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The study of the elemental composition of *Iris hungarica* and varieties of irises

Aim. To determine the elemental composition of leaves and rhizomes of *Iris hungarica* and dwarf bearded irises.

Materials and methods. The objects of the study were leaves and rhizomes of *Iris hungarica* Waldst et Kit. and 5 varieties of standard dwarf bearded irises (*Iridaceae)*. The content of macro- and microelements in the leaves and rhizomes of irises was determined by atomic emission spectrometry.

Results and discussion. For the first time the quantitative content of the mineral complex of *Iris hungarica* and dwarf bearded irises has been determined by atomic emission spectrometry. In total, 19 elements have been identified; among them there are 5 macroelements (K, Ca, Mg, Na, P), 10 microelements elements (Fe, Si, Al, Mn, Pl, Ni, Mo, Cu, Zn, Sr), 4 ultramicroelements (Co, Cd, As, Hg). The content of heavy, toxic elements are within the permissible limits. The experimental data will be further used to standardize the raw material of irises.

Conclusions. The quantitative content of the mineral complex of *Iris hungarica* and dwarf bearded irises has been identified. According to the research results the raw material of irises can be recommended as an additional source of macro- and microelements.

Key words**:** *irises; leaves; rhizomes; elemental composition; atomic emission spectrometry*

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Дослідження елементного складу *Iris hungarica* та сортів півників

Мета. Встановити елементний склад листя та кореневищ півників угорських та карликових бородатих півників.

Матеріали та методи. Об'єктами дослідження були листя та кореневища півників угорських (*Iris hungarica* Waldst et Kit.) та 5 сортів стандартних карликових бородатих півників (*Iridaceae*). Вміст макро- та мікроелементів у листі та кореневищах півників встановлювали методом атомно-емісійної спектрометрії.

Результати та їх обговорення. Вперше кількісний вміст мінерального комплексу півників угорських та карликових півників був встановлений методом атомно-емісійної спектрометрії. Були ідентифіковані 19 елементів, серед яких 5 – макроелементи (K, Ca, Mg, Na, P), 10 – мікроелементи (Fe, Si, Al, Mn, Pb, Ni, Mo, Cu, Zn, Sr), 4 – ультрамікроелементи (Co, Cd, As, Hg). Вміст важких, токсичних елементів знаходиться у допустимих межах. Дані експерименту будуть використані для стандартизації сировини півників.

Висновки. Встановлений кількісний вміст мінерального комплексу півників угорських та карликових бородатих півників. Результати досліджень можуть рекомендувати сировину півників як додаткове джерело макро- та мікроелементів.

Ключові слова**:** *півники; листя; кореневище; елементний склад; атомно-емісійна спектрометрія*

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Исследование элементного состава *Iris hungarica и* сортов ирисов

Цель. Установить элементный состав листьев и корневищ ириса венгерского и карликовых бородатых ирисов методом атомно-эмиссионной спектрометрии с дуговым возбуждением спектра.

Материалы и методы. Объектами исследования были листья и корневища ириса венгерского (*Iris hungarica* Waldst et Kit.) и 5 сортов стандартных карликовых бородатых ирисов (*Iridaceae*). Содержание макро- и микроэлементов в листьях и корневищах ирисов устанавливали методом атомно-эмиссионной спектрометрии.

Результаты и их обсуждение. Впервые количественное содержание минерального комплекса ириса венгерского и карликовых ирисов был установлен методом атомно-эмиссионной спектрометрии. Были идентифицированы 19 элементов, среди которых 5 – макроэлементы (K, Ca, Mg, Na, P), 10 – микроэлементы (Fe, Si, Al, Mn, Pb, Ni, Mo, Cu, Zn, Sr), 4 – ультрамикроэлементы (Co, Cd, As, Hg). Содержание тяжелых, токсических элементов находится в допустимых пределах. Данные эксперимента будут использованы для стандартизации сырья ирисов.

Выводы. Установлено количественное содержание минерального комплекса ириса венгерского и карликовых бородатых ирисов. Результаты исследований могут рекомендовать сырье ирисов как дополнительный источник макро- и микроэлементов.

Ключевые слова**:** *ирисы; листья; корневища; элементный состав; атомно-эмиссионная спектрометрия*

Since the middle of the last century the interest in medicinal plants has increased considerably, therefore, a more detailed study of biologically active substances (BAS) of the plant origin continues [1]. The peculiarity of plants is that they are able to accumulate different groups of substances with a high biological activity, as well as vitamins, amino acids and minerals, which have also an impact on the physiological processes of both the plant itself and humans. Macro- and microelements are the integral components of plant cells, providing the normal physiological state and plant development. They can also affect the activity of one or another major BAS synthesized by a medicinal plant: they can be antagonists, synergists, or can increase or neutralize toxicity [2]. Macroelements (more than 0.01 % of the content in living organisms) and microelements (less than 0.001 % of the content in living organisms) are the mineral parts that are insignificant, but play an important role. These elements also perform the regulatory function within the human internal environment. For example, sodium (Na) is one of the components that maintains the acid – base balance; calcium (Ca) is an activator of a large number of enzymes, and is part of vitamin B_{15}; magnesium (Mg) takes part in nerve conduction; iron (Fe) is the main component of hemoglobin, which provides transportation of oxygen; potassium (K) provides the muscle contraction and osmotic pressure [3]. The presence of such elements as lead, cadmium, rubidium, lanthanum, chromium, strontium, arsenic and stibium in the medicinal raw material may indicate toxicity and environmental hazard [4]. Therefore, determination of the mineral composition of the plant raw material is an integral part of the pharmacognostic study of medicinal plants.

Continuing the research of plants of the *Iridaceae* family *Iris hungarica* and 5 varieties of dwarf bearded irises were selected at this stage of the study. Along with the already known official medicinal plants, determination of the mineral complex in the cultivated plants is an important stage when introducing them into the pharmaceutical industry. This can further lead to a future outlook of developing phytoprepations based on them.

Iris hungarica Waldst et Kit., representatives of the genus *Iris* L., are widely distributed on the territory of Ukraine and the near abroad. This is a perennial herbaceous plant, from 15 to 40 cm in height. Leaves are sharp at the ends, linearly obvious, appear later in the peduncle. The rhizome is thickened – up to 2 cm in diameter, with a lot of roots [5].

Standard dwarf bearded irises (SDB) are a cultivated species of irises. Due to their decorative qualities this species is widespread throughout the world. The plants reach from 21 to 40 cm in height, with the color of leaves varying from blue to dark green. As a rule, on the flower peduncle there are 2-4 flowers with the most diverse color of petals and beards. The rhizome is up to 2 cm in thickness [6].

Throughout history, irises have been used in folk medicine: they have analgesic, antiseptic [7], diuretic [8], anti-inflammatory [9], astringent [10], expectorant [11], antiviral, anti-TB effects [12]. In traditional medicine, the raw material of irises iris is part of 8 drugs and biologically active additives [13]. According to the results of the previous studies, in the raw material of *Iris hungarica* the following components were identified: isoflavones (daidzein, formononetin, genistein), flavonols (quercetin), hydroxycinnamic acids (cinnamic, hydroxycinnamic, ferulic, chlorogenic), phenolic acids (galic), xanthones (magniferine, isomangiferine) [14]. The substances of phenolic nature, such as tectorigenin, tectoridin, irigenin, iristectorigenin B, iristectorin B, daidzein, genistein, formononetin, kaempferol, quercetin, mangiferine were also isolated [15, 16].

The aim of this work was to determine the elemental composition of leaves and rhizomes of *Iris hungarica* and DSB varieties by the atomic emission spectroscopy method with an arc excitation of the spectrum.

Materials and methods

The objects of the study were leaves and rhizomes of *Iris hungarica* Waldst et Kit. harvested during the growing season in 2014, as well as 5 varieties of standard dwarf bearded irises: *Iris x hybrida hort*. "Bright white", *Iris x hybrida hort*. "Indian Pow Waw", *Iris x hybrida hort*. "Galleon Gold", *Iris x hybrida hort*. "Mini Dynamo", *Iris x hybrida hort*. "Little Dream" were also collected during the growing season in 2016 at the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv).

The mineral complex was studied in the State Scientific Institution "Institute for Single Crystals" of the National Academy of Sciences of Ukraine (Department of Analytical Chemistry of Functional Materials and Objects of the Environment).

The atomic emission spectroscopy with arc excitation was used to determine the elemental composition of the objects studied.

Pre-treated by sulfuric acid the crushed raw material of the objects (3-4 mm) studied was incinerated in porcelain crucibles at a temperature of 500 °C for 1 hour in a muffle furnace. Excitation of IBS – 28 type spectra occurred in the discharge of the electric arc at the current of 16 A and the exposure time of 60 seconds [17]. To obtain and record the spectra of samples a DFS – 8 spectrograph with diffraction gratings of 600 ps/mm and the three-line slit illumination system was used. The intensity of the emission lines was measured using a MF – 4 microphotometer. The wavelength was from 240 nm to 347 nm. The sample data were compared with standard samples. The results were obtained by averaging 4 – 5 parallel tests and processed by the method of mathematical statistics [18].

Results and discussion

The absorption and transport of minerals reflects genotypic features (the ability to bioaccumulate chemical elements) and the conditions of the plant growth (soil composition, water regime, climatic conditions) [19]. As a result of the analysis it has been found that the ash content

Table

Mineral complex of leaves and rhizomes of *Iris hungarica* and SDB irises

Sample	The study object	The element content, mg/100g .															The ash content, %
		Fe	Si	P	Al	Mn	Mg	Pb	Ni	Mo	Ca	Cu	Zn	Na	K	Sr	
Iris hungarica	leaves	20	815	100	35	0.6	715	<0.03	<0.03	<0.03	1900	0.6	6.0	24	1190	24	11.93
	rhizome	58	585	80	23	1.9	140	<0.03	<0.03	<0.03	750	0.7	3.8	23	430	4.7	7.32
Iris x hybrid hort. «Galleon Gold»	leaves	15.8	84	126	23.1	6.3	365	<0.03	<0.03	0.031	1050	0.31	9.4	52	2100	12.6	10.56
	rhizome	15.2	115	115	38	5.7	215	<0.03	0.076	0.038	685	0.30	15.2	61	1900	13.7	7.6
Iris x hybrid hort. «Little Dream»	leaves	20.0	120	160	265	2.0	400	<0.03	<0.03	0.04	1330	0.66	10.6	67	3990	20.0	13.3
	rhizome	21.5	215	145	86	2.1	260	<0.03	0.086	0.043	1030	0.34	21.5	60	2150	17.2	8.61
Iris x hybrid hort. «Bright white»	leaves	18.1	100	170	20	12.6	305	<0.03	0.05	0.05	810	0.75	10.0	50	3030	15.1	9.63
	rhizome	28.8	240	125	38	3.4	290	<0.03	0.096	0.096	960	0.48	24.0	67	2880	17.3	9.6
Iris x hybrid hort. «Mini Dynamo»	leaves	12.0	86	205	25.8	2.6	515	<0.03	<0.03	0.086	1720	0.70	13.8	52	4300	25.8	17.2
	rhizome	86	430	170	105	3.4	260	0.086	0.043	0.043	1030	0.51	15.5	69	2150	17.2	8.6
Iris x hybrid hort. «Indian Pow Waw»	leaves	17	115	170	34	4.0	340	<0.03	<0.03	0.056	1020	0.50	10.2	34	3390	13.5	11.41
	rhizome	87	520	150	87	5.2	260	<0.03	0.043	<0.03	1045	0.43	17.4	43.5	1740	19.1	8.67

Note. In all samples: Co < 0.03\mg/100g; Cd < 0.001 mg/100g; As < 0.001 mg/100g; Hg < 0.001 mg/100g.

of the objects studied ranges from 7 to 17 %. The content of ash in rhizomes is lower (7.32-9.6 %) than in leaves (from 9.63 % to 17.2 %).

In the raw materal of irises 19 elements in total were identified, among them there were 5 macroelements (K, Ca, Mg, Na, P), 10 microelements elements (Fe, Si, Al, Mn, Pl, Ni, Mo, Cu, Zn, Sr), 4 ultramicroelements (Co, Cd, As, Hg), the quantitative content was determined (Table). There was a significant amount of potassium (430-4300 mg/100 g), calcium (685-1900 mg/100 g) and magnesium (140-715 mg/100 g). Such macroelements as phosphorus (80-205 mg/100 g) and sodium (23-69 mg/100 g) accumulated in smaller quantities (Fig. 1, 2). The raw material of irises accumulated a considerable amount of silicium (84-815 mg/100 g), aluminum (20-265 mg/100 g), iron (12.0-87 mg/100 g), strontium (4.7-25.8 mg/100 g), zinc (3.8-24 mg/100 g). It was noted that the rhizome of irises accumulated more nickel (Ni), molybdenum (Mo) and lead (Pb) than leaves. Such elements as cobalt (Co), cadmium (Cd), mercury (Hg), arsenic (As) were detected within the scope of capabilities (Co < 0.03 mg/100g; Cd, As, Hg < 0.001 mg/100g). Heavy, toxic metals were within the permissible limits for the medicinal raw material and food products [20].

The content of the elements in the samples of the raw materal of *Iris hungarica* can be arranged in the following decreasing sequence of the content: for leaves – Ca > K > Si > Mg > P > Al > Fe > Na = Sr > Zn > Mn = Cu > Mo = Pb = Ni > Co = As = Hg = Cd; for rhizomes – Ca > Si > K > Mg >P > Fe > Al = Na > Sr > Zn > Mn > Cu > Mo = Pb = Ni > Co = As = Hg = Cd.

By the quantitative content of the elements potassium (K), calcium (Ca) and magnesium (Mg) dominate, their greatest amount is accumulated in leaves of irises. Such elements as iron (Fe), aluminum (Al), sodium (Na), strontium (Sr), zinc (Zn) and silicium (Si) have a higher content in rhizome of irises.

It is known that plants are able to accumulate secon dary metabolites, such as alkaloids, triterpene and phenolic compounds. In turn, the pharmacological effects of plants depend precisely on the characteristics of the chemical composition of the secondary metabolites.

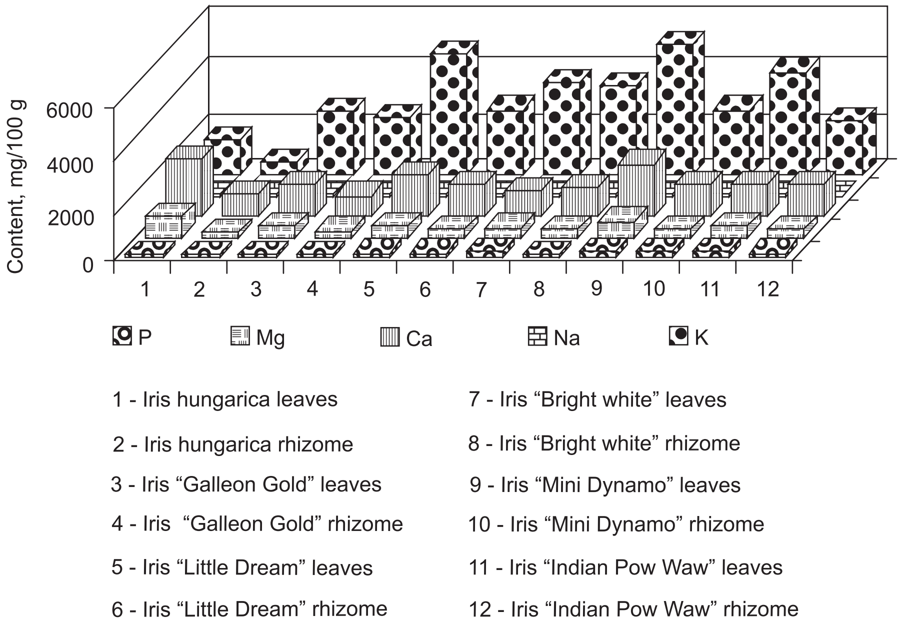

Fig. 1. Macroelements of irises

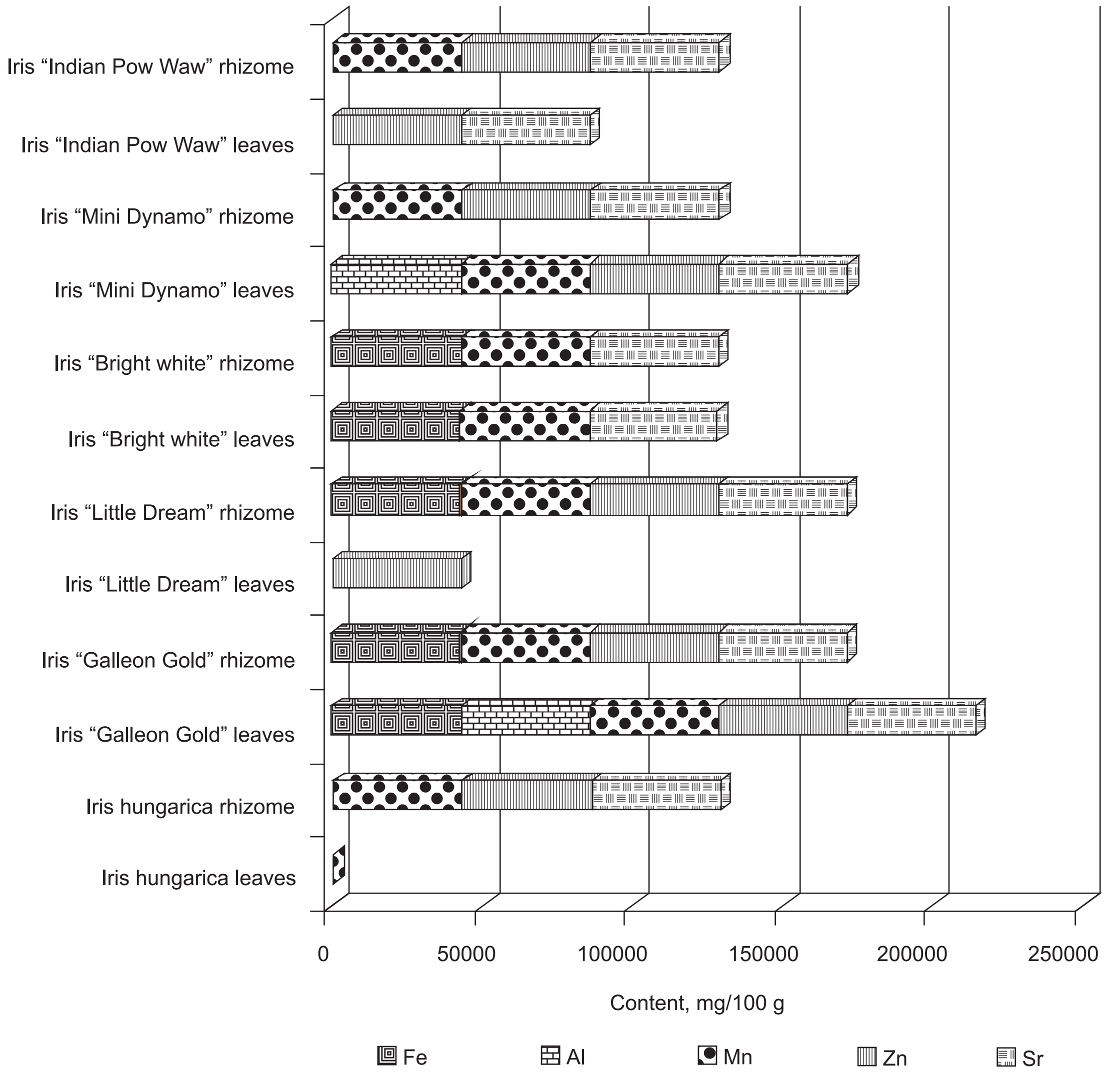

Fig. 2. Microelements of irises

Note. In all samples: Pb, Mo, Ni, Co < 0.03 mg/100g; Cd, As, Hg < 0.001 mg/100 g.

Thus, phenolic compounds have a rather wide spectrum of the biological activity; they possess the anti-inflammatory, diuretic, antibacterial, hepatoprotective effect, etc. Alkaloids are characterized by different activity: cardiotonic, antitussive, antihypertensive, sympatholytic, analgesic. Triterpenes show the antitumor, hypocholesterolemic, expectorant, adaptogenic activity. The elements accumulated by the plant affect formation of certain biologically active substances. Cu, Mn, Fe, Co promote the biogenesis of phenolic compounds, Mo, Mn, Sr – triterpene compounds, Mg, Cr – polysaccharides. Macro- and microelements regulate not only the vital activity of the plant cell, but also affect the metabolic processes of the human body, the cardiovascular system, the immune, endocrine, nervous system, and the reproductive function in human. It is known that mineral substances are capable of neutralizing or facilitating assimilation of certain groups of biologically active substances, and are also an integral part of enzymes. Based on these data the raw material of irises can be used as an additional source of macro- and microelements.

It should be noted that varieties of irises accumulate a greater amount of potassium, sodium, phosphorus and zinc in the raw material than *Iris hungarica*. *Iris x hybrid hort*. "Mini Dynamo" has the highest potassium and phosphorus content, *Iris x hybrid hort*. "Little Dream" – the sodium content. But varieties of irises have a smaller amount of calcium, magnesium and silicium than *Iris hungarica.*

CONCLUSIONS

For the first time the quantitative content of the mineral complex of *Iris hungarica* and dwarf bearded irises has been determined by atomic emission spectrometry. The content of 19 elements in leaves and rhizomes of irises has been determined. According to the research results the raw material of irises can be recommended as an additional source of macro- and microelements. Experimental data will be further used to standardize the raw material of irises. The study of plants of the genus *Iris* L. continues.

Conflict of Interests: authors have no conflict of interests to declare.

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