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Determination of Macro- and Microelements from *Astragalus nematodes* Plant Roots by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

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ABSTRACT. This article presents a detailed overview of the root sample of *Astragalus nematodes*, focusing on its botanical characteristics, natural habitat, and optimal growth conditions. Special attention is given to the beneficial properties of the root, which have potential applications in pharmacology, nutrition, and environmental sciences. In order to determine the elemental profile of the sample, a comprehensive analysis was conducted to identify both macro- and microelements essential for evaluating its bioactive potential. The elemental composition was quantified using the method of Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), providing precise and reliable data. The measurements were performed with the AVIO-200 spectrometer, a high-sensitivity instrument capable of detecting trace elements in complex biological matrices. The results contribute to a better understanding of the phytochemical value of *Astragalus nematodes* and may serve as a basis for further research in its medicinal and ecological applications.

I. INTRODUCTION

In recent years, natural medicinal products derived from plants have gained widespread use due to their therapeutic potential and minimal side effects. These plant-based medicines play a crucial role in supporting human health and have shown both curative and preventive effects against a wide range of diseases that are prevalent in modern society. Among the vast diversity of medicinal plants, the *Asteraceae* family stands out for its high number of biologically active species. This family includes several thousand plant species known for their pharmacological and ecological importance.

One of the most notable genera within this family is *Astragalus*, a group of plants long recognized for their medicinal properties. The Latin name "Astragalus" originates from the term used by the ancient Greek physician Dioscorides, who applied it to describe a leguminous plant. The word itself is derived from the ancient Greek "ἀστράγαλος" (astragalos), meaning a knucklebone or bead made from a ram's ankle bone, which closely resembles the shape of the plant's seed. Over time, the name has been retained in scientific nomenclature and is now used to describe a large genus of herbaceous plants and shrubs.

The *Astragalus* genus is exceptionally diverse, comprising over 3,200 known species worldwide, making it one of the largest genera of flowering plants. These species are commonly found throughout the Northern Hemisphere, especially in temperate and arid regions, including parts of Europe, Asia, and North America. *Astragalus* plants are also colloquially referred to as "catnip" in some regions, although this name can cause confusion with other unrelated plants.

Many species within this genus have been traditionally used in herbal medicine, particularly in Chinese, Persian, and Central Asian medicinal systems. Their roots, in particular, are rich in bioactive compounds such as polysaccharides, saponins, flavonoids, and essential trace elements. These components contribute to a wide range of biological effects, including immune system modulation, anti-inflammatory activity, antioxidant protection, and adaptogenic support. Due to these properties, *Astragalus* continues to be a subject of extensive scientific research aimed at identifying its full therapeutic potential.

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II. LITERATURE SURVEY

The *Astragalus* genus, one of the largest among flowering plants, has been the subject of increasing scientific interest due to its rich phytochemical profile and extensive use in traditional medicine systems. Numerous studies have confirmed the therapeutic value of various *Astragalus* species, particularly in relation to immune modulation, antioxidant activity, and anti-inflammatory properties.

In terms of chemical composition, *Astragalus* plants are known to be a good source of macro- and microelements, which contribute to their biological activity. Recent studies employing Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) have provided quantitative data on the elemental profiles of various species. This technique allows for precise measurement of essential trace elements such as zinc, selenium, and iron, which are associated with immunological and metabolic functions.

Despite the growing body of literature, there remains a gap in the comprehensive evaluation of lesser-known *Astragalus* species. Research is particularly limited for endemic species, which may have unique pharmacological profiles and ecological importance. Further interdisciplinary studies involving botany, pharmacology, and analytical chemistry are necessary to fully assess their medicinal potential and ensure sustainable use.

Analyses using ICP-OES have become central to evaluating macro- and micro-element profiles in plants due to the method's accuracy, sensitivity, and multi-element detection capability. This technique typically involves acid digestion of plant tissues, followed by spectrometric quantification of elements ranging from major nutrients to potential contaminants.

A comprehensive ICP-OES study measured 24 elements in Brazilian medicinal plants (*Cynara scolymus*, *Harpagophytum procumbens*, *Maytenus ilifolia*) after microwave-assisted acid digestion. Results showed high concentrations of Ca (2,877–19,957 µg/g), K (1,786–32,297 µg/g), Mg (506–6,175 µg/g), Na (1,717–18,596 µg/g), Fe (8.5–627 µg/g), and Zn (2.6–30.6 µg/g). Toxic elements (As, Cd, Co, Mo, Pb, Sb) were below detection limits. For *Ziziphora clinopodioides*, ICP-OES quantified essential (Ca, K, Mg) and toxic (Pb, Ni, Cr, Cd) elements across roots and shoots from 14 regions. Calcium and iron exceeded WHO safety levels (Ca ~614 µg/g; Fe ~15 µg/g), while Cu, Zn, Mn, and Pb remained within permissible limits. *Bredemeyera floribunda* roots were evaluated using ICP-OES (Thermo iCAP 6300 Duo) following microwave digestion. They contained Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Se, and Zn, with detection limits determined via IUPAC methods. Calibration yielded $R^2 \geq 0.999$. An investigation in Brazil compared acid digestion and dry ashing with ICP-OES analysis for nine medicinal plants. Element concentrations (µg/g) included Ca 100–462, Co 0.54–0.85, Cu 0.32–7.82, Fe 2.74–18.0, Mg 18.4–521, Mn 0.17–55.1, Ni 0.56–1.25, Zn 2.96–20.9. Microwave digestion provided the best recovery (94–102%) and precision (RSD < 10%).

III. RESEARCH METHODOLOGY

0.1000 g of accurately weighed plant roots were placed in a Teflon autoclave. 3 ml of purified nitric acid (HNO_3) and 2 ml of hydrogen peroxide (H_2O_2) were added to it. The autoclaves were placed in a microwave oven (Berghof Speed Wave Xpert) and digested for 35–45 minutes at a temperature of 50–230°C and a maximum pressure of 40 bar according to a special program. The cooled solution was transferred to a 50 or 100 ml volumetric flask, the autoclave was rinsed 2–3 times, and the solution was filled to the mark with double-distilled water. The solution was mixed and placed in an autosampler. The analysis was performed on a Perkin Elmer Avio-200 (ICP-OES) device. Quantification against standards, recalculation of results, and RSD (relative standard deviation) were performed automatically.

IV. EXPERIMENTAL RESULTS

The results are collected in a table and are shown below (Table 1).

Table 1. Quantitative contents and spectral indices of chemical elements from plant material samples

№	Chemical Element	Spectral line (nm)	Quantity (mg/10g)		№	Chemical Element	Spectral line (nm)	Quantity (mg/10g)
1	Li	670.784	0.083		16	Cd	228.802	0.000
2	Al	396.153	0.573		17	V	292.464	0.009
3	Mo	202.031	1.282		18	Zn	206.200	0.496

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4	S	181.975	3.927	19	Cu	327.393	0.326
5	Se	196.026	0.017	20	Ag	328.068	0.000
6	Sb	206.836	0.000	21	Hg	253.652	0.000
7	Sn	283.998	0.000	22	Co	228.616	0.014
8	Si	251.611	2.113	23	K	766.490	227.84
9	Ba	233.527	0.007	24	Pb	220.353	0.017
10	Cr	267.716	0.049	25	P	213.617	15.163
11	Mn	257.610	0.268	26	Sr	407.771	0.286
12	B	249.677	0.892	27	Na	589.592	18.843
13	Ca	317.933	87.218	28	Ni	231.604	0.367
14	As	193.696	0.007	29	Mg	285.213	85.972
15	Fe	238.204	1.854	*29 chemical elements are recognized*			

The table presents the results of spectral analysis aimed at determining the content of 29 chemical elements in the analyzed sample. For each element, the following parameters are provided: the name or symbol of the chemical element, the wavelength of the corresponding spectral line (in nanometers), the quantitative content of the element expressed in milligrams per 10 grams of the sample (mg/10g).

For clarity, the quantitative content of the five elements is embedded in the diagram, in order of increasing quantity in the samples (Fig. 1).

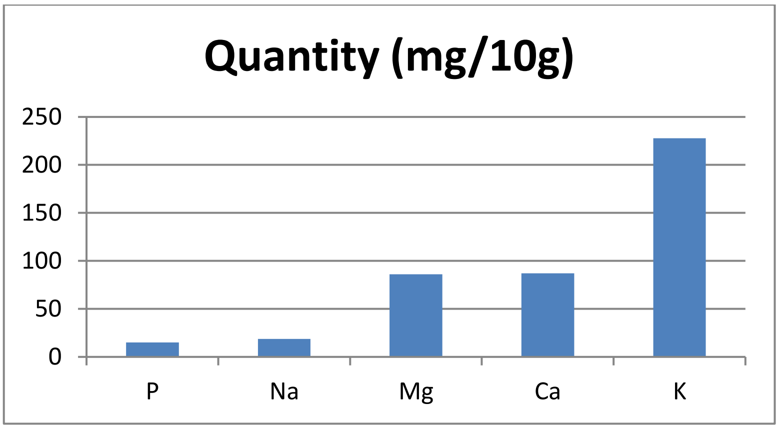

Fig.1. Quantitative contents of the five predominant chemical elements in the samples

Quantitative values equal to zero indicate concentrations below the detection limit of the spectroscopic method used. The highest concentrations are observed for potassium (K, 227.84 mg/10g), sodium (Na, 18.843 mg/10g), phosphorus (P, 15.163 mg/10g), calcium (Ca, 87.218 mg/10g), and magnesium (Mg, 85.972 mg/10g). Certain elements, such as silver (Ag), mercury (Hg), antimony (Sb), and tin (Sn), were not detected in the sample. A total of 29 chemical elements were identified, each associated with a characteristic spectral line used for analytical determination.

V. CONCLUSION

The comprehensive elemental analysis of *Astragalus nematodes* root sample, conducted using ICP-OES, has revealed the presence of 29 chemical elements, including both macro- and microelements essential for evaluating its phytochemical and therapeutic potential. Notably high concentrations of potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), and phosphorus (P) highlight the nutritional and pharmacological relevance of this plant species. The absence or trace levels of toxic elements such as cadmium (Cd), mercury (Hg), antimony (Sb), and silver (Ag) suggest a favorable safety profile for potential medicinal or nutritional applications. These findings contribute to the growing body of scientific literature that supports the traditional use of *Astragalus* species and underscore the value of lesser-studied endemic varieties in future pharmaceutical, nutraceutical, and environmental studies. Moreover, the use of ICP-OES has demonstrated its efficacy as a reliable and sensitive technique for multi-elemental profiling in complex biological matrices. The results presented here may serve as a foundation for further in-depth pharmacological studies, standardization efforts, and sustainable utilization strategies of *Astragalus nematodes* in modern herbal medicine.

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