Essential and Trace Element Contents from Nonea Pulmonarioides by Using Micro-Wave Assisted Digestion, Inductively Coupled Plasma Optical Emission Spectrometry and Inductively Coupled Plasma Mass Spectrometry

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Abstract: Determination of elements in the medicinal plants plays a paramount role in the treatment of illness. According to the World Health Organization (WHO) the utilization of traditional medicines spreading not only in the developing countries but, also in the industrial ones, as a complementary way of treatment. In this study, for the first time, some elemental analyses, of *Nonea pulmonarioides* growing in Kurdistan are carried out using ICP-OES and ICP-MS techniques. The results showed that the contents of the elements such as, B, Ba, Al, Ca, Ce, Co, Cr, Cu, Ga, K, La, Li, Mn, Nd, Ni, Pb, Rb, Sr, V, Y, Zn and Zr are between 1-100 mg/kg. K has the highest concentration in the aerial components (3980 mg/kg), followed by Ca, Mg, Fe, Al, P and S) (2460, 492, 467, 460, 328 and 260mg/kg) respectively, and are considered as essential elements of aerial components from *Nonea pulmonarioides*. Low concentrations of Pt were recorded from 0.002 and 0.001mg/kg of aerial parts and roots respectively in *N. pulmonarioides*. The element analysis by using ICP-MS and ICP OES demonstrated the sensitive methods for determination of elements in *N. pulmonarioides*. These results can facilitate any study of this medicinal plant as there is not enough cognizance of this plant within the literature.

Keywords: Nonea Pulmonarioides, Medicinal Plants, Elemental Analysis, ICP-MS and ICP-OES

1. Introduction

Conventional Kurdish medicine remains the primary selection for treatment of many diseases, particularly by folks who cannot purchase high-priced artificial medications, up to nowadays (Fuad *et al.*, 2018; Avicenna, 1980; Intidhar. 2013). Traditional Kurdish medicine is widely used in remote villages, such as in those on Kodo Mountain. Various methods found in local herbal traditions have provided the only medicinal remedies for centuries among Kurdish people (Alsamarkandi, 1985; Fuad, 2016; Evan & Hugo, 2011).

Several factors present in vegetation used as medicinal plants play an essential function in the remedy of disease. These days, in keeping with the World Health Organization, documentation of traditional drug use have spread within the developing countries but, also inside the industrialized or developed ones, as a complementary manner of treatment (Ora, 2013). The elements widely categorized as essential and trace factors are based on their everyday requirements for human life and nutrition, according to the WHO. The necessity of mineral elements is nicely demonstrated in human, animal and plant nutrition as deficiencies in these nutrients can predispose an organism to infections and other types of disorders. Humans and other animals are exposed daily to numerous factors, in varying degrees, from consumption or absorption of food, water, and other products (Dileep, 2013). Several researches were performed on the fitness and components of wild plants for human consumption and determination of elements in these plants. For instance, macro elements such as K, Cu, Zn, Cr, Mn, and Fe are recognized as essential components of important enzymes required for the chemical processes that help to rejuvenate the body therapeutically and to boost immunity.

An improved immunity maintained in the body can increase resistance to bacterial and viral infections, and also to limit the effects of cancerous growths that flourish or die, depending on the operation of the immune system (Bhanisana & Sarma, 2013; Guierrero *et al*., 1998; Imelouane *et al*., 2011). For elemental analysis several techniques have been used, such as: Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Electrothermal Atomic Absorption Spectroscopy (ETAAS), X-ray fluorescence analysis, Flame Atomic Absorption Spectrometry (FAAS). [12-16] (Veldkamp & Zonneveld, 2012; Hanawa *et al*., 1993; Xie *et al*., 2014; Rodushkin *et al*., 1999; Wu *et al*., 1997). ICP-MS and ICP-OES are advanced and sensitive techniques that have started to find use in the determination of chemical elements in various medicinal plants (Fuad *et al*, 2017).

Nonea is one of the largest genera in the family Boraginaceae, which includes borage and related plants. Plants belonging to this genus are generally hairy and are also known as monkswort. The plants produce five-petaled flowers of various colors, including red, purple, white, and yellow. The leaves of this genus are oval-shaped or tapered at the ends. There are fifty-five species of genus *Nonea* found worldwide and in Iraq the genus is represented by five species, including *N. melanocarpa*, *N. obtusifolia*, *N. pulmonarioides*, *N. pulla* and *N. ventricosa*. At least two species of *Nonea*, *N. pulla* and *N. lutea*, have been studied chemically, leading to identification of flavonoids in this genus. Two *Nonea* species have been recognized in the Kurdistan region. In the world the genus is found in central-western Asia, northern Africa and Europe (Selvi & Bigazzi 2001; Myagmar & Aniya, 2000). The *N. pulmonarioides*, growing on Kodo Mountain of Kurdistan region-Iraq, is traditionally used for the treatment of inflammatory diseases. The purpose of this investigation was to determine and evaluate the concentration of some elements in the roots and aerial parts of *N. pulmonarioides* using sensitive techniques such as ICP-MS and ICP-OES.

2. Materials and Methods

2.1 Collection of Plant Material

The plant materials (roots and aerial parts) of *Nonea pulmonarioides* were collected during a ripe stage from Kodo Mountain, Iraqi Kurdistan, in March. A voucher specimen was deposited at Salahaddin University by the number 7486. The plant parts were dried beneath shade for one week. Then the roots and aerial parts were separately ground using a grain mill, to produce homogeneous powder for the analysis. Pulverized materials were stored in a dark glass bottle at room temperature until retrieved for analysis.

2.2 Determination of Metals

Prepared dried aerial parts and roots of the plant (1.0 g) were cold digested separately for approximately 8.0 hours in 65-71 % nitric acid and 1.0 ml hydrogen peroxide (30 %), samples were then heated gradually up to 180 ºC for 2.5 hours and treated to reduce the acid to small volume (Feng *et al.*, 1999). Resulting solutions were analysed by ICP-AES (agilent 725-ES Radial) and ICP-MS (Agilent 7700x). Analytical results are corrected for inter-element spectral interferences (Table 1).

2.3 Setting Parameters

Power (kW) 1.2, Plasma flow (l/min) 15, Auxiliary flow (l/min) 1.50, Nebulizer flow (l/min) 0.85, Nebulizer cyclonic type, Replicate read time (s) 10, Number of replicates 3, Instrument stabilization delay (s) 30, Rinse time (s) 60, Sample uptake delay (s) 10, Pump rate (rpm) 15.

3. Results and Discussion

For the first time, some chemical elements were measured and identified by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) methods. The elements content of two different portions, aerial parts and roots, of *N. pulmonarioides* have been determined. Some chemical elements have been quantitatively determined and considered as essential and nutrient elements for the plants such as K, Ca, Mg, Fe, Al, P and S (3980, 2460, 492, 467, 460, 328 and 260 mg/kg respectively (Table 1). The experiment results indicate that the contents of the trace elements such as, B, Ba, Al, Ca, Ce, Co, Cr, Cu, Ga, K, La, Li, Mn, Nd, Ni, Pb, Rb, Sr, V, Y, Zn and Zr are between 1-100 mg/kg. Among these elements, K has the highest concentration in the aerial parts of *N. pulmonarioides*. Pt, a trace element, was detected as concentrations of 0.002 and 0.001mg/kg in the aerial parts and roots respectively in *N. pulmonarioides*.

The metal content observed in this plant shows the ability of the medicinal plant to accumulate high amounts of both macro and micro-elements. The most abundant chemical element concentrations are in the aerial parts followed by the roots. The results indicated that potassium existed in a high concentration (3980 mg/kg), a high figure for K in most plants and for each essential element. The habitat this species occurs in may be the source of the high concentrations observed for several essential and trace elements, for example, the base of the building walls near where it was harvested. The high quantity of those elements in *N. pulmonarioides i*s most probably due to the adhesion of rich soil particles on roots of herbaceous plants. Some toxic metals exist in the aerial parts, with measured concentrations of Cd (0.145 mg/kg), Pb (1.46 mg/kg), As (1.04 mg/kg), Hg (0.009 mg/kg) and Cr (30.7 mg/kg). The toxic metals also occur in the roots with recorded concentrations for Cd (0.269 mg/kg), Pb (0.76 mg/kg) As (0.68 mg/kg), Hg (0.006 mg/kg) and Cr (20 mg/kg) (Table 1).

The heavy metals that were found in the medicinal plants can be attributed to many cases including environmental pollution, underground water, polluted soil and growth of factories. These toxic elements are widely distributed and mobilized in the local environment. The permissible limits of heavy metals for medicinal plants are listed by the WHO. In the plant, *N. pulmonarioides*, the concentration of heaviest metals was below the permissible limit, except for chromium, which was above the permissible limit according to the WHO recommendations for a herbal drug already found in plants. (Samira *et al*., 2013; WHO, 2007). Furthermore, concentrations of some elements could not be determined (Table 1) due to their concentrations being below the threshold of the quantitative methods in *N. pulmonarioides* e.g., Palladium, Platinum, Indium, Tellurium and Rhenium in both aerial parts and roots of *N. pulmonarioides.*

Table 1: Essential and trace elements of N. pulmonarioides by using ICP-MS and ICP-OES.

Elements	Symbol	LOD (ppm)	Elemental content in (ppm or %) of N. pulmonarioides	
			Aerial parts	Roots
Gold	Au	0.0002	0.0024	0.0022
Palladium	Pd	0.001	ND	ND
Platinum	Pt	0.001	0.002	0.001
Silver	Ag	0.001	0.015	0.034
Aluminum	Al	0.01	0.46%	0.27%
Arsenic	As	0.05	1.04	0.68
Boron	B	10	50	40
Barium	Ba	0.1	76.8	126.5
Beryllium	Be	0.01	0.13	0.07
Bismuth	Bi	0.001	0.018	0.018
Calcium	Ca	0.01	2.46%	2.81%
Cadmium	Cd	0.002	0.145	0.269
Cerium	Ce	0.003	2.93	1.68
Cobalt	Co	0.002	3.96	2.6
Chromium	Cr	0.5	30.7	20
Cesium	Cs	0.005	0.172	0.091
Copper	Cu	0.01	33.7	86.6
Dysprosium	Dy	0.005	0.364	0.234
Erbium	Er	0.003	0.184	0.129

Europium	Eu	0.003	0.088	0.056
Iron	Fe	0.001	0.47%	0.28%
Gallium	Ga	0.01	1.22	0.75
Gadolinium	Gd	0.005	0.373	0.242
Germanium	Ge	0.005	0.11	0.076
Hafnium	Hf	0.002	0.037	0.037
Mercury	Hg	0.001	0.009	0.006
Holmium	Ho	0.001	0.065	0.045
Indium	In	0.005	N.D	ND
Potassium	K	0.01	3.98%	2.30%
Lanthanum	La	0.002	1.435	0.912
Lithium	Li	0.1	3.8	2.2
Lutetium	Lu	0.001	0.021	0.017
Magnesium	Mg	0.001	0.49%	0.31%
Manganese	Mn	1	157	118
Molybdenum	Mo	0.01	0.98	0.38
Sodium	Na	0.001	0.02%	0.04%
Niobium	Nb	0.002	0.414	0.273
Neodymium	Nd	0.001	1.725	1.095
Nickel	Ni	0.04	31.3	20.2
Phosphorus	P	0.001	0.33%	0.14%
Lead	Pb	0.01	1.46	0.76

Praseodymiu m	Pr	0.003	0.386	0.245
Rubidium	Rb	0.01	5.86	3.44
Rhenium	Re	0.001	ND	ND
Sulfur	S	0.01	0.26%	0.11%
Antimony	Sb	0.02	0.07	0.08
Scandium	Sc	0.01	0.4	0.57
Selenium	Se	0.1	0.1	0.1
Samarium	Sm	0.003	0.362	0.256
Tin	Sn	0.01	ND	0.39
Strontium	Sr	0.02	61.9	80.8
Tantalum	Ta	0.005	ND	ND
Terbium	Tb	0.001	0.056	0.037
Tellurium	Te	0.02	ND	ND
Thorium	Th	0.002	0.054	0.061
Titanium	Ti	0.001	0.01%	0.01%
Thallium	Tl	0.002	0.023	0.011
Thulium	Tm	0.001	0.025	0.018
Uranium	U	0.005	0.065	0.108
Vanadium	V	1	10	7
Tungsten	W	0.01	0.03	0.03
Yttrium	Y	0.003	2.05	1.535
Ytterbium	Yb	0.003	0.145	0.103
Zinc	Zn	0.1	34.5	46.8

Zirconium	Zr	0.02	1.6	1.53

LOD: Limit of detection in ppm, ND: Not detected

4. Conclusion

We conclude from this report that *Nonea pulmonarioides* is a source of essential and trace, but biochemically important element. Specifically, K, Ca, Mg, and Fe were shown to have significant concentrations in the roots and aerial parts. However, some toxic elements were detected in the plant. We strongly recommend that washing fresh parts of the plant to remove and extract toxic chemical elements be performed before using any part of it as a medicine. Further assessment of these observations have to be conducted to fully assess the quality of medicinal plants for consumption and use in traditional medicine.

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