (Lisnyky)	Leaves with shoots (Lisnyky)	Soil (Lisnyky)	Fruits (Skvyra)	Leaves with shoots (Skvyra)	Soil (Skvyra)
S	559.82	1122.96	520.17	728.52	633.12	417.22
Cl	0	0	93.60	0	0	36.18
K	455.78	572.75	1280.80	658.41	484.69	1295.65
Ca	309.88	406.60	684.62	423.62	519.55	1110.18
Mn	0.13	0.81	73.29	0.18	1.11	81.26
Fe	2.36	4.62	1312.61	2.93	7.08	2063.08
Cu	0.63	0.13	1.33	0.45	0.23	1.16
Zn	1.19	0.83	2.19	2.09	1.68	4.56
Se	0	0	0	0	0	3.78
Rb	0.45	0.32	4.95	0.21	0.37	6.09
Sr	1.51	2.62	3,88	1.33	2.19	4.12
Br	0.11	0.18	0	0	0.17	0.78
Pb	0	0	0.57	0	0	1.97
Cr	0.22	0	4.82	0.33	0.20	4.33
Co	0	0.22	48.13	0	0.14	86.45
Ni	0.12	0.24	5.67	0.16	0.25	10.47
Ti	0	0	319.40	0	0	287.05
Zr	0	0.24	44.55	0	0	41.18
Sn	0	0	30.57	0	0	29.65
Y	0	0	0.21	0	0	0.86
Ba	0	0	0	0	0	36.21

with twice as much sulfur, 1.2 times more potassium, 1.3 times more calcium, and twice as much iron.

The total mineral element content (mg/100 g) in the leaves and shoots of P. tricuspidata (Lisnyky) is 2112.52, including 2102.31 macroelements, 9.51 microelements, and 0.7 ultramicroelements. In the fruits of this species, the mineral element content is lower at 1332.20 mg/100 g, including 1325.48 macroelements, 6.38 microelements, and 0.34 ultramicroelements.

The mineral element content in P. tricuspidata fruits (Lisnyky) follows the order: S > K > Ca > Fe > Sr > Zn > Cu > Rb > Cr > Mn > Ni > Br. For leaves and shoots, the order is: S > K > Ca > Fe > Sr > Zn > Mn > Rb > Ni > Zr > Co > Br > Cu.

The predominant accumulation of potassium and calcium in the leaves, shoots, and fruits of P. tricuspidata correlates with their high content in the soil (1280.80 mg/100 g and 684.62 mg/100 g, respectively). A similar pattern is observed for most other elements, except sulfur, which is slightly higher in fruits and twice as high in leaves and shoots of P. tricuspidata. Therefore, the high sulfur content can be considered characteristic of the plant itself.

It is noteworthy that the high iron content in the soil (Lisnyky) did not influence its accumulation in the P. tricuspidata raw materials. The same can be said for heavy metals such as titanium, cobalt, zirconium, and tin, which were either not detected or present in negligible amounts (up to 0.3 mg/100 g) in the P. tricuspidata samples.

In the fruits of P. tricuspidata harvested in Skvyra town, the total mineral element content (mg/100 g) is 1818.23, including 1810.55 macroelements, 7.19 microelements, and 0.49 ultramicroelements. The order of element accumulation is as follows: S > K > Ca > Fe > Zn > Sr > Cu > Cr > Rb > Mn > Ni. Leaves and shoots from this region contain a total of 1650.78 mg/100 g of mineral elements, including 1637.36 macroelements, 12.83 microelements, and 0.59 ultramicroelements. The order of element accumulation is: S > Ca > K > Fe > Sr > Zn > Mn > Rb > Ni > Cu > Cr > Br > Co.

The soil sample from Skvyra town exhibits predominant levels of iron, potassium, calcium, sulfur, titanium, cobalt, and manganese. The total mineral element content (mg/100 g) in the soil is 5522.23, including 2859.23 macroelements, 2166.80 microelements, and 496.20 ultramicroelements.

When comparing the mineral composition of *P. tricuspidata* raw materials and the soil (Skvyra), a similar pattern is observed as in the previously described samples of Virginia creeper: a direct dependence of potassium and calcium content in the raw materials on their soil content, predominant sulfur accumulation in the fruits and leaves with shoots of *P. tricuspidata*, and the absence of titanium, zirconium, tin, and other heavy metals in the raw materials.

It should also be noted that the content of heavy metals in all studied samples of Virginia creeper raw materials is within normal limits and complies with the requirements of the State Pharmacopoeia of Ukraine (SPhU, 2014; SPhU, 2015).

All studied samples contained small amounts of strontium (from 0.75 to 5.26 mg/100 g), but this does not raise concerns, as according to the recommendations of the World Health Organization (WHO), the safe level of consumption of natural (non-radioactive) strontium for humans is 2–4 mg/kg body weight per day, while the toxic dose is approximately 90–150 mg/kg body weight (Watts, 2010).

The modern scientific literature lacks reliable data on the mineral element content in P. quinquefolia and P. tricuspidata raw materials for comparison.

Based on our results, it can be noted that leaves with shoots of both *Parthenocissus* species accumulate a greater total amount of mineral elements compared to fruits. The mineral element content in the leaves with shoots of P. quinquefolia (2297.23 mg/100 g) is slightly higher than that in P. tricuspidata (2112.52 mg/100 g) collected in Lisnyky and in P. tricuspidata (1650.78 mg/100 g) collected in Skvyra, and significantly exceeds the content in the leaves with shoots of P. quinquefolia (524.88 mg/100 g) collected in Skvyra.

In the fruits of P. quinquefolia (1371.17 mg/100 g) and P. tricuspidata (1332.20 mg/100 g) collected in Lisnyky, the total element content is almost identical and slightly lower than in the fruits of P. tricuspidata (1818.23 mg/100 g) and 2.2 times lower than in the fruits of P. quinquefolia (3097.57 mg/100 g) collected in Skvyra.

Among macroelements, sulfur, potassium, and calcium dominate in both species across different collection sites, although their proportions vary: in P. quinquefolia (Lisnyky and Skvyra), leaves with shoots accumulate more calcium, while fruits (Lisnyky and Skvyra) accumulate more potassium and sulfur, respectively. In P. tricuspidata (Lisnyky and Skvyra), sulfur predominates in both leaves with shoots and fruits.

Both species actively accumulate potassium and calcium from the soil: P. quinquefolia has a specific ability to accumulate more calcium in leaves with shoots, while sulfur is typical for fruits regardless of soil composition. In P. tricuspidata, sulfur is also characteristic of the plant, significantly exceeding the content of this element in the soil. Both *Parthenocissus* species do not accumulate heavy metals (titanium, cobalt, zirconium) even in the presence of their significant soil levels, demonstrating the ecological safety of the raw materials.

The predominant accumulation of sulfur, potassium, and calcium in the raw materials of P. quinquefolia and P. tricuspidata has practical importance. Potassium is one of the essential macroelements for the normal functioning of the human body. Its critical role lies in nerve impulse transmission, which controls muscle contractions, including the myocardium. Thus, potassium is indispensable for the cardiovascular system and muscle tissue function. A low potassium intake is associated with hypertension and hypokalemia, whereas adequate intake helps reduce blood pressure, maintain bone health, and prevent cardiovascular diseases (D'Elia, 2011; Weaver, 2013; Konovalova, 2012). Calcium, beyond its role in bone tissue formation, contributes to reducing arterial pressure, particularly in younger individuals, preventing osteoporosis and colorectal adenomas, and lowering cholesterol levels. Adequate calcium intake is crucial for maintaining optimal metabolic processes (Cormick, 2019).

Sulfur is an essential element involved in synthesizing numerous proteins, enzymes, coenzymes, vitamins, and hormones, which are integral to metabolic reactions and homeostasis maintenance. It plays a vital role in protein synthesis, DNA methylation and repair, gene expression regulation, and lipid metabolism. Sulfur is critical in redox reactions, enabling free radical neutralization and xenobiotic detoxification. Furthermore, plant-based products rich in sulfur exhibit hypoglycemic, neuroprotective, anticancer, anti-inflammatory, and antioxidant properties (Francioso, 2020; Hill, 2022).

Conclusions

Using XRF spectroscopy, the qualitative and quantitative composition of mineral elements in two types of raw materials (leaves with shoots and fruits**) of** P. quinquefolia **and** P. tricuspidata **from two different growth locations (Lisnyky village and Skvyra town, Kyiv Oblast) was studied and compared with their content in the soil sampled beneath the plants.**

In the raw materials of P. quinquefolia **from Lisnyky, 12 mineral elements were identified: in leaves with shoots – 3 macroelements (S, K, Ca), 7 microelements (Mn, Fe, Cu, Zn, Rb, Sr, Br), and 2 ultramicroelements (Ni, Zr); in fruits – 4 macroelements (S, Cl, K, Ca), 5 microelements (Fe, Cu, Zn, Rb, Sr), and 2 ultramicroelements (Cr, Ni).**

In the raw materials of P. quinquefolia **from Skvyra, 13 mineral elements were identified: in leaves with shoots – 3 macroelements (S, K, Ca), 7 microelements (Mn, Fe, Cu, Zn, Rb, Sr, Br), and 3 ultramicroelements (Cr, Co, Ni); in fruits – 3 macroelements (S, K, Ca), 6 microelements (Mn, Fe, Cu, Zn, Rb, Sr), and 2 ultramicroelements (Cr, Ni).**

In the raw materials of P. tricuspidata **from Lisnyky, 13 mineral elements were identified: in leaves with shoots – 3 macroelements (S, K, Ca), 7 microelements (Mn, Fe, Cu, Zn, Rb, Sr, Br), and 3 ultramicroelements (Co, Ni, Zr); in fruits – 3 macroelements (S, K, Ca), 7 microelements (Mn, Fe, Cu, Zn, Rb, Sr, Br), and 2 ultramicroelements (Cr, Ni).**

In the raw materials of P. tricuspidata **from Skvyra, 13 mineral elements were identified: in leaves with shoots – 3 macroelements (S, K, Ca), 7 microelements (Mn, Fe, Cu, Zn, Rb, Sr, Br), and 3 ultramicroelements (Cr, Co, Ni); in fruits – 3 macroelements (S, K, Ca), 6 microelements (Mn, Fe, Cu, Zn, Rb, Sr), and 2 ultramicroelements (Cr, Ni).**

The raw materials of P. quinquefolia **contains a slightly higher total mineral element content compared to** P. tricuspidata**.**

Both *Parthenocissus* species have a similar elemental composition, predominantly sulfur, potassium, and calcium, regardless of growth conditions, and do not accumulate heavy metals (titanium, cobalt, zirconium) even when present in significant amounts in the soil, indicating the ecological safety of the raw materials. P. tricuspidata **is characterized by higher sulfur accumulation compared to** P. quinquefolia**, particularly in leaves with shoots, which may be a species-specific trait.**

Thus, the presented results of the mineral composition study of *P. quinquefolia* and *P. tricuspidata* raw materials confirm the prospects for further phytochemical and pharmacological research on this raw material, aiming to develop and introduce phytomedicines with hypoglycemic, neuroprotective, anti-inflammatory, and antioxidant effects.

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