

DETERMINATION OF MINERAL ELEMENTS CONTENT IN *Teucrium chamaedrys* L. HERB AND HERBAL DUST AQUEOUS EXTRACTS OBTAINED BY ULTRASOUND-ASSISTED EXTRACTION

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Wall germander (*Teucrium chamaedrys* L., Lamiaceae) is an aromatic medicinal plant widely used in folk medicine. Beyond its ethnopharmacological value, it tends to accumulate specific minerals selectively. Consequently, rigorous quality control of its products is essential before they are placed on the market. Monitoring the presence of heavy metals is particularly critical, as these elements can accumulate in human and animal tissues, leading to significant health issues. The goal of the present study was to determine the elemental composition (K, Ca, P, S, Mg, Na, Si, Cu, Zn, Sr, Ba, Fe, Li, Mn, Bi, Ag, B, Ce, Cr, Co, Ni, As, Cd, Pb, Tl, and Hg) of wall germander aqueous extracts. These extracts were produced from both the aerial part (herb) and the herbal dust (a by-product of tea processing). Ultrasound-assisted extraction was employed under the following next conditions: distilled water as the solvent, a constant temperature of 50 °C, a liquid-to-solid ratio of 15 mL/g, and an ultrasonic power of 150 W, with varying time intervals (10, 20, and 30 min). Following wet digestion, the elemental concentrations (expressed in mg/L) were evaluated using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES). All extracts exhibited high concentrations of K, followed by P and Ca. The results indicated that aqueous extracts from both the herb and herbal dust obtained after 20 minutes contained the highest mineral content, suggesting that this extraction duration is the most efficient and suitable for producing extracts intended for human consumption.

Keywords: ICP-OES, wall germander, herb, herbal dust, ultrasound-assisted extraction

Introduction

Wall germander or wild germander (*T. chamaedrys* L., Lamiaceae, genus *Teucrium*) is a perennial medicinal plant, valuable in folk medicine, with its bitter aerial parts being the most used for the preparation of phytopharmaceutical products. This plant and its extracts are used for the treatment of digestive disorders, respiratory infections, cellulitis and skin problems, wound healing, and as diuretic stimulant [1,2]. Due to its characteristic biochemical profile (flavonoid aglycones and their glycosides, phenolic and hydroxycinnamic acid derivatives, phenylethanoid glycosides and neo-clerodane diterpenoids, it expresses different activities, such as spasmolytic, anti-inflammatory, antioxidant, antiviral and antimicrobial activities [1-4].

Besides phytochemicals, the content of minerals in plants is also a crucial factor for their selection as raw material in order to produce high-quality extracts. These minerals are categorized as macrominerals (found in concentrations exceeding 1 µg/g in bodily fluids and tissues), microelements or trace elements (present in less than 1 µg/g), and toxic elements, which require strict monitoring due to their adverse biological effects [5].

These minerals are needed for growth, maintaining physiological functions, and proper activation of enzymes in biological systems; therefore, their supplementation by food is necessary [6]. For humans, the most important minerals needed in macronutrient amounts are Ca, K, Mg, and Na, whereas minerals necessary in trace amounts include Cu, Fe, Ni, Zn, Mn, Cr, Co, and Se [6,7]. As part of quality control of medicinal plants and their products, it is necessary to include analysis of toxic minerals (Al, Cd, Cr, Hg, and Pb), since these elements accumulate in biological systems, causing severe and even life-threatening problems [6,7].

Depending on the type of soil where it is cultivated, *Teucrium chamaedrys* L. possesses the tendency to accumulate beneficial minerals, primarily Fe, Ni, Cr, Mg, Ca, Mn, Zn, and K [8]; however, it can also contain undesirable Cd and Pb [9]. Bulgarian *Teucrium chamaedrys* L. grown on serpentine soils contained the highest amounts of Ca, Mg, and Fe, while Ni, Mn, Cr, Co, Cd, As, Cu, Zn, and Pb were detected in smaller concentrations [10].

Therefore, studies focused on the elemental content

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of plant extracts are also crucial to determine the quality of extracts and their capacity for consumption.

The primary objectives and novelties of this study are:

a) to optimize the aqueous ultrasound-assisted extraction (UAE) of minerals from wall germander herb and herbal dust using distilled water across different time intervals (10, 20, and 30 min) at a constant temperature (50 °C), liquid-to-solid ratio (15 mL/g), and ultrasonic power (150 W), and

b) to evaluate and compare the mineral profiles of these extracts using ICP-OES.

To the best of the authors' knowledge, UAE of minerals from wall germander herb and herbal dust cultivated in Serbia were not previously compared in the literature. These results are expected to contribute to the development and optimization of wall germander production and processing.

Materials and methods

Plant material

Two plant materials were evaluated: the herb and the herbal dust (waste), provided by "Jeligor" d.o.o., Svrlijig, Serbia (43°24'55.4" N, 22°07'12.4" E). Both materials were stored in a sealed paper bag. The determined moisture contents were 9.83% and 10.55% for the herb and the herbal dust, respectively.

Prior to extraction, the crude herb was ground using an electric mill (Gorenje, Slovenia) for 2 min. The resulting powder was sieved (0.5 mm fraction), transferred to a sealed dark glass flask, and stored at 4 °C (protected from light) until further use. The pulverized herb was sieved on a sieve shaker (0.5 mm fraction was chosen for the experiments), transferred into a sealed dark glass flask and refrigerated until further use, protected from light. Herbal dust was used without any modifications. Due to a particle size smaller than the filter bag pores (< 0.315 mm), herbal dust cannot be packed into teabags and is discarded during production as a by-product or waste.

Chemicals and reagents

For the samples analyzed by ICP-OES, purified distilled water (HPLC grade, Fisher Chemical) and HNO₃ (65%, Zorka, Šabac, Serbia) were employed. As a precaution for reducing the risk of metal contamination, all glassware was first soaked in 50% aqueous H₂SO₄ for 24 h, rinsed with double-distilled water, then soaked in 5 M HNO₃ overnight, washed with double-distilled water, and thoroughly dried in an oven at 105 °C, as detailed in Veličković et al. (2024).

Ultrasound-assisted extraction (UAE)

All experiments were conducted following the procedure detailed in our previous papers [11,12]. In a 50 mL glass flask, equipped with a reflux condenser, the pulverized plant material and distilled water were added in a liquid-to-solid ratio of 15 mL/g. The flask was placed in

an ultrasonic bath (Sonic, Niš, Serbia) and experiments were conducted at a temperature of 50 °C, ultrasonic power of 150 W (operating frequency of 40 kHz). Two series of extracts were prepared: wall germander herb extracts (WGH-10, WGH-20, WGH-30) and herbal dust extracts (WGHD-10, WGHD-20, WGHD-30), corresponding to extraction times of 10, 20, and 30 min, respectively. Upon completion of the extraction, the obtained mixtures were centrifuged (TH16B centrifuge, Hong Kong, China) at 4000 rpm for 10 min, allowing the separation of the liquid extract from the solid residue. The resulting extracts were stored at 4 °C until further analysis.

ICP-OES Analysis

The samples were prepared using a wet digestion method, as reported in the literature [13,14]. Argon 5.0 (99.999% purity) served as the carrier gas. Instrumental conditions included plasma power of 1400 W, coolant and auxiliary gas flow rates of 13 and 0.80 L/min, respectively, and a cross-flow nebulizer with a flow rate of 0.95 L/min and a pump speed of 30 rpm. For calibration, a standard arsenic (As) solution for ICP analysis was used, with a concentration of 1 g/L, prepared in diluted nitric acid (HNO₃) (Arsenic (As) ICP Standard Solution 1 g/L in dilute HNO₃, traceable to NIST; Loba Chemie). A certified multi-component reference standard solution containing 32 components at a concentration of 100 mg/L (Ag, Al, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Ge, In, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Re, Sb, Si, Sn, Ta, Ti, V, W, and Zn) in 5% HNO₃ (CPA Chem, Bogomilovo, Bulgaria) was also used, as well as a multi-component ICP standard solution IV containing 23 elements at a concentration of 1000 mg/L (Ag, Al, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, In, K, Li, Mg, Mn, Na, Ni, Pb, Sr, Ti, and Zn) in HNO₃. For the determination of cerium (Ce), a single-element ICP standard solution with a concentration of 1000 mg/L Ce prepared in 5% HNO₃ (Cerium ICP Standard Solution, ROTI®Star, Carl ROTH) was used, while for the determination of sulfur (S), a single-element ICP standard solution with a concentration of 1000 ppm (Sulfur, ICP Standard Solution; GFS Chemicals) was used. Table 1 presents the key analytical parameters of the calibration curves used for the determination of the selected elements. It includes the detection wavelengths (λ, nm), correlation coefficients (R), and the linearity ranges expressed in mg/L, along with the corresponding detection limits. These parameters were evaluated to assess the reliability, sensitivity, and linear response of the ICP method applied in this study.

Table 1. Parameters of the calibration curve for the determined elements: λ (nm), R, LR (mg/L).

Element	Detection wavelength (nm)	Correlation coefficient (R)	Linearity range (detection limit) (mg/L)
As	189.042	0.99982	2.55×10^{-3} –3.60
	197.262	1.00000	8.25×10^{-3} –2.40
Ag	328.068	0.99995	1.66×10^{-3} –12.00
	182.641	0.99999	7.37×10^{-3} –12.00
B	249.773	0.99999	6.43×10^{-3} –12.00
	233.527	0.99998	1.15×10^{-4} –12.00
Ba	233.527	0.99998	1.15×10^{-4} –12.00
Bi	190.241	0.99991	3.53×10^{-3} –12.00
	223.061	0.99996	3.68×10^{-3} –12.00
Ca	183.801	1.00000	1.6–12.00
	396.847	1.00000	1.26×10^{-2} –2.41
Ce	418.660	0.99995	1.2×10^{-3} –60
Cd	214.438	0.99989	1.11×10^{-4} –2.40
Co	228.616	0.99980	3.27×10^{-4} –12.00
Cr	283.563	0.99998	4.35×10^{-4} –12.00
Cu	224.700	0.99999	9.07×10^{-4} –12.00
	324.754	0.99999	2.59×10^{-4} –12.00
Fe	259.941	0.99995	1.99×10^{-3} –12.00
Hg	184.950	0.99992	1.92×10^{-4} –12.00
	194.227	0.99994	5.79×10^{-4} –12.00
	253.652	0.99986	2.02×10^{-3} –12.00
K	404.721	0.99996	1.56×10^{-1} –60.00
Li	323.261	1.00000	7.98×10^{-2} –12.00
	670.780	0.99997	5.74×10^{-5} –1.20
Mg	285.213	0.99996	2.06×10^{-3} –12.10
Mn	257.611	0.99997	1.05×10^{-4} –12.00
Na	330.237	0.99995	7.98×10^{-1} –12.00
	589.592	1.00000	5.83×10^{-3} –1.200
Ni	231.604	0.99994	4.74×10^{-4} –12.00
P	214.914	0.99995	0–120.00
Pb	220.353	0.99998	1.60×10^{-3} –12.00
S	180.731	1.00000	2.9×10^{-3} –24.00
Si	251.612	0.99998	1.24×10^{-3} –60
	288.158	0.99998	5.82×10^{-3} –60
Sr	407.781	1.00000	1.21×10^{-4} –2.41
Tl	190.864	0.99999	1.72×10^{-3} –12.00
Zn	213.856	0.99997	8.2×10^{-5} –12.00

Table 2. Concentrations of minerals (mg/L) in different UAE/aqueous extracts from wall germander herb and herbal dust.

Extract	WGH-10	WGH-20	WGH-30	WGHD-10	WGHD-20	WGHD-30
Macro-minerals (macro-elements)						
K	32.51	42.02	36.015	42.895	41.475	41.615
P	15.65	19.805	18.61	19.805	21.72	23.925
Ca	15.28	21.93	17.445	15.29	16.865	19.235
S	5.335	8	4.665	5.62	5.57	6.355
Mg	1.92	2.78	3.51	4.03	4.425	3.535
Na	0.33	2.215	0.27	1.495	0.265	0.79
Microelements (trace elements)						
Si	0.885	1.51	1.165	1.16	1.305	1.315
Sr	0.22	0.305	0.215	0.395	0.45	0.495
Zn	0.22	0.22	0.215	0.27	0.335	0.26
Cu	0.1	0.08	0.09	0.06	0.125	0.085
Fe	0	0.115	0.08	0	0.085	0.05
Ba	0.045	0.04	0.04	0.055	0.1	0.08
Mn	0	0.005	0.03	0.065	0.085	0.09
Bi	0.005	0	0.01	0.005	0	0.06
Li	0.005	0.005	0.01	0.01	0.005	0.005
Ag, B, Ce, Cr, Co, Ni	0	0	0	0	0	0
Toxic elements						
As, Cd, Pb, Tl	0	0	0	0	0	0
Hg	0.01	0.015	0.01	0.005	0.005	0.07
In	0.005	0	0.005	0.005	0	0.005

Statistical analysis

The SPSS 23.0 (IBM, USA) software was used for the analysis. Numeric variables were checked for normality with the Shapiro-Wilk test. Kruskal-Wallis H tests (one-way ANOVA on ranks) were performed, appropriately followed by the post-hoc comparisons using Dunn's method with a Bonferroni correction for multiple tests, where applicable (statistically significant probability of $p \leq 0.05$ was set).

Results and discussion

The contents of minerals are summarized in Table 2.

Among the macro-minerals, K was the most abundant in both series of extracts (32.51–42.90 mg/L), followed by P (15.65–23.93 mg/L), Ca (15.28–21.93 mg/L), S (4.67–8.00 mg/L), Mg (1.92–4.43 mg/L), and Na (0.27–2.22 mg/L). Wall germander herb extracts contained higher concentrations of Ca, S, and Na, while exhibiting lower levels of K, P, and Mg compared to the herbal dust extracts.

Regarding microelements, Si was the most prominent Si (0.885–1.51 mg/L), followed by Sr (0.215–0.495 mg/L), Zn (0.215–0.335 mg/L), Cu (0.06–0.125 mg/L), Fe (0–0.115 mg/L), Ba (0.04–0.1 mg/L), Mn (0–0.09 mg/L), Bi (0–0.06 mg/L) and Li (0.005–0.01 mg/L). The concentrations of Ag, B, Ce, Cr, Co, and Ni remained below the limit of detection (LOD). Notably, wall germander herb extracts showed higher levels of only two microelements—Si and Fe—compared to the herbal dust extracts.

Importantly, toxic elements such as As, Cd, Pb, and Hg were detected, confirming the safety of the prepared extracts. Overall, the results indicate that aqueous extracts obtained after 20 minutes of extraction (from both herb and herbal dust) yielded the highest mineral content. This suggests that a 20-minute extraction duration is the most efficient and suitable for producing extracts intended for human consumption.

Regarding the safety profile of the investigated extracts, the concentrations of highly toxic elements, including As, Cd, Pb, and Tl, were not detected (below the LOD) in any of the samples. This is a highly positive result from a toxicological perspective, as Pb and Cd are among the most common environmental contaminants found in medicinal plants. Their absence suggests that the raw material originates from a clean environment and that the extraction process does not introduce metallic contamination.

However, trace amounts of Hg and In were identified. Hg was detected in all extracts, with concentrations ranging from 0.005 to 0.07 mg/L. A notable trend was observed: while the Hg levels remained very low and stable in the herb extracts (WGH), there was a significant increase in the herbal dust extracts (WGHD) when the extraction was extended to 30 minutes, reaching 0.07 mg/L.

The presence of Hg, particularly in the herbal dust, could potentially be attributed to the storage and pro-

cessing conditions. Due to its significantly larger specific surface area compared to the whole herb, herbal dust is more susceptible to the adsorption of volatile elements or trace environmental contaminants during storage. Furthermore, while the herb was ground immediately before extraction, the herbal dust remained in a pulverized state for a longer duration, increasing its vulnerability to cross-contamination or moisture-induced adsorption. Indium (In) was found in trace amounts (up to 0.005 mg/L) in most samples. Although Indium is not typically a primary focus in herbal safety studies, its presence in such minute quantities does not pose a known risk to human health.

In conclusion, these findings further support the selection of 20 minutes as the optimal extraction time. At this interval, the extracts achieve a peak in beneficial mineral content while maintaining a very low and safe toxicological profile, avoiding the significant spike in Hg levels observed during the 30-minute extraction of herbal dust.

Statistical analysis results: Since the Shapiro-Wilk test indicated that the values of concentrations of minerals were not normally distributed, the Kruskal-Wallis H test (one-way ANOVA on ranks) was performed. According to the Kruskal-Wallis H test, the distributions of Ag, As, B, Cd, Ce, Co, Cr, Ni, Pb, and Tl were the same in all extracts. However, statistically significant differences in concentrations were observed among the six tested extracts for the following minerals:

Ba (χ^2 (5, $N = 18$) = 16.155, $p = 0.006$),
Bi (χ^2 (5, $N = 18$) = 16.27, $p = 0.006$),
Ca (χ^2 (5, $N = 18$) = 16.158, $p = 0.006$),
Cu (χ^2 (5, $N = 18$) = 16.787, $p = 0.005$),
Fe (χ^2 (5, $N = 18$) = 14.33, $p = 0.014$),
Hg (χ^2 (5, $N = 18$) = 16.849, $p = 0.005$),
In (χ^2 (5, $N = 18$) = 17.0, $p = 0.004$),
K (χ^2 (5, $N = 18$) = 12.509, $p = 0.028$),
Li (χ^2 (5, $N = 18$) = 17.0, $p = 0.004$),
Mg (χ^2 (5, $N = 18$) = 16.158, $p = 0.006$),
Mn (χ^2 (5, $N = 18$) = 16.225, $p = 0.006$),
Na (χ^2 (5, $N = 18$) = 15.339, $p = 0.009$),
P (χ^2 (5, $N = 18$) = 13.043, $p = 0.023$),
S (χ^2 (5, $N = 18$) = 15.129, $p = 0.01$),
Si (χ^2 (5, $N = 18$) = 11.152, $p = 0.048$),
Sr (χ^2 (5, $N = 18$) = 15.69, $p = 0.008$),
Zn (χ^2 (5, $N = 18$) = 13.552, $p = 0.019$).

Following the post-hoc comparisons using Dunn's method with a Bonferroni correction for multiple tests, the following differences were statistically significant: the differences in Ba concentration between WGH-20 and WGHD-20 ($p = 0.029$) and WGH-30 and WGHD-20 ($p = 0.029$), the differences in Bi concentration between WGH-20 and WGH-30 ($p = 0.024$) and WGH-30 and WGHD-20 ($p = 0.024$), the differences in Ca concentration between WGH-10 and WGH-20 ($p = 0.02$) and WGHD-10 and WGH-20 ($p = 0.043$), the differences in Cu concentration be-

tween WGH-10 and WGH-20 ($p = 0.008$), the differences in Hg concentration between WGH-10 and WGH-30 ($p = 0.02$) and WGH-20 and WGH-30 ($p = 0.02$), the differences in Mg concentration between WGH-10 and WGH-20 ($p = 0.009$), the differences in Mn concentration between WGH-10 and WGH-20 ($p = 0.042$) and WGH-10 and WGH-30 ($p = 0.019$), the differences in Na concentration between WGH-30 and WGH-20 ($p = 0.033$), the differences in P concentration between WGH-10 and WGH-30 ($p = 0.02$), and the differences in S concentration between WGH-30 and WGH-20 ($p = 0.009$).

According to Zlatić et al. (2017), soil composition significantly influences the mineral profile of *T. chamaedrys*. Serpentine soil (e.g., Goč mountain) typically results in higher levels of Mg, Fe, Ni, Cr, and Mn, while calcareous soil (e.g., Kopaonik mountain) promotes higher concentrations of Ca, K, Zn, and Pb. The results obtained in this work align with these observations, particularly regarding the high abundance of K, P, and Ca in the aqueous extracts.

K is crucial for maintaining proper cellular fluid balance, osmolality, and neural signal transmission, as well as regulating cardiac and muscle functions [5]. Adequate K levels are also essential for the proper functioning of the thyroid, parathyroid, and adrenal glands [5,15]. As a dietary supplement, K reduces the risks of cardiovascular and kidney diseases and aids in lowering blood pressure [16]. Similarly, Ca is vital for bone mineralization, osteogenesis, maintaining muscle strength, and facilitating the transmission of nerve signals between the brain and the body [16]. P plays a critical role in metabolism, osteogenesis, tissue repair, and hormonal regulation, including insulin and thyroid hormones (T3, T4) [5,15]. The remaining macrominerals (S, Mg, and Na) are detected in concentrations below 10 mg/l. S is necessary for cellular biochemical processes, primarily DNA replication and repair [17]. Mg acts as a key regulatory agent in controlling different cellular and physiological functions: mainly enzymatic-associated processes, energy production, proper transmission of neuromuscular signals, osteogenesis, myelination, regulation of blood pressure, etc. [15]. Mg is crucial for the proper metabolism of glucose, lipids, and minerals (mainly K and Ca), control of hormones (estrogen, testosterone, insulin, and parathyroid hormone), and regulating activity in the hypothalamic-pituitary-adrenal axis, providing anxiolytic effect and sleep improvement [15]. Na, as the primary extracellular ion, is indispensable for blood pressure regulation and metabolic balance [5,15].

Microelements, as integral components of enzymes and proteins, drive essential biochemical pathways. Zn is fundamental for carbohydrate metabolism and metalloenzyme activity, while Fe and Mn are necessary for energy production and osteogenesis [7]. Cu, in combination with Zn and vitamin C, is responsible for maintaining the health of skin, hair, and bones. Notably, a diet sufficient in Zn, Fe, and Cu can inhibit the accumulation of

toxic metals like Cd and Pb, thereby preventing serious health complications [7].

Regarding toxic elements, only Hg and In were detected, and their concentrations remained within permissible safety limits. As previously discussed, their presence is likely associated with environmental factors or storage conditions rather than the plant's physiological uptake.

Conclusion

The comparative analysis of wall germander extracts revealed significant differences in mineral content depending on the raw material and extraction duration. Elemental analysis via ICP-OES confirmed the overall safety of the samples, with K identified as the dominant mineral, followed by P and Ca. The absence of highly toxic elements (As, Cd, Pb, and Tl) further validates the potential of these extracts for pharmaceutical and dietary applications. The results demonstrate that aqueous extracts obtained from both the herb and the herbal dust (a tea-processing by-product) reached their peak mineral concentrations after 20 minutes of extraction. This duration represents the optimal balance, providing the highest mineral yield while maintaining Hg levels significantly lower than those observed in longer extraction intervals. Consequently, these findings suggest that wall germander herbal dust, often discarded as waste, can be effectively repurposed to produce mineral-rich extracts suitable for human consumption.

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List of abbreviations

ICP-OES Inductively Coupled Plasma – Optical Emission Spectrometry

UAE Ultrasound-assisted extraction

WGH-10 Wall germander herb extract obtained after 10 min

WGH-20 Wall germander herb extract obtained after 20 min

WGH-30 Wall germander herb extract obtained after 30 min

WGH-10 Wall germander herbal dust extract obtained after 10 min

WGH-20 Wall germander herbal dust extract obtained after 20 min

WGH-30 Wall germander herbal dust extract obtained after 30 min

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Izvod

ODREĐIVANJE SADRŽAJA MINERALNIH ELEMENATA U VODENIM EKSTRAKTIMA HERBE I HERBALNE PRAŠINE PODUBICE (*Teucrium chamaedrys* L.) DOBIJENIM ULTRAZVUČNOM EKSTRAKCIJOM

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Podubica (*T. chamaedrys* L., Lamiaceae) je aromatična lekovita biljka koja se široko koristi u narodnoj medicini. Pored svoje etnofarmakološke vrednosti, ova vrsta ispoljava tendenciju ka selektivnoj akumulaciji specifičnih minerala. Shodno tome, rigorozna kontrola kvaliteta njenih proizvoda je neophodna pre njihovog plasiranja na tržište. Praćenje prisustva teških metala je posebno kritično, s obzirom na to da se ovi elementi mogu akumulirati u tkivima ljudi i životinja, što dovodi do značajnih zdravstvenih problema. Cilj ovog istraživanja bio je da se utvrdi elementarni sastav (K, Ca, P, S, Mg, Na, Si, Cu, Zn, Sr, Ba, Fe, Li, Mn, Bi, Ag, B, Ce, Cr, Co, Ni, As, Cd, Pb, Tl i Hg) vodenih ekstrakata podubice. Ekstrakti su dobijeni iz nadzemnog dela biljke (herbe) i biljnog praha (nusproizvoda prerade čaja). Primenjena je ultrazvučna ekstrakcija pod sledećim uslovima: destilovana voda kao rastvarač, konstantna temperatura od 50 °C, odnos tečno-čvrsto 15 ml/g i snaga ultrazvuka od 150 W, uz variranje vremenskih intervala (10, 20 i 30 minuta). Nakon vlažne digestije, koncentracije elemenata (izražene u mg/l) određene su primenom optičke emisije spektrometrije sa induktivno kuplovanom plazmom (ICP-OES). Svi ekstrakti su pokazali visoke koncentracije K, P i Ca. Rezultati su ukazali na to da su vodeni ekstrakti i herbe i biljnog praha dobijeni nakon 20 minuta sadržali najveći udeo minerala, što sugeriše da je ovo vreme trajanja ekstrakcije najefikasnije i najpogodnije za proizvodnju ekstrakata namenjenih humanoj upotrebi.

Ključne reči: ICP-OES, podubica, biljka, biljna prašina, ultrazvučna ekstrakcija

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