Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 24, No. (2) : 2022 : 414-418

ISSN-0972-3005

DOI No.: http://doi.org/10.53550/AJMBES.2022.v24i02.035

MACROELEMENTS AND MICROELEMENTS CONTENT OF SOME WILD EDIBLE PLANTS

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(Received 18 February, 2022; Accepted 30 March, 2022)

***Key words** : Micronutrients, Dietary potential, Wild medicinal plants, Microelement, Macroelements*

Abstract– The present study aims to determine the micronutrients content of six wild edible plants (*Malva sylvestris, Portulaca oleracea, Silene vulgaris, Nasturtium officinale, Emex spinosa,* and *Scolymus hispanicus*) used as wild vegetables in the Al-Haouz, Morocco. Macroelements (Ca, Mg, Na, P, K, and S) and microelements (Cu, Mn, Fe, Zn, and B) were analyzed by the inductively coupled plasma - optical emission spectrometry (ICP-OES). The results showed that the assessed wild species are very rich in micronutrients. The Zn and S contents were significantly higher in *Nasturtium officinale* ($P<0.05$) compared to other species, while *Emex spinosa* has the highest level of Na, Mg, Ca, and Mn. On the other hand, the Fe content was important in *Scolymus hispanicus, Emex spinosa* and *Nasturtium officinale* (1833.3 mg/kg, 1338.8 mg/kg and 1333.4 mg/kg, respectively). Finally, these wild species seem to be important nutritional resources and food supplements in the human diet.

INTRODUCTION

Biodiversity preservation has the potential to reduce hunger and improve food security (Toledo and Burlingame, 2006). In Morocco, wild edible plants are still used in many regions and form a source of income for poor communities (Bellakhdar, 1997). The wild edible plants represent for organizations and researchers one of the solutions to solve several food problems (Abubakar *et al.,* 2021). Furthermore, the current diets are trending toward decreasing red meat in favor of plant-based foods (Aberoumand and Deokule, 2009). The correlation noted between the latter diet and the reduction of diet-related diseases calls for a further consumption of fruits and vegetables (Stratton *et al.,* 2021).

Micronutrients are provided daily to the body through the diet and have a fundamental role in the prevention of diseases. These elements are involved in a series of biochemical reactions for better homeostatic regulation (Shergill-Bonner, 2013). On the other hand, some wild edible plants are rich in micronutrients compared to many domesticated foods (Garekae and Shackleton, 2020). Therefore, the promotion of these plants will ensure important nutritional sources while respecting biodiversity.

This work aimed to determine the nutritional value and micronutrients content including macroelements (Ca, Mg, Na, P, K, and S) and microelements (Cu, Mn, Fe, Zn, and B) of six wild edible plants used as vegetables in traditional Moroccan dishes.

MATERIALS AND METHODS

Samples preparation

Six wild edible plants (*Nasturtium officinale, Malva sylvestris, Portulaca oleracea, Silene vulgaris, Scolymus hispanicus, and Emex spinosa*) were collected during

2020. The botanical identification was done by Professor Ahmed Ouhammou in the regional herbarium "MARK" of the FSSM-Marrakech, University Cadi Ayyad(Morocco). The selected species were known for their use as wild vegetables in the Al-Haouz region, Morocco. These wild edible plants were collected at the mature stage where the stems and leaves are well grown and tender. The samples were rinsed under the tap water and the inedible parts were removed. The edible parts were dried under shade and then powdered in a blender for further study.

Micronutrients content

The dried samples (0.5 g) were mixed with 5 ml of nitric acid (HNO_3 69%) and digestion was continued at 120°C until the solid was completely transformed into a fine solution. 0.5 to 1 ml of H_2O_2 was added to the mixture and the final volume was adjusted to 50 ml with bi-distilled water. The samples were then filtered through Whatman paper and the filtrates were used for metal analysis by ICP-OES (Sharma, 2020).

Statistical analysis

All tests were performed in triplicate, the mean values and standard deviations were calculated by using SPSS 20. The results were compared by one-way ANOVA followed by Tukey-test, using the same software. Differences were considered to be significant at $P < 0.05$.

RESULTS AND DISCUSSION

Macroelements content

Calcium (Ca)

The calcium (Ca) content of the *Emex spinosa* (2.433%) was the highest followed by the two species *Scolymus hispanicus* (2.21%) and *Malva sylvestris* (2.01%). This macroelement is very abundant in our body with almost 99% in the bones as hydroxyapatite (crystalline structure composed of calcium and phosphorus) in addition to the teeth. In contrast, a small proportion is found in body fluids and soft tissues (Beto, 2015). Calcium is also essential for vital biological processes such as muscle contraction (heart muscle) and the secretion of neurotransmitters (Theobald, 2005).

Magnesium (Mg)

The highest magnesium (Mg) value was observed in *Emex spinosa* with a level of 1.38%, followed by 0.99% in *Portulaca oleracea* and 0.58% in *Silene vulgaris*. This element has an important role in many biological processes such as intermediary metabolism, transport of potassium and calcium ions, DNA replication and repair, and signal transduction (Blaszczyk and Duda-Chodak, 2013; Hartwig, 2001). According to Blaszczyk, (2013) The richest dietary sources of magnesium are unrefined cereals, almonds, walnuts, and green leafy vegetables which make these wild plants a good source of magnesium (Blaszczyk and Duda-Chodak, 2013).

Sodium (Na)

The highest amount of sodium (Na) was observed in *Emex spinosa* (18260.21 mg/kg), followed by *Malva sylvestris* (7069.6 mg/kg) and *Scolymus hispanicus* (3671.6 mg/kg). This element is essential for cellular homeostasis and several physiological functions. However, its excess has been associated with elevations in blood pressure (Farquhar *et al.*, 2015).

Phosphorus (P)

The six wild vegetables showed significant differences ($P<0.05$) in phosphorus (P) content (Table 1). The (P) level in *Malva sylvestris* (0.433%) was the highest compared with the other plants, followed by *Scolymus hispanicus* (0.376%) and *Nasturtium officinale* (0.326%). Inorganic phosphate

Table 1. Macroelements content of the six wild edible plants

	Ca %	Mg %	Na (mg/kg)	P %	K %	S %
E. spinosa	2.433±0.004^{A}	1.38±0.007^{A}	18260.21±71^{A}	0.21±00^{A}	1.513±0.004^{A}	0.6±00^{A}
M. sylvestris	2.01±0.007^{B}	0.4±00^{B}	7069.6±56^{B}	0.433±0.004^{B}	2.573±0.022^{B}	0.61±00^{B}
S. vulgaris	0.85±0.007^{C}	0.58±0.007^{C}	1585±13^{C}	0.28±00^{C}	5.413±0.069^{C}	0.436±0.004^{C}
P. oleracea	1.13±0.007^{D}	0.993±0.009^{D}	2340±35^{D}	0.273±0.004^{C}	6.513±0.004^{D}	0.27±00^{D}
N. officinale	1.573±0.004^{E}	0.233±0.004^{E}	2021.3±7,7^{E}	0.326±0.004^{D}	2.923±0.011^{E}	1.036±0.004^{E}
S. hispanicus	2.21±0.013^{F}	0.39±00^{B}	3671.6±21^{F}	0.376±0.004^{E}	3.576±0.011^{F}	0.51±00^{F}

Data expressed as mean ± standard deviation (n=3). In each column, different letters are significantly different by the Tukey-test ($P<0.05$)

(Pi) is part of the skeletal hydroxyapatite and it is crucial for ATP synthesis (Berndt and Kumar, 2009). Pi forms the main source of dietary phosphorus and deficiency in this element can cause rickets and osteomalacia(Serna and Bergwitz, 2020).

Potassium (K)

Regarding the highest level of potassium (K), it was observed in *Portulaca oleracea* (6.513%), *Silene vulgaris* (5.413%), and *Scolymus hispanicus* (3.576%), respectively. The result obtained in *Portulaca oleracea* was higher than that reported by Aberoumand and Deokule, (2009). These plants studied in addition to other fruits and vegetables must have great attention to cover the recommended daily intake of (K) which is 3.5g while increasing the nutritional value of meals and reducing energy intake (Demigné *et al*., 2004). Furthermore, a high and adequate intake of (K) ensures good blood pressure in addition to its major role in osmolarity and glucose metabolism (Ekmekcioglu *et al*., 2016).

Sulfur (S)

Sulfur (S) was remarkably abundant in *Nasturtium officinale* (1.036%) compared to other species and even *Malva sylvestris* which comes second showed only content of 0.61% which is almost half. This element (S) is the third most abundant mineral element in our body after calcium and phosphorus (Parcell, 2002). It is present in our diet and comes almost exclusively from proteins, although only 2 amino acids (methionine and cysteine) among the 20 amino acids present in proteins contain sulfur (Nimni *et al*., 2007). Moreover, methionine is an essential amino acid and therefore cannot be synthesized by our body and must be supplied through the diet (Nimni *et al*., 2007).

Microelements content

Copper (Cu)

The highest copper value was observed in *Scolymus hispanicus* (19.93 mg/kg), *Portulaca oleracea* (14.24 mg/kg), and 13.04 mg/kg for *Malva sylvestris*. Copper (Cu) is an essential element for human development and growth (Lutsenko *et al*., 2008). Inadequate diet in Cu can lead to poor myelination of neurons, cardiac hypertrophy, and impaired immune response (Gupta and Lutsenko, 2009).

Manganese (Mn)

Emex spinosa showed the highest manganese content (145mg/kg), followed by *Scolymus hispanicus* (78.22mg/kg) and then *Nasturtium officinale* (63.20 mg/kg). Manganese (Mn) plays an essential role in the functioning of many enzymes and the regulation of lipid and glucose metabolism (Li and Yang, 2018). This element is also necessary for manganese superoxide dismutase (MnSOD), which is a mitochondrial enzyme responsible for the elimination of reactive oxygen species (Li and Zhou, 2011).

Iron (Fe)

Regarding Iron content, the differences among the six wild vegetables were significant at P<0.05 (Table 2). The three species richest in iron element were *Scolymus hispanicus*, *Emex spinosa*, and *Nasturtium officinale* with 1833.3 mg/kg, 1338.8 mg/kg, and 1333.4 mg/kg, respectively. Iron (Fe) is involved in a wide range of metabolic reactions including oxygen transport, DNA synthesis, and electron transport (Abbaspour *et al*., 2014). On the other hand, Fe deficiency is one of the most common problems worldwide, which may be dietary or genetic in origin, leading to serious health problems (Burke *et al*., 2001).

Zinc (Zn)

The element Zn was present in relatively similar amounts in the majority of the studied plants, except in *Nasturtium officinale* which showed the highest amount (84.34 mg/kg). This species showed almost

Table 2. Microelements content of the six wild edible plants

	CU (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	B (mg/kg)
E. spinosa	9,71±0,022^{A}	145,40±0,23^{A}	1338,88±1,6^{A}	42,08±0,01^{A}	28,50±0,17^{A}
M. sylvestris	13,04±0,018^{B}	44,83±0,09^{B}	346,35±0,4^{B}	48,22±0,09^{B}	25,50±0,05^{B}
S. vulgaris	5,85±0,038^{C}	43,09±0,16^{C}	204,18±1,3^{C}	32±0,10^{C}	13,63±0,016^{C}
P. oleracea	14,24±0,129^{D}	43,08±0,21^{C}	419,14±2,8^{D}	49,93±0,28^{D}	34,77±0,28^{D}
N. officinale	7,29±0,051^{E}	63,20±0,33^{D}	1333,42±7,3^{A}	84,34±0,26^{E}	15,07±0,20^{E}
S. hispanicus	19,93±0,091^{F}	78,22±0,11^{E}	1833,31±1,6^{E}	55,21±0,11^{F}	30,93±0,19^{F}

Data expressed as mean ± standard deviation (n=3). In each column, different letters are significantly different by the Tukey-test (P<0.05)

the double quantity of (Zn) observed in *Silene vulgaris* or *Emex spinosa*. This microelement plays a key role during growth and in the immune functions (Frassinetti *et al.,* 2006). It is necessary for the functioning of more than 300 enzymes as well as in the regulation of gene expression (Dion *et al.,* 2007; Frassinetti *et al.,* 2006).

Boron (B)

The highest amounts of boron were observed in *Portulaca oleracea*, *Scolymus hispanicus*, and *Emex spinosa* with 34.77mg/kg, 30.93 mg/kg, and 28.50 mg/kg, respectively. Boron (B) has an essential role in the prevention of nutritional disorders. On the other hand, boron deficiency has been associated with a high incidence of osteoporosis and low immune functioning (Abdelnour *et al.,* 2018). In addition, several studies suggest that this microelement (B) participates actively in the mediation of inflammation and oxidative stress, which are capable of aggravating the effect of the main cardiovascular risk factors (Donoiu *et al.,* 2018).

CONCLUSION

The present study is the first to evaluate the content of some micronutrients among six forgotten species used as vegetables in traditional Moroccan dishes. ICP-OES was used to analyze the micronutrients content (Ca, Mg, Na, P, K, S, Cu, Mn, Fe, Zn, and B) of six wild edible plants. The results showed that Zn and S contents were significantly higher in *Nasturtium officinale* ($P<0.05$) compared to other species, while *Emex spinosa* has the highest level of Na, Mg, Ca, and Mn. On the other hand, the Fe content was important in *Scolymus hispanicus, Emex spinosa,* and *Nasturtium officinale* (1833.3 mg/kg, 1338.8 mg/kg and 1333.4 mg/kg, respectively). Therefore, these wild species seem to be important nutritional resources and food supplements in the human diet.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGMENTS

The research was supported by the University of Cadi Ayyad – faculty of Sciences Semlalia.

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