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ORIGINAL ARTICLE

MINERAL ELEMENTS OF SOME WILD PLANTS OF TRADITIONAL USES IN THE MOROCCAN RIF MOUNTAINS

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ABSTRACT

Background. Wild edible plants (WEPs) that are part of the Mediterranean diet and used in Moroccan traditional food and therapy are now less or not used. This requires their valorization to avoid the threat of their disappearance. The objective of this work was therefore to determine the mineral content in the parts of some WEPs species used for their health benefits in the Rif in Morocco.

Material and Methods. The parts of the WEPs species used, the leaves of *Tetraclinis articulata* (Vahl) masters, the aerial parts of *Lavandula stoechas* L., the stems of *Rubia peregrina* L., the seeds of *Ammodaucus leucotrichus* Coss. & Dur., known under the local names of Laaraar, Halhal, Foua, and Kamoun soufi respectively, are washed with distilled water, dried in an oven and crushed. The extracts of the powders obtained are analyzed for the quantification of mineral elements by ICP spectrophotometer.

Results. The analysis results of ICP-OES show that the aerial parts of *Lavandula stoechas* L. are rich in K, Mg, Fe, Na, and Zn. The stems of *Rubia peregrina* L. are rich in Fe, Na, Mg, Zn, K, Ca, and Mn. The leaves of *Tetraclinis articulata* (Vahl) masters are rich in Fe, Ca, K, Na, Mn and Mg and the seeds of *Ammodaucus leucotrichus* Coss. & Dur. are rich in K, Ca, Mg, Na.

Conclusion. The results reported in the samples of the WEPs analyzed present significant contents in minerals, in particular in K, Fe, Ca, Mg, Na, Zn and Mn and show that in addition to their medicinal values these species have a nutritional potential and could contribute to the dietary balance.

Key words: *wild edible plants, Morocco, nutrients, minerals, analysis*

INTRODUCTION

The rural world of Mediterranean countries has always been a repository of culinary and medicinal knowledge of many plant species in ethnobotany. In Mediterranean regions, the *Asteraceae*, *Lamiaceae* and *Apiaceae* families are the most represented in many ethnobotanical studies for food or medicinal use. These are used as infusions, decoctions, poultices, etc. in traditional cooking and in the treatment of several diseases [1].

Today, nutritional problems still persist and dominate on a global scale despite the efforts and progress of health systems. Even when they are in moderate forms, consequences of malnutrition and micronutrient deficiencies, much more considerable than previously recognized, have been reported over the last two decades. At the same time, changes in dietary habits have been observed due to several factors including demography, economic and technological progress, urbanization and the shift from a rural lifestyle to a more sedentary urban one. These factors have affected agricultural systems and policies, socio-cultural and economic characteristics and lifestyle in addition to globalization. The impact of these factors on the dietary balance in terms of energy and micronutrient intake linked to the change in dietary habits, also affects the nutritional and health statuses of populations. Deficiencies in these nutrients are indeed known for their adverse effects on the populations health and performance.

Revaluing forgotten or unused plant biodiversity as an additional source of carbohydrates, vitamins, fats, proteins and minerals through the use of wild plant species can help reduce these health problems [2]. These plants were, indeed, a dietary component of the Mediterranean diet and contribute to its sustainability. In addition, balanced diets have evolved in recent

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years towards a decrease in red meat and an increase in vegetables and fruits [3]. Indeed, global dietary guidelines recommend increasing the consumption of fruits and vegetables to mitigate the threat of diet-related diseases, including metabolic disorders, cancer and cardiovascular diseases [4]. Therefore, promoting these plants will ensure important nutritional sources while respecting biodiversity. It is in this perspective that this work aimed to determine the chemical composition of four wild plants used in cooking and traditional medicine as declared by populations of previous ethnobotanical surveys carried out in the Casablanca settat region [1] and in the Rif of Morocco. Therefore, the question in this work is of promoting these plants as essential sources of minerals that can contribute to nutrient intake and combat certain dietary deficiencies and various diseases. Specifically the objective is to determine the mineral composition of four species: *Tetraclinis articulata* (Vahl) masters, *Lavandula stoechas* L., *Rubia peregrina* L., *Carum carvi, Ammodaucus leucotrichus* Coss. & Dur. collected in the Tanounat region.

MATERIAL AND METHODS

Sample preparation

Four different wild plants used by the population of the Moroccan Rif Mountains were selected namely *Tetraclinis articulata* (Vahl) masters, *Lavandula stoechas* L., *Rubia peregrina* L. and *Ammodaucus leucotrichus* Coss. & Dur. were collected in 2023. The identification of the scientific nomenclature of these plants was determined using a digital herbarium, the help of the National Herbarium (Rabat, Morocco), the Agronomic and Veterinary Institute and with the help of a botanist from the Faculty of Sciences of El-Jadida (UCD, Morocco) as well as the literature documents [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. The samples preparation and analysis are conducted according to the protocole used in the study team laboratory [17, 18].

The selected plants are species that are used in traditional medicine and in cooking dishes in the Taounat region of Morocco. These WEP were harvested at their phenological maturity stage, when the stems and leaves are well developed but still tender. After washing the used plants parts with distilled water, the samples were dried in an oven at 37°C for one week. The dried material was milled into powder (1 mm) using an electric blender (Moulinex type LM 207, France), and then stored for later analysis (Figure 1). To 1 g of plant powder, a volume of 100 mL of boiling distilled water was added, the mixture was filtered through Whatman filter paper No. 1 after standing for 5 minutes at room temperature and the water was evaporated to dryness using a rotary evaporator to obtain the dried aqueous extract.

Mineral content determination by ICP-OES spectrometer

The plant powder and aqueous extract was analyzed repeated 3 times for their mineral content namely P, K, Ca, Mg, trace elements and heavy metals determined using a complete ICP-OES spectrometer from Agilent Technologis (serial number 17390015). Na determination was performed by an atomic absorption spectrophotometer (Agilent Technologis, serial number 17360001). One gram of powder from each sample was weighed into crucibles and then placed in a muffle furnace at 525°C for 4 hours to complete calcination. The resulting ashes were then broken with nitric acid (65%) under a fume hood added as approximately 2 ml of concentrated acid per crucible and 100 ml of ultrapure water. The resulting liquid is poured into smoothed and sealed polypropylene bottles to allow suspended particles to settle for 24 hours [19, 20].

RESULTS AND DISCUSSION

Table 1 presents the results of the analysis of the proximal composition of the aerial parts of the species studied: *Lavandula stoechas* L. (local name: Halhal), stems of *Rubia peregrina* L. (Foua), seeds of *Ammodaucus leucotrichus* Coss. & Dur. (Kamoun soufi) and leaves of *Tetraclinis articulata* (Vahl) masters (Laaraar). The table shows that the mineral contents values that are determined after three repetitions and expressed per kg dry weight, are different in samples analyzed from a species to another. The aerial parts of *Lavandula stoechas* L. were characterized by high contents of several micronutrients and trace elements (Figure 1) with potassium as the main element present at a concentration of 16234.36 mg/kg, followed by magnesium 4223 mg/kg, iron 3158.52 mg/kg, sodium 1116.00 mg/kg and zinc 320.29 mg/kg. Table 1 also shows that these minerals were the main elements among a total of 23 minerals determined in this study and are in decreasing order K>Mg>Fe>Mn>Na>Zn. The contents of these plants in Ca, Al, Mn, Cr, B, Ba, N and Cu were lower while those of the other mineral elements analyzed (P, As, Cd, Co, Li, Mo, Sb) were presented at values of less than 3.

The same results have been previously obtained in the aerial parts of the plants analyzed for mineral content by ICP spectrometry in western Algeria [21] and in Izmir, Turkey [13]. Similarly, as revealed in the present study, the same trace elements were determined in Turkish and Algerian plants. These contents of K, Mg, Na and trace elements Fe, Zn, Cu and Mn were expressed per 100 g of dry weight.

Table 1. Mineral content of 4 plants

Mineral	Symbol		*Lavandula stoechas* Halhal	*Ammodaucus leucotrichus* Kamoun soufi	*Rubia peregrina* Foua	*Tetraclinis articulata* Laaraar
Nitrogen	N	mg/kg	10.34±0.13	1.71±0.09	1.10±13	0.96±12
Phosphorus	P	mg/kg	0.09±0.36	0.18±0.01	0.15±18	0.07±4.39
Potassium	K	mg/kg	16234.36±7.65	17470.98±99	2890.20±49	1234.87±7.29
Sodium	Na	mg/kg	1116.00±13	1193.53±26	3207.19±18.43	1217.70±8.39
Calcium	Ca	mg/kg	142.78±0.89	8346±16	1302.66±9.79	1293.66±7.83
Magnesium	Mg	mg/kg	4223±0.09	2204±40	189.66±8.29	179.66±8.78
Aluminium	Al	mg/kg	130.55±9.49	114.30±4.4	104.30±7.92	214.30±5.2
Arsenic	As	mg/kg	<1	<1	<1	<1
Boron	B	mg/kg	47.24±0.13	27.91±10	25.31±9.49	28.70±7.39
Barium	Ba	mg/kg	29.41±0.09	3.22±0.04	17.13±7.87	18.61±4.56
Cadmium	Cd	mg kg	<0.3	<0.3	<0.3±10.05	<0.3
Cobalt	Co	mg/kg	<1	<1	<1	<1
Chromium	Cr	mg/kg	60.50±0.08	3.70±0.06	6.83±3.02	4.51±12.28
Copper	Cu	mg/kg	8.98±0.04	6.46±4.44	5.95±9.49	7.01±6.47
Iron	Fe	mg/kg	3158.52±6.22	1524.59±5.24	3879.20±6.97	9076.32±7.29
Lithium	Li	mg/kg	<1	2.58±0.06	1.30±10	1.11±18.29
Manganese	Mn	mg/kg	2189.73±0.22	14.40±6	238.70±8.64	529.64±12
Molybdenum	Mo	mg/kg	<1	<1	<1	<1
Nickel	Ni	mg/kg	1.63±0.56	<1	<1	1.74±8.28
Lead	Pb	mg/kg	1.94±3.23	1.86±0.02	1.20±2.28	2.90±4.95
Antimony	Sb	mg/kg	<1	<1	<1	<1
Selenium	Se	mg/kg	1.36±10.45	1.15±0.07	<1	<1
Zinc	Zn	mg/kg	320.29±0.23	15.53±0.9	210.36±14.34	137.31±9.49

Figure 1. Photos taken during chemical analysis

Furthermore, the content of 142.78 mg/kg of Ca revealed in the present study is similar to that obtained in the Algerian study. However, this result is different compared to that of the Turkish plant where this mineral was not detected. The geographical location of the studies conducted on the plant *Lavandula stoechas* L. (Morocco, Algeria and Turkey) may be the cause of the difference in the physicochemical characteristics that may influence the mineralogical composition of the plant. This may explain the similarity of the research results between Morocco and the neighboring country Algeria, which differ from those obtained for Turkey. The mineral content may also vary depending on the growing area, the vegetation period of the plant and the characteristics of the soil [22].

As for the plant *Rubia peregrina*, the results of the analyses per kg dry weight carried out show that the content of the stems of this species constitutes an important source of iron (3879.20 mg/kg), sodium (3207.19 mg/kg), potassium (2890.20 mg/kg) and calcium (1302.66 mg/kg). It also contains in smaller quantities contents of magnesium (189.66 mg/kg), manganese (238.70 mg/kg), zinc (210.36 mg/kg), aluminum (104.30 mg/kg), boron (25.31 mg/kg), barium (17.13 mg/kg), chromium (6.83 mg/kg) and copper (5.95 mg/kg) as well as contents evaluated at less than 3 mg/kg in other mineral elements analyzed such as N, P, As, Cd, Co, Li, Mo, Ni, Pb, Sb, Se were found in this species of plant. These results could not be compared to those in the literature as at the best of our knowledge, there are no similar quantitative studies on the mineralogical composition of this plant stems, which reveals the originality of the present research work.

On the other hand, maximum contents of mineral components are also reported in the leaves of *Tetraclinis articulata* for iron (9076.32 mg/kg), calcium (1293.66 mg/kg), potassium (1234.87 mg/kg), sodium (1217 mg/kg) in the following order Fe>Ca>K>Na as well as manganese (529.64 mg/kg), magnesium (189.66 mg/kg), aluminum (214.30 mg/kg), zinc (137.31 mg/kg), boron (28.70 mg/kg), barium (18.61 mg/kg), chromium (4.51 mg/kg) and copper (7.01 mg/kg) (Table 1). The other mineral elements analyzed, N, P, As, Cd, Co, Li, Mo, Ni, Pb, Sb, Se, were found to be at values <3 mg/kg. To our knowledge, the majority of studies conducted on this plant have focused on its biological activities, and there is few research focused on the dosage of these mineral elements in the used part of this plant. This observation can be explained by a lack of knowledge on the use of this plant by populations elsewhere.

The results of the analyses of the seeds of *Ammodaucus leucotrichus* show that the seeds of this plant were characterized by high contents of potassium 17470.98 mg/kg, calcium 8346 mg/kg, magnesium 2204 mg/kg, sodium 1193.53 mg/kg and aluminum 114.30 mg/kg and lower contents of boron 27.91 mg/kg, zinc 15.53 mg/kg and manganese 14.40 mg/kg. The analysis also revealed other mineral elements N, P, As, Ba, Co, Cr, Cu, Li, Mo, Ni, Pb, Sb, Se at contents lower than 3 mg/kg. Similar results o the composition of this plant in the Sahara of Algeria or in the seeds of *Ammodaucus leucotrichus* have been reported for their meningeal content [21]. Indeed, the same trace elements and macroelements were revealed with roughly similar contents. The high content of these minerals in these plants could contribute to reduce malnutrition problems related to the deficiency of these elements, such as growth retardation and anemia which are prevalent in several populations [21]. In addition, calcium, whose daily requirements in human are in the order of 1000 to 1500 mg, also plays a role in bone structure and contributes to the sensitivity of nerves and muscles as well as its role in the activation of enzymes involved in digestion and metabolism [22, 23, 24, 25].

The importance of phosphorus (P) is also known for the health of the skin, hair, nails and nervous system, in addition to ensuring the neutrality of body fluids. The recommended dietary intake of P is 800 to 1300 mg per day [23, 25]. The minerals Na and K also play an important role in muscle and nerve function and the daily requirements are 6 g/day for Na and 2 to 4 g per day for K. Na deficiency can lead to circulatory, respiratory and nervous system disorders. Insufficient levels of K can lead to unbalanced blood pressure, irregular heartbeat and disorders of the renal and urinary systems [23, 25]. Regarding Mg, it plays a role as a cofactor for many enzymes and is involved in energy metabolism. It is the vital mineral required for the absorption of minerals, Ca, P, Na and K, by the body. The recommended daily intake of Mg is 200 to 400 mg. Mg deficiency is implicated in depression, migraine, cardiovascular disease, and hypertension [23, 25]. For boron, human studies suggest its involvement in the metabolism of calcium, copper, magnesium, amino acids, blood sugar, triglycerides, and estrogens. It is involved in erythropoiesis, immune defenses, and brain function as well as in anti-inflammatory action. The best documented effects concern its positive impact on bones, particularly calcification and stabilization of bone mass. Iron is a mineral necessary for energy production that provides oxygen to cells. Daily iron requirements are 10 to 15 mg and iron deficiency leads to anemia. As for zinc, it has an essential role in cell growth and differentiation. Zinc also plays an important role in the treatment of diabetes mellitus, infectious diseases, depression, and fatty liver. The daily requirement of Zn is 10-12 mg. A deficiency of this mineral leads to sweating of the joints, enlargement of the liver and spleen, poor appetite, and growth retardation [23, 25]. As for copper, it is essential for the brain, nerves, and connective tissue and helps iron to make hemoglobin. The daily requirement of copper is 2-3 mg.

The results obtained for the dried plants studied, it can be deduced that the contribution of 1 g of aerial parts of *Lavandula stoechas* L. (locally called Halhal) is 16.234 mg of potassium, 4.223 mg of magnesium, 3.158 mg of iron, 1.116 mg of sodium and 0.320 mg of zinc. Similarly, 1 g of stems of *Rubia peregrina* (Foua) provides 3.879 mg of iron, 2.890 mg of potassium, 3.207 mg of sodium, 1.302 mg of calcium, 0.189 mg of magnesium, 0.238 mg of manganese and 0.210 mg of zinc. *Tetraclinis articulata* (Laaraar) leaves can also provide iron (9.076 mg), calcium (1.302 mg), magnesium (0.189 mg), manganese (0.238 mg) and zinc (0.210 mg). In addition, 1 g of *Ammodaucus leucotrichus* (Kamoun soufi) seeds provides 17.470 mg of potassium, 8.346 mg of calcium, 2.204 mg of magnesium and 1.193 mg of sodium.

Limitations of the study

The plant parts analyzed, belong to plants collected from a single site, which does not reflect the variability of mineral contents that may exist depending on the growing geographical area of these plants and soil characteristics.

CONCLUSIONS

The results of this study reveal the richness of the plants examined in minerals whose contents are confirmed in other studies conducted in Turkey and Algeria for some species such as *Lavandula stoechas* L., *Ammodaucus leucotrichus*. However, the mineral contents of *Tetraclinis articulata* and *Rubia peregrina* determined quantitatively by ICP spectroscopy are reported for the first time in this study. These data highlight the prospect of using these plants and their extracts as an alternative to chemical-based synthetic products in industrial sectors.

This work also suggests that thanks to their mineral constituents, the parts of the plants studied could be used as a real natural source to enrich certain nutraceutical recipes or drinks. In addition, these wild plant species can be used as fortifiers for bakery products including bread and its derivatives, for an effective dietary strategy aimed at enhancing the nutritional value of these foods.

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Conflict of interest

The authors declare no conflict of interest.

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