JOTCS A
Journal of the Turkish Chemical Society
Section: A
Chemistry
TURKISH CHEMICAL SOCIETY

Macro and Trace Element Contents of Some Wild Plants Consumed as Vegetable in Manisa District, Turkey

Şerif TARGAN[1]*, Ersin Göksel YELBOĞA[1], Mustafa CİTTAN[1]

[1] Manisa Celal Bayar University, Faculty of Science and Letters, Department of Chemistry, 45140, Manisa, Turkey

Abstract: In this study, macro elements (Na, Mg, and Ca) and trace elements (Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd, and Hg) in wild edible plant samples (*Campanula sp, Anethum graveolens, Malva sylvestris, Onopordum tauricum, Cichorium endivia, Rumex patientia, Urtica diocia, Papaver rhaeas, Opopanax hispidus, Rumex acetosella, Eradium sp, Petroselinum crispum, Metha viridis, Eruca sativa, Sinapis arvensis, Lepidium sativum, and Cardaria draba)* purchased from three different markets in Manisa district were analyzed using inductively coupled plasma-mass spectrometry after microwave digestion procedure. Selected plants for analysis are mostly consumed by people throughout the season. The mean concentrations of Na, Mg, Ca, Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co and Cd were determined as 201 to 15896, 1597 to 4783, 3676 to 13290, 0.27 to 4.37, 144 to 666, 18.0 to 52.0, 21.2 to 86.5, 0.08 to 0.25, 111 to 693, 2.18 to 5.67, 2.62 to 13.4, 1.32 to 6.30, 6.40 to 38.7, 0.12 to 0.78, 1.07 to 3.25, 0.05 to 0.47, 0.08 to 0.50 (µg g^{-1},dry weight), respectively. Hg values for plant samples were well below the detection limit of the method.

Keywords: ICP-MS, macro element, trace element, microwave digestion, wild plant.

Submitted: Dec 06, 2017. **Accepted:** May 02, 2018.

Cite this: Targan Ş, Yelboğa E, Cittan M. Macro and Trace Element Contents of Some Wild Plants Consumed as Vegetable in Manisa District, Turkey. JOTSCA. 2018;5(2):751–62.

DOI: http://dx.doi.org/10.18596/jotcsa.363151.

***Corresponding author.** E-mail: serif.targan@cbu.edu.tr.

INTRODUCTION

People living in Aegean region in Turkey consume wild edible plants to provide their nutritional requirements. Wild plants that are not well known in other geographical regions in Turkey constitute the Aegean main cuisine. However, wild plants with leaves have an important role in recent well-balanced diet programs. In dietary programs, the idea of getting less amounts of red meat and more vegetable and fruits becomes more popular (1,2). Due to their high water content, with few exceptions, wild plants are believed to occupy a modest place as a source of trace elements (3).

The trace elements and other essential nutrients are necessary for growth, and maintaining of life. Since the body cannot synthesize them, trace elements must be supplied by food. There is no clear classification of trace vs. macro minerals, but traces are often considered as minerals required by the body in amounts less than 100 mg daily (4). The nutritional and toxicity values have also been studied and extensively discussed (5). Elements, above threshold concentrations, can cause morphological abnormalities, and mutagenic effects in humans (6). Therefore, determination of macro and trace element contents in edible wild plants is important.

Flame and graphite furnace atomic absorption spectrophotometry (7) (FAAS and GFAAS), inductively coupled plasma-optical emission spectrometry (8) (ICP-OES) and inductively coupled plasma-mass spectrometry (9) (ICP-MS) were used in the studies of element concentrations in plant samples. Especially, ICP-MS is considered excellent technique for the analysis of trace and macro elements in plants. MS is, without a doubt, one of the most important and widely used analytical techniques for the detection and determination of element and molecule concentrations. The mass spectrometer is a highly sophisticated instrument that can aid in the measurement of concentrations in the trace and ultra-trace range (10).

Several studies has been carried out to determine the element contents of some plants in different habitats in Turkey (11–13). The aim of present work was to determine the macro (Na, Mg and Ca) and trace (Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd and Hg) element content of seventeen wild plants sold in three different markets of Manisa after microwave digestion using ICP-MS.

EXPERIMENTAL

Sampling

Approximately 100 g of each plants were purchased from each of the three markets. Table 1 summarizes botanical features including the scientific name, regional name, family, edible part, and usage.

Table 1: Analysis of characteristics of the plants

Scientific Name	Regional Name	Family	Edible Part	Usage
Campanula sp	Çıngırak otu	Campanulaceae	Aerial	Vegetable
Anethum graveolens	Dere Otu	Apiaceae	Aerial	Vegetable, tea
Malva sylvestris	Ebe Gümeci	Malvaceae	Aerial	Vegetable, tea
Onopordum tauricum	Eşek Helvası	Asteraceae	Aerial	Vegetable
Cichorium endivia	Hindiba	Asteraceae	Aerial	Vegetable
Rumex patientia	Labada	Polygonaceae	Aerial	Vegetable
Urtica diocia	Isırgan Otu	Urticaceae	Aerial	Vegetable, tea
Papaver rhaeas	Kapurcak	Papaveraceae	Aerial	Vegetable
Opopanax hispidus	Kaymak Otu	Apiaceae	Aerial	Vegetable
Rumex acetosella	Kuzu Kulağı	Polygonaceae	Aerial	Vegetable
Eradium sp	Leylek Gagası	Geraniaceae	Aerial	Vegetable
Petroselinum crispum	Maydanoz	Apiaceae	Aerial	Vegetable
Metha viridis	Nane	Lamiaceae	Aerial	Vegetable, tea
Eruca sativa	Roka	Brassicaceae	Aerial	Vegetable
Sinapis arvensis	Tatlı Hardal	Brassicaceae	Aerial	Vegetable
Lepidium sativum	Tere	Brassicaceae	Aerial	Vegetable
Cardaria draba	Toklu Başı	Brassicaceae	Aerial	Vegetable

Sample preparation

Samples were washed with ultra-pure water and 100 g samples from each species were dried in an oven at 80 °C for 24 hours before homogenization. Samples milled in a micro-hammer cutter and sieved through 0.2 mm after homogenization process and placed temporarily in clean self-sealing plastic bags until their analysis for their Na, Mg, Ca, Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd and Hg content. An appropriate quantity (1 g) from each 100 g sample was used for analysis. All the samples were analyzed in triplicate and the results were reported as mean values ± standard deviation.

Instruments

All metal measurements were carried out using a Perkin Elmer, DRC-e; CCD Simultaneous ICP-MS. The ICP-MS operating conditions are listed in Table 2. Microwave MARS 5 closed vessel microwave system (CEM, Matthews, NC, and USA) was used for microwave digestion.

Table 2: The operating parameters of determination of elements by ICP- MS

Plasma conditions	Value
RF power	1.2 kW
Plasma Ar flow rate	15 L min^{-1}
Auxiliary Ar flow rate	0.89 L min^{-1}
Carrier Ar flow rate	0.95–1.0 L min^{-1}
Torch horizontal alignment	(0.5–1.0) mm
Torch vertical alignment	0.2–0.5 mm
Sampling depth	6.0–8.0 mm
Sample uptake rate	0.80 mL min^{-1}

Reagents and chemicals

Suprapure grade chemicals were employed in the preparation of all solutions. Ultrapure water (Milli-Q Millipore 18.2Ω/cm) was used in all experiments. HCl, HNO_3 and H_2O_2 were of suprapure quality (E. Merck). All the plastic and glassware were cleaned by soaking in dilute nitric acid and were rinsed with distilled water prior to use. The standard solutions of analytes for calibration procedure were produced by diluting individual stock solutions of the investigated element supplied by Sigma.

Digestion procedure

Microwave digestion procedure was applied to the plant samples; microwave digestion (with HNO_3–H_2O_2 in microwave oven). Approximately 1.0 g of sample was digested with 6 mL of HNO_3 and 2 mL of H_2O_2 in microwave digestion system. The temperature program was as follows: 2 min for 400 w, 2 min for 400 w, 6 min for 400 w, 5 min for 400 w, 8 min for 800 w and 8 min for vent. The resulting solutions were cooled and diluted to 10 mL with distilled water. The clear solutions were analyzed by ICP-MS after additional dilution if necessary.

Calibration and detection limits

Calibration standard solutions were prepared by dilution of the stock standard solutions to desired concentration in 1% HNO_3. The ranges of the calibration curves (7 points) were selected to match the expected concentrations (0–30 μg g^{-1}) for all the elements of the sample studied by ICP-MS. The correlation coefficient r^2 obtained for all cases was 0.9999. The detection limits (LOD) were calculated as the concentrations of an element that gave the standard deviation of a series of ten consecutive measurements of microwave digested blank solutions. The LOD values of Na, Mg, Ca, Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd and Hg were calculated as; 0.0036, 0.0012, 0.0003, 0.0042, 0,0018, 0.0018, 0.0021, 0.0018, 0.0006, 0.0003, 0.0033, 0.0024, 0.0036, 0.0009, 0.0003, 0.0027, 0.0021 and 0.0009 (μg g^{-1}) respectively.

Statistical analysis

All the samples were analyzed in triplicate and mean values along with standard deviation (±) are shown in the Table 3 and 4.

RESULTS AND DISCUSSION

Levels of the macro (Na, Mg and Ca) and the trace (Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd and Hg) elements in plant samples are given in Tables 3 and 4, respectively. The mean concentrations of Na, Mg, Ca, Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co and Cd were found as 201 to 15896, 1597 to 4783, 3676 to 13290, 0.27 to 4.37, 144 to 666, 18.0 to 52.0, 21.2 to 86.5, 0.08 to 0.25, 111 to 693, 2.18 to 5.67, 2.62 to 13.4, 1.32 to 6.30, 6.40 to 38.7, 0.12 to 0.78, 1.07 to 3.25, 0.05 to 0.47, 0.08 to 0.50 μg g^{-1}, dry weight in plant samples, respectively (Figures 1, 2, 3 and 4). Hg values for selected plant samples were well below the detection limit of the method.

Table 3: Macro element contents in selected 17 different plants from 3 different markets (51 samples) (μg g^{-1} dry weight) (n=3)

Sample	Na	Mg	Ca
Campanula sp	643±143	2593±1925	9012±1266
Anethum graveolens	13617±11613	4353±1624	5851±155
Malva sylvestris	2919±1704	2877±1425	7621±631
Onopordum tauricum	15896±10472	2594±1729	6722±702
Cichorium endivia	1847±256	2224±1275	4417±103
Rumex patientia	2862±1847	2433±3165	3676±535
Urtica diocia	1185±133	4783±3281	13290±724
Papaver rhaeas	706±90	2834±3106	6871±54
Opopanax hispidus	201±49	2181±1443	5381±717
Rumex acetosella	1442±1034	3824±2266	4435±991
Eradium sp	1494±1165	1918±1494	8190±1138
Petroselinum crispum	1518±1027	1736±1238	4757±656
Metha viridis	391±60	3224±1735	5370±566
Eruca sativa	441±73	3266±1382	6926±487
Sinapis arvensis	1082±202	1919±1591	6554±357
Lepidium sativum	675±108	1597±1424	7675±2179
Cardaria draba	3451±1644	3364±1553	6469±1161
Minimum	201±48	1597±1424	3676±535
Maximum	15896±10472	4783±3280	13290±724
Mean	2962±1105	2807±220	6659±544

Table 4: Trace element contents in selected 17 different plants from 3 different markets (51 samples) (μg g^{-1} dry weight) (n=3)

Sample	Li	Al	V	Cr	Mn	Fe	Co	Ni
Campanula sp	0.93±0.14	327±94.8	2.30±1.32	3.85±0.29	29.2±8.09	364±50.9	0.18±0.17	4.22±1.00
Anethum graveolens	1.00±0.02	287±117	5.17±2.43	5.40±1.75	86.5±28.0	423±142	0.20±0.19	5.10±0.78
Malva sylvestris	1.00±0.19	288±100	2.18±1.60	4.65±1.18	33.4±5.95	334±84.4	0.18±0.09	3.97±0.71
Onopordum tauricum	1.10±0.12	227±81.5	3.95±1.87	4.43±0.60	54.7±5.61	270±71.7	0.08±0.07	6.30±3.57
Cichorium endivia	1.13±0.14	242±64.2	2.48±2.01	3.67±0.76	33.5±3.29	265±54.9	0.17±0.08	2.57±0.45
Rumex patientia	4.37±3.08	420±113	2.63±0.31	5.70±2.17	30.1±0.40	432±124	0.17±0.16	4.02±1.08
Urtica diocia	2.42±0.95	155±49.1	2.83±1.12	2.62±0.20	21.2±0.23	246±34,1	< LOD	2.72±0.23
Papaver rhaeas	1.02±0.27	195±96.5	3.03±2.14	13.4±6.91	45.2±4.28	289±102	0.10±0.09	2.92±0.55
Opopanax hispidus	0.27±0.09	111±35.8	2.22±1.83	5.15±1.08	22.2±0.12	144±26.0	< LOD	1.32±0.16
Rumex acetosella	0.82±0.13	403±155	3.43±2.35	5.52±2.08	53.9±4.74	434±136	0.28±0.16	3.37±0.78
Eradium sp	0.90±0.25	298±43.9	2.18±1.17	6.58±2.52	40.8±4.57	370±41.0	0.13±0.08	3.38±0.97
Petroselinum crispum	1.05±0.27	192±121	3.33±1.34	4.23±1.04	48.9±7.11	262±77.5	0.08±0.07	2.62±0.31
Metha viridis	1.28±0.06	693±60.7	5.67±1.57	7.07±1.43	45.3±6.71	666±75.7	0.47±0.06	5.32±0.75
Eruca sativa	0.60±0.10	163±12.1	2.19±1.28	3.38±0.49	29.5±5.84	243±1.16	< LOD	2.83±0.40
Sinapis arvensis	0.95±0.13	144±15.6	4.95±0.98	11.5±4.78	33.2±3.58	212±8.67	0.05±0.04	2.75±0.40
Lepidium sativum	1.23±0.35	490±103	4.32±1.72	6.95±1.76	61.1±7.57	470±40.5	0.40±0.23	6.30±0.50
Cardaria draba	0.70±0.57	310±88.4	4.30±1.58	4.63±1.10	33.3±5.20	352±91,9	0.22±0.11	3.87±1.64
Minimum	0.27±0.09	111±35.8	2.18±1.17	2.62±0.20	21.2±0.23	144±26.0	0.05±0.04	1.32±0.16
Maximum	4.37±3.07	693±60.7	5.67±1.57	13.4±6.91	86.5±28.0	666±75.7	0.47±0.06	6.30±3.57
Mean	1.22±0.22	291±35.7	3.36±0.28	5.81±0.68	41.29±3.98	340±29.8	0.19±0.03	3.74±0.33

Sample	Cu	Zn	As	Se	Cd	Pb	Hg
Campanula sp	6.40±0.70	33.5±12.3	1.72±1.16	< LOD	< LOD	0.18±0.09	< LOD
Anethum graveolens	18.2±5.50	26.7±3.12	1.53±1.34	< LOD	< LOD	0.32±0.16	< LOD
Malva sylvestris	9.20±0.98	20.7±3.29	1.30±1.11	< LOD	0.13±0.12	0.67±0.48	< LOD
Onopordum tauricum	10.2±0.69	22.1±2.77	2.35±1.18	< LOD	0.08±0.07	0.22±0.11	< LOD
Cichorium endivia	9.60±1.23	21.4±4.51	1.08±0.89	0.25±0.24	< LOD	0.15±0.09	< LOD
Rumex patientia	9.52±1.05	31.3±4.45	1.33±0.16	< LOD	< LOD	0.52±0.13	< LOD
Urtica diocia	38.7±22.3	18.0±0.81	3.25±1.23	< LOD	< LOD	0.12±0.11	< LOD
Papaver rhaeas	18.1±6.46	34.9±5.55	1.75±1.38	0.08±0.07	0.27±0.14	0.30±0.03	< LOD
Opopanax hispidus	16.4±9.86	32.3±4.91	1.07±0.92	< LOD	< LOD	0.12±0.11	< LOD
Rumex acetosella	10.2±1.73	22.3±1.27	1.13±0.76	< LOD	< LOD	0.65±0.17	< LOD
Eradium sp	25.4±8.68	21.9±1.97	1.37±1.05	< LOD	< LOD	0.30±0.03	< LOD
Petroselinum crispum	6.68±0.97	19.5±4.05	1.67±0.76	< LOD	< LOD	0.25±0.14	< LOD
Metha viridis	12.9±3.78	31.1±2.43	2.63±0.94	< LOD	< LOD	0.47±0.07	< LOD
Eruca sativa	7.93±0.92	22.6±2.08	1.52±0.83	< LOD	0.12±0.11	0.65±0.30	< LOD
Sinapis arvensis	11.9±1.85	26.9±6.71	2.20±0.82	< LOD	0.50±0.14	0.78±0.27	< LOD
Lepidium sativum	9.78±2.62	52.0±18.6	2.33±1.03	< LOD	0.37±0.20	0.45±0.31	< LOD
Cardaria draba	10.3±2.89	24.3±1.73	2.12±0.84	< LOD	0.10±0.09	0.35±0.08	< LOD
Minimum	6.40±0.70	18.0±0.81	1.07±0.92	0.08±0.08	0.08±0.07	0.12±0.11	< LOD
Maximum	38.7±22.3	52.0±18.6	3.25±1.23	0.25±0.24	0.50±0.14	0.78±0.27	< LOD
Mean	13.6±1.97	27.2±2.01	1.79±0.15	0.17±0.09	0.22±0.06	0.38±0.05	< LOD

The results of macro elements are provided in Table 3. All values are expressed as dry weight in μg g^{-1}. In the plants, Na was highest in *Onopordum tauricum* (15896), lowest in *Opopanax hispidus* (201), Mg was highest in *Urtica diocia* (4783), lowest in *Lepidium sativum* (1597), Ca was highest *Urtica diocia* (13290), lowest in *Rumex patientia* (3676).

Trace element results of the plants are presented in Table 4. All values are expressed as dry weight in μg g^{-1}. The table shows that Li was highest in *Rumex patientia* (4.37), lowest in *Opopanax hispidus* (0.27), Al was highest *Metha viridis* (693), lowest in *Opopanax hispidus* (111), V was highest in *Metha viridis* (5.67), lowest in *Malva sylvestris* and *Eradium sp* (2.18), Cr was highest in *Papaver rhaeas* (13.4), lowest in *Urtica diocia* (2.62), Mn was highest in *Anethum graveolens* (86.5), lowest in *Urtica diocia* (21.2), Fe was highest in *Metha viridis* (666), lowest in *Opopanax hispidus* (144), Co was highest in *Metha viridis* (0.47), lowest in *Sinapis arvensis* (0.05), Ni was highest in *Onopordum tauricum* (6.30), lowest in *Opopanax hispidus* (1.32), Cu was highest in *Urtica diocia* (38.7), lowest in *Campanula sp* (6.40), Zn was highest in *Lepidium sativum* (52.0), lowest in *Urtica diocia* (18.0), As was highest in *Urtica diocia* (3.25), lowest in *Opopanax hispidus* (1.07), Se was highest in *Cichorium endivia* (0.25), lowest in *Papaver rhaeas* (0.08), Cd was highest in *Sinapis arvensis* (0.50), lowest in *Onopordum tauricum* (0.08), Pb was highest in *Sinapis arvensis* (0.78), lowest in *Urtica diocia* and *Opopanax hispidus* (0.12).

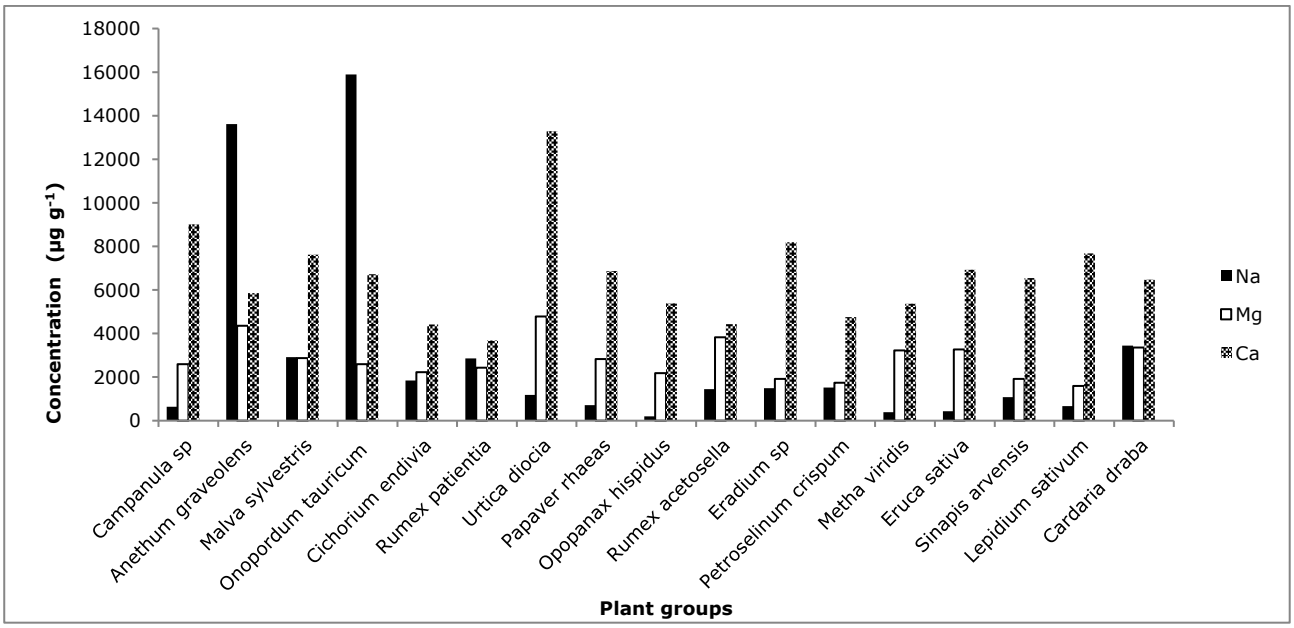

Figure 1: Concentrations of Na, Mg and Ca in selected wild plant samples (μg g^{-1}, dry weight).

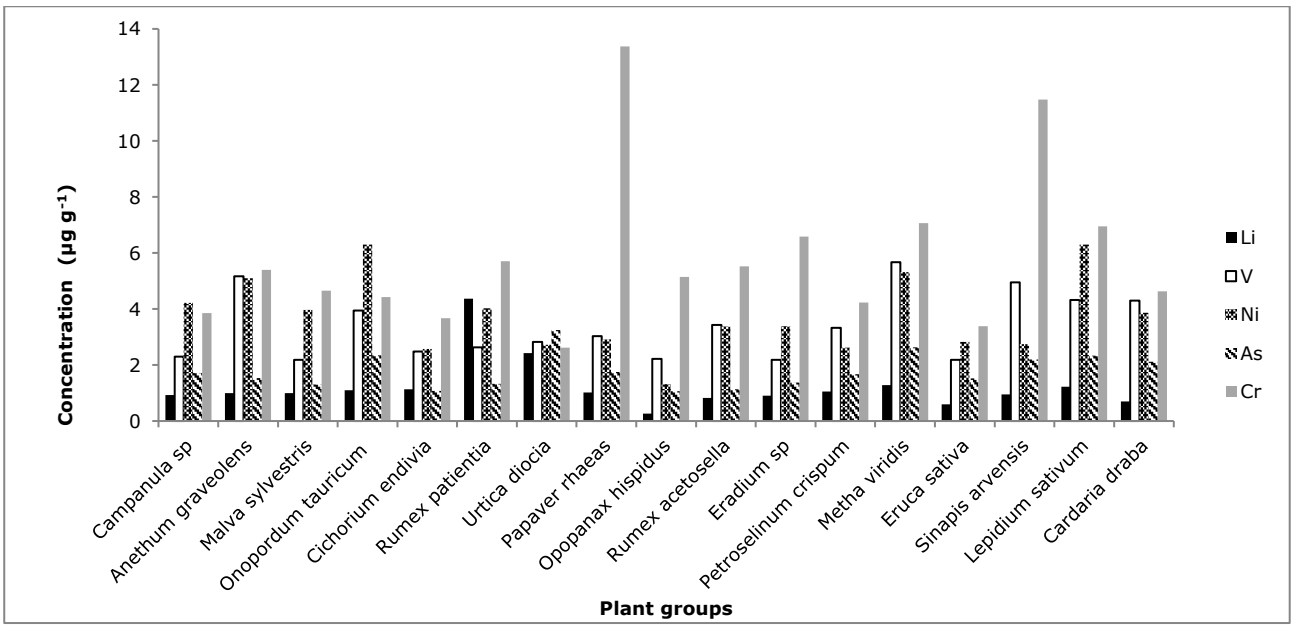

Figure 2: Concentrations of Li, V, Ni, As and Cr in selected wild plant samples (µg g^{-1}, dry weight).

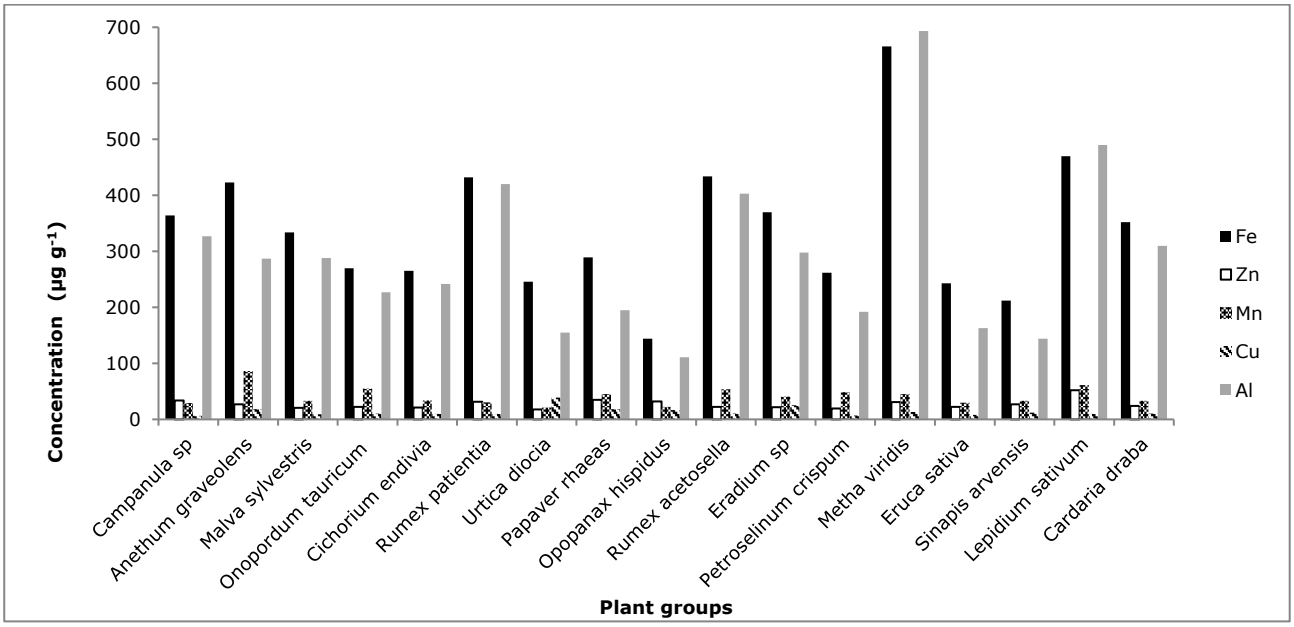

Figure 3: Concentrations of Fe, Zn, Mn, Cu and Al in selected wild plant samples (µg g^{-1}, dry weight).

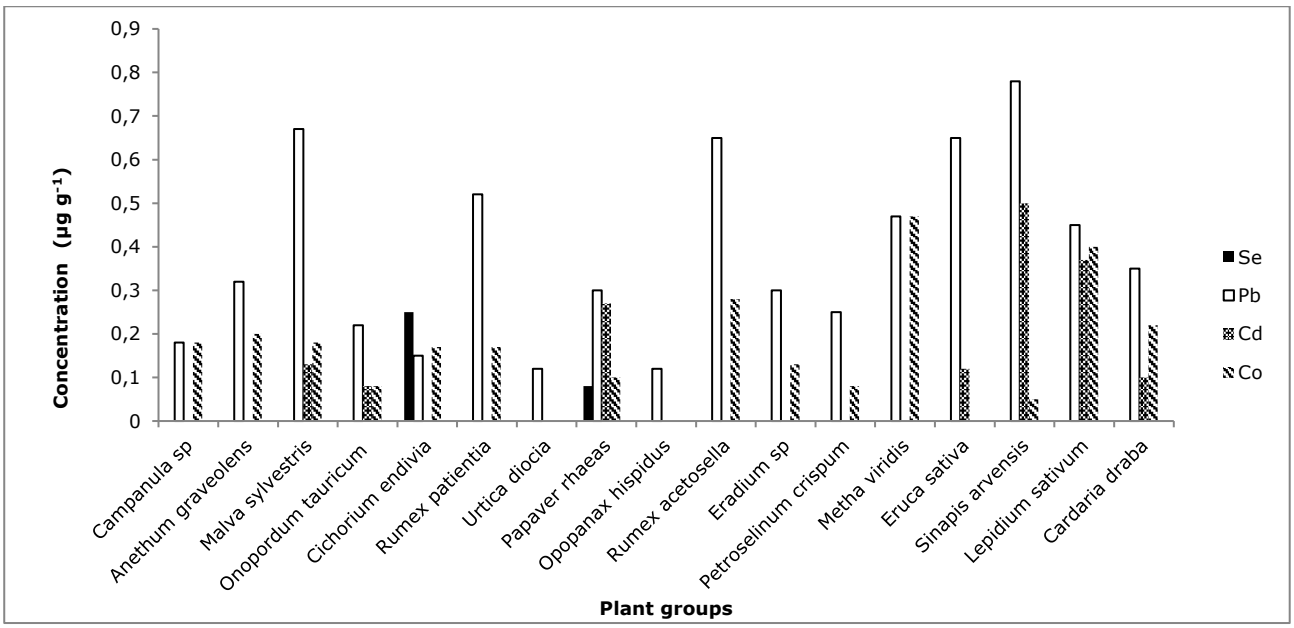

Figure 4: Concentrations of Se, Pb, Cd and Co in selected wild plant samples (µg g^{-1}, dry weight).

CONCLUSION

In this study, the concentrations of trace elements: Na, Mg, Ca, Li, Fe, Zn, Mn, Se, Al, V, Cr, Ni, Cu, Pb, As, Co, Cd and Hg in seventeen wild plant samples (*Campanula sp, Anethum graveolens, Malva sylvestris, Onopordum tauricum, Cichorium endivia, Rumex patientia, Urtica diocia, Papaver rhaeas, Opopanax hispidus, Rumex acetosella, Eradium sp, Petroselinum crispum, Metha viridis, Eruca sativa, Sinapis arvensis, Lepidium sativum,* and *Cardaria draba)* purchased from three different markets in Manisa district were analyzed using ICP-MS after microwave digestion procedure. The quantitative results obtained from the study provide significant information about the macro and trace element contents of the wild edible plants that are frequently consumed by the people of the region.

ACKNOWLEDGEMENTS

The authors are grateful to the Academic Dean for College of Science Prof. Dr. Mustafa ERSÖZ and Specialist İlker AKIN at the University of Selçuk for the availability of the ICP-MS instrument**.**

REFERENCES

1. Kris-Etherton PM, Krummel D, Russell ME, Dreon D, Mackey S, Borchers J, et al. The effect of diet on plasma lipids, lipoproteins, and coronary heart disease. J Am Diet Assoc. 1988;88(11):1373–1400.

2. Osler M, Heitmann BL, Gerdes LU, Jørgensen LM, Schroll M. Dietary patterns and mortality in Danish men and women: a prospective observational study. Br J Nutr. 2001;85(2):219–225.

3. Gibson RS. Zinc nutrition in developing countries. Nutr Res Rev. Cambridge University Press; 1994;7:151–173.

4. Lesniewicz A, Jaworska K, Zyrnicki W. Macro- and micro-nutrients and their bioavailability in polish herbal medicaments. Food Chem. 2006;99:670–679.

5. Goldhaber SB. Trace element risk assessment: essentiality vs. toxicity. Regul Toxicol Pharmacol. 2003;38:232–242.

6. Falade OS, Adepoju OO, Owoyomi O, Adewusi SR. Chemical composition and toxic trace element composition of some Nigerian edible wild mushrooms. Int J Food Sci Technol. 2008;43(1):24–29.

7. Tüzen M. Determination of heavy metals in soil, mushroom and plant samples by atomic absorption spectrometry. Microchem J. 2003;74:289–297.

8. Mikula B, Puzio B. Determination of trace metals by ICP-OES in plant materials after preconcentration of 1,10-phenanthroline complexes on activated carbon. Talanta. 2007;71:136–140.

9. Krachler M, Mohl C, Emons H, Shotyk W. Analytical procedures for the determination of selected trace elements in peat and plant samples by inductively coupled plasma mass spectrometry. Spectrochim. Acta Part B At. Spectrosc. 2002;57:1277–1289.

10. Vogiatzis CG, Zachariadis GA. Tandem mass spectrometry in metallomics and the involving role of ICP-MS detection: A review. Anal Chim Acta. 2014;819:1–14.

11. Yilmaz S, Zengin M. Monitoring environmental pollution in Erzurum by chemical analysis of Scots pine (Pinus sylvestris L.) needles. Environ Int. 2004;29:1041–1047.

12. Yildiz D, Kula I, Ay G, Baslar S, Dogan Y. Determination of trace elements in the plants of Mt. Bozdag, Izmir, Turkey. Arch Biol Sci. 2010;62(3):731–738.

13. Ugulu I, Dogan Y, Baslar S, Varol O. Biomonitoring of trace element accumulation in plants growing at Murat Mountain. Int J Environ Sci Technol. 2012;9:527–534.