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Macro, trace and toxic elements of 4 different edible wild plants from Karadeniz Region

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Abstract: The study was conducted to assess the content (mg kg^{-1} fresh wt.) of macro, trace and toxic elements in the 4 different edible wild plants. The percentage of dry matter and ash ranged from 6.77 to 20.56 and 0.79 to 2.26, respectively. The contents of Ca (1074), Fe (160.5), Mn (18.21), Ni (6.11), B (2.61), Cr (0.93), Co (0.50), Mo (1.80), Be (0.009) and Se (0.076) of *U. diocia* were richer than in other plants. Other hand, K (7742), Mg (954), Al (10.79), V (9.77) and Ag (0.109) in *T. orientalis*, Zn (12.47), Cu (9.98) and Ba (130.3) in *O. umbellatum* were taken the highest value. Also As, Hg, Tl, Cd and Pb were determined mg kg^{-1} level in fresh plants. Conversely, antimony (Sb) in wild plants could not be detected by ICP-MS. The results of statistical analysis of forty plants showed that moisture, total dry matter, ash, K, Ca, Mg, Fe, Zn, Cu, Mn, Ba, Ni, Al, V, B, Cr, Co, Mo, Be, Se, Ag, As, Tl, Cd and Pb contents were varied significantly compared to plant species except for Na and Hg ($p<0.05$). Consequently, wild plants may be used as popular vegetables in many people diet as a source of minerals (Fe, Cu, Mn, Cr, Mo, K, Zn and Mg). Excessive plant consumption may be adversely affected human health with Cd, As, Hg, Tl and Pb.

Keywords: Edible wild plants, Macro-Microelements, Toxic elements, ICP, Traditional foods

1. INTRODUCTION

Although the number of edible plants on earth is known to be about 70000, today people use about 7000 plant species for food, medicine and other needs. However, the number of consumed plants as culture vegetables only is 150 [1]. Moreover, distribution of edible wild plants on the earth depending on the climate is quite varied. Turkey is one of the richest natural resource for wild plants and has nearly 9000 plant species, of which 3000 are endemic [2, 3].

Nowadays, the demand for wild plants is increasing day by day due to the idea of positive impact on human health. Moreover, wild plants all over the world have an important place in agricultural production also many industrial sectors (agricultural struggle, pharmaceutical, beekeeping, textiles etc.). The protection of wild genetic resources for agricultural production is another important issue [2, 3]. Therefore, harvesters and manufacturers should be responsible for the conservation of plant species for the continuation of biodiversity.

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Many wild species as *Urtica diocia* (regional name is Isırgan), *Trachystemon orientalis* (regional names are Galdırik, Kaldırik), *Similax excelsa* (known names in the region are Melocan, Melvocan, Silcan, Diken otu, Mamula, Melevcen, Sıraca, Kırçan and Çıtırgı) and *Ornithogalum umbellatum* (regional names are Sakarca and Çökülce) are common used for human consumption in Karadeniz region [4, 5]. These species are annual wild herb and their vegetation is concentrated in hazelnuts orchards. These wild plants rarely found in valleys, pastures and forested areas in the region are collected by local people and are preferably cooked like green leafy vegetables. Wild vegetables are used widely as traditional foods such as soups, pickles, meals, pastries, salads and fried products. Their formulations in Turkey varies according to local consumption habits (fried or cooked with wheat or corn meal, egg, cheese, onion, garlic, meat, rice, spices, oil etc.).

Wild vegetables also are popular foods for vegetarians. Moreover, these plants are widely considered a potential rich source of minerals (Ca, Fe, Mg, P, K, Na, Zn etc.), phytochemicals (phenolics, carotenoids, strerols), vitamins (vitamin A, B and C) and dietary fibres for human consumption [1, 6-8].

The main constraint for the nutritional use of these species is the presence of certain anti-nutritional and toxic substances such as nitrates [9, 10], pesticides [10], oxalate [6, 7], saponins [12, 13], tannins [7], glicosinolate [14], alcoloids [13] and heavy metals [15].

On the other hand, it is known that the natural components of vegetables such as minerals, vitamins, phytochemicals and dietary fibers contribute significantly to the protection of human health and the increase of body resistance. For this reason, studies conducted in recent years are focused on relationships health and nutrient resources. Indeed, it has been determined that complaints related to serious health problems such as cardiovascular diseases, osteoporosis, breast, prostate and bowel cancer are less common in societies fed on rich diet with basic minerals [16].

Despite the known macro and some micro mineral composition (K, P, Mn, Ca, Na, Mg, etc.) of wild vegetables, there is scarce literature about its micro (trace) and toxic element contents such as Co, Cr, Mo, As, Tl, Pb, Hg etc. The aim of the present work is to assess the concentration of macro, micro and toxic elements in wild vegetable samples from grown in Karadeniz region (Ordu-Giresun) of the Turkey.

2. MATERIAL and METHODS

2.1. Sample Preparations

Four plant species were collected from the ten locations of the natural vegetation (hazelnut orchard) in the Karadeniz region of Turkey (Ordu-Giresun province) during the harvest period between March and May 2008. Before analysis, the leaves were washed, first with tap water and then with distilled water, and residual moisture was removed by Whatman No:1 filter paper and evaporated at room temperature. Only the edible parts of young plant leaves were used. One-hundred-gram plant samples for each plant were taken randomly from portions of about 1.0 kg. Samples were ground with a mortar and pestle. Then, the ground samples were packed in plastic bags and stored in deep freeze until analysis.

2.2. Analytical Procedures

2.2.1. Dry Matter and Ash Analysis

Dry matter was determined gravimetrically by drying by convection in an oven at 105 °C for 2 h. Ash analysis were performed by incineration in an oven at 550°C [17].

2.2.2. Digestion Procedure

Approximately 6 g samples per plant were accurately weighed to the nearest milligram (0.001 g) into six Teflon microwave digestion vessel (about 100 ml with standing a pressure of at least 800 psi) in 1 g portions. After adding 10 ml concentrated HNO_3 (65%), the vessel was sealed and placed into the microwave digestor (CEM MARS 5, CEM Corporation, North Carolina, USA) for dissolution. Six weighed samples were digested in each digestion program. The applied digestion program at the first stage time was 600 W power, 10 min ramp time, 600 psi pressure, 180^0C temperature and 5 min hold values. For the second stage time, these values were 600 W, 10 min, 800 psi, 200^0C and 10 min, respectively. Thereafter, the vessel was cooled and 0.5 ml H_2O_2 (30%) was added in a microwave digestion system for 30 min. Digested samples were transferred to a volumetric flask and diluted to 100 ml with deionized water (18 MV/cm). Nitric acids (Merck 100452) and H_2O_2 (Merck 107209) used were of highest purity grade. A blank digest free from samples was carried out in the same way.

2.2.3. Mineral Analysis

Minerals in samples were determined by ICP-MS (Model Agilent 7500a) using argon as the inert gas (99.99%). The instrumental operating conditions for the determination of the elements are summarized in Table 1. In order to detect the polyatomic interferences for V, Zn, As, Cd and Pb, the different isotopes of V (51-52), Zn (66-69), As (75-77-82-83), Cd (106-108-111) and Pb (206-207-208) were measured for standard mode. The proposed method was standardized utilizing standard solutions of different concentrations from micro and macro elements.

Table 1. Instrumental operating conditions for ICP-MS

Spectrometer	Mass
RF power (W)	1350
Plasma gas flow rate (L/ min) (Argon)	15
Auxiliary gas flow rate (L/ min)	0,90
Carrier gas flow rate (L/ min)	1,02
Sampling depth (mm)	7,0
Acquisition Mode	Spectrum
Number Replicates	3
Spray chamber temp.(^{0}C)	2
Nebulizer	Babington type
Sampler Cone	Nickel cone
Analytical masses	^{9}Be,^{11}B, ^{23}Na, ^{24}Mg, ^{27}Al,^{39}K,^{43}Ca,^{51}V,^{53}Cr, ^{55}Mn,^{57}Fe, ^{59}Co, ^{60}Ni, ^{65}Cu, ^{66}Zn, ^{75}As, ^{78}Se, ^{95}Mo, ^{107}Ag, ^{111}Cd, ^{121}Sb, ^{137}Ba, ^{202}Hg, ^{205}Tl,^{208}Pb

The standard solutions for calibration were 0, 5, 10, 25, 50, 100 and 200 $\mu g\ l^{-1}$ for minor elements (Fe, Zn, Cu, Mn, Ba, Ni, Al, V, B, Cr, Co, Mo, Be, Se, Ag As, Cd, Tl and Pb) and 0, 25, 50, 100, 200 and 400 mg l^{-1} for major elements such as K, Ca, Mg and Na. Furthermore, standard reference materials (SRM) of NIST-SRM 1515 apple leaves were used as controls. The recovery values of this procedure were nearly quantitative for SRM (>93%) and standards (>95%). Table 2 shows the detection limits (LOD) and the quantification limits (LOQ) for the elements studied. In order to prevent mineral element contamination, no glassware was used (particularly for B contamination). Dilutions were made with deionized water (Millipore Water Purification System, Billerica, MA, USA) in volumetric flasks manufactured from High-density polyethylene (HDPE) and kept until used.

Table 2. LOD and LOQ values for the elements

Minerals	LOD (mg kg^{-1})	LOQ (mg kg^{-1})	Minerals	LOD (mg kg^{-1})	LOQ (mg kg^{-1})
K	0,025	0,075	Cr	0,005	0,015
Ca	0,021	0,063	Co	0,004	0,012
Mg	0,020	0,060	Mo	0,007	0,021
Na	0,030	0,090	Be	0,008	0,024
Fe	0,010	0,030	Se	0,004	0,012
Zn	0,005	0,015	Ag	0,006	0,018
Cu	0,004	0,012	As	0,002	0,006
Mn	0,005	0,015	Hg	0,001	0,003
Ba	0,010	0,030	Tl	0,005	0,015
Ni	0,006	0,018	Cd	0,002	0,006
Al	0,004	0,012	Pb	0,002	0,006
V	0,008	0,024	Sb	0,004	0,012
B	0,015	0,045			

Note: LOD: limits of detection, LOQ: limits of quantification

All the plastic equipment was cleaned by NaOH solution (130 g NaOH+130 ml distilled water+880 ml ethanol) and then by HNO3 solution (500 ml HNO3 (65%)+4,500 ml distilled water) and rinsed four or five times with deionized water.

2.2.4. Statiscal Analysis

All results of mineral elements were obtained from ten repetition and the data were expressed as the arithmetic mean, min, max, standard deviation, standard error and coefficient of variation. The data were also analyzed by one-way analysis of variance using the MINITAB statistical program, and Duncan's multiple range test was used to detect significant differences ($p<0.01$) among the variety means [18].

3. RESULTS and DISCUSSIONS

Dry matter, ash and the mineral matter contents of the investigated samples are shown in Table 3. The amount of moisture in wild plant species as consumed vegetables were changed between in *U. diocia* 79.44-86.35%, in *T. orientalis* 89.23-93.23%, in *S. excelsa* 85.28-89.76% and in *O. umbellatum* 80.44-85.53%. On the other hand, the ash content of these plants ranged from 0.79 to 2.26%. These results are in agreement with previously reported values [19, 20].

All trace element concentrations were expressed as mg kg^{-1} in fresh weight. The concentrations of macro, micro and toxic elements in edible wild plants varieties to be min, max, mean, SD, SE, CV (%) and results of Duncan's Multiple Comparison tests are given in Table 3, 4 and 5. According to variance analysis (One-way ANOVA), the effect of species on moisture, ash and minerals were found to be significant except for Na and Hg ($p <0.05$). In addition, amount of Sb (antimony) from the toxic elements in majority of samples was below detection limit. A large variation in minerals among plant species were observed from the coefficients of variation (14.7-138.6%).

In the result of this study, K concentration in wild plants species was determined highest level than other elements, followed by Mg, Ca, Fe, Na, Mn, Ba, Zn, Cu, V, Al, Ni, B etc. In our samples, potassium from the macro elements was determined a very wide range of oscillation as 213-7742 mg kg^{-1}. The highest mean of K was determined in *T. orientalis* (4850 mg kg^{-1}) and followed by *U. diocia* (4342 mg kg^{-1}), *O. umbellatum* (2189 mg kg^{-1}) and *S. excelsa* (349 mg kg^{-1}) respectively. The amount of Ca in plants was similar to statistically for *T. orientalis* and *S. excelsa*. The highest mean of Ca was found in *U. diocia* with 623 mg kg^{-1} that were followed by *O. umbellatum* (334 mg kg^{-1}). According to the Duncan Multiple Comparison Test, the highest and lowest Mg values were found in *T. orientalis* (535 mg kg^{-1}) and *S. excelsa* (94 mg kg^{-1}), respectively. The Na from macro-elements in plants was determined in *U. diocia* between 26 and 66 mg kg^{-1}, in *T. orientalis* between 11 and 56 mg kg^{-1}, in *S. excelsa* between 29 and 61 mg kg^{-1}, and in *O. umbellatum* between 17 and 56 mg kg^{-1} (Table 3).

Table 3. The moisture of dry matter (DM), ash and macro-elements composition belonging to wild plant species and Duncan Multiple Comparison Test results [*]

Plant Species	Variation	Moisture (%)	DM (%)	Ash (%)	Mineral Matters (mg kg^{-1} fresh weight)			
					K	Ca	Mg	Na
U. diocia (Isırgan) n=10	Min	79.44	13.66	1.54	2487.67	283.88	268.48	26.63
	Max.	86.35	20.56	2.26	6327.68	1074.52	484.85	65.71
	Mean	82.17c	17.83a	1.92a	4342.5a	623.44a	386.45b	42.83ns
	SD	2.4	2.4	0.22	1184.81	256.71	73.57	11.26
	SE	0.76	0.76	0.07	374.67	81.18	23.26	3.56
	CV (%)	2.92	13.48	11.2	27.28	41.18	19.04	26.28
T. orientalis (Kaldırık) n=10	Min	89.23	6.77	0.93	1703.61	41.84	194.7	11.61
	Max.	93.23	10.77	1.52	7741.89	142.49	953.73	56.32
	Mean	90.98a	9.02c	1.17b	4850.37a	90.36c	534.74a	34.43ns
	SD	1.23	1.23	0.2	1674.07	26.15	218.54	16.21
	SE	0.39	0.39	0.06	529.39	8.27	69.11	5.13
	CV (%)	1.35	13.58	17.17	34.51	28.94	40.87	47.09
S. excelsa (Melocan) n=10	Min	85.28	10.24	0.87	213.34	14.96	66.79	29.67
	Max.	89.76	14.72	1	590.35	24.4	123.52	60.88
	Mean	86.94b	13.06b	0.93c	349.44c	19.52c	94.09c	43.02ns
	SD	1.43	1.43	0.04	123.17	2.87	16.82	10.34
	SE	0.45	0.45	0.01	38.95	0.91	5.32	3.27
	CV (%)	1.64	10.93	4.77	35.25	14.71	17.88	24.04
O. umbellatum (Sakarca) n=10	Min	80.44	14.47	0.79	1147.01	168.19	69.06	17.33
	Max.	85.53	19.56	0.95	3593.16	657.78	179.64	56.14
	Mean	82.64c	17.36a	0.86c	2188.7b	334.06b	112.22c	33.49ns
	SD	1.67	1.67	0.06	821.89	141.91	34.5	12.37
	SE	0.53	0.53	0.02	259.9	44.88	10.91	3.91
	CV (%)	2.02	9.6	6.5	37.55	42.48	30.74	36.95

Notes: SD- Standard Deviation SE- Standard Error CV- Coefficient of Variation ns: not significant
[*] : Same letter marked as statistical averages are not different from each other ($P<0.05$).

While the highest and the lowest amount of Fe were in *U. diocia* (108 mg kg^{-1}) and in *S. excelsa* (1.79 mg kg^{-1}) respectively, the amounts of Fe in *O. umbellatum* and *T. orientalis* were between these two values. The Zn contents of *U. diocia*, *T. orientalis*, *S. excelsa* and *O. umbellatum* plants localized under the hazelnut were varied between 3.80-8.39 mg kg^{-1}. The traditional leafy vegetables with the highest values of Cu concentration were *O. umbellatum* (5.66 mg kg^{-1}). While the amount of Mn in *U. diocia* (10.55 mg kg^{-1}) was more than other 3 wild plants, this plant was followed by *T. orientalis* (7.49 mg kg^{-1}) plants. The amount of Mn of *S. excelsa* (1.31 mg kg^{-1}) and *O. umbellatum* (2.26 mg kg^{-1}) were statistically similar. K, Ca, Mg, Fe, Zn, Cu, and Mn values of the studied wild plants are similar to that previously reported by other authors [7, 16, 21, 22, 23, 24, 25, 26]. One other hand, our Na, Mn and Cu results are higher than those reported earlier [18]. Our Cu and Zn values are lower than literature reports [27-29].

The highest mean of Ba concentration, on a fresh mass basis, was found in *O. umbellatum* (80.01 mg kg^{-1}), and followed by *U. diocia* (17.99 mg kg^{-1}), *S. excelsa* (8.48 mg kg^{-1}) and *T. orientalis* (4.61 mg kg^{-1}). Barium values are similar to values found in India [30]. The wild vegetable species with the lowest concentration of Ni were found in *T. orientalis* (0.87 mg kg^{-1}), followed by *O. umbellatum* (1.48 mg kg^{-1}), *U. diocia* (3.45 mg kg^{-1}) and *S. excelsa* (3.60 mg kg^{-1}) respectively. Our Ni values are similar to values found in Saudi Arabian [24] and higher than values found in Ghana [28] and in Niger [27]. Duncan Multiple Comparison test showed that Al contents of *O. umbellatum* (6.15 mg kg^{-1}) and *T. orientalis* (5.54 mg kg^{-1}) were statistically higher than those of *U. diocia* (2.75 mg kg^{-1}) and *S. excelsa* (0.196 mg kg^{-1}). Three wild plants, *U. diocia*, *T. orientalis*, *S. excelsa* and *O. umbellatum*, had V levels above 1 mg kg^{-1} and the highest value was found in *T. orientalis* (9.77 mg kg^{-1}). Tables 1, 2 and 3 show that, the amount of B in *U. diocia, T. orientalis, S. excelsa* and *O. umbellatum* varied among 0.29-2.61 mg kg^{-1} and the average B value of plant species taken value of 1.01 mg kg^{-1}. Cr content oscillated from 0.046 mg kg^{-1} (*S. excelsa*) to 0.93 mg kg^{-1} (*U. diocia*) in fresh weight of edible portion. The Cr levels of our samples are comparable to those present in common green leafly vegetables consumed in India [7]. Among edible wild plants, the highest Co level was found in *U. diocia* (0.21-0.50 mg kg^{-1}) and were followed by *O. umbellatum* (0.08-0.30 mg kg^{-1}), *T. orientalis* (0.02-0.10 mg kg^{-1}) and *S. excelsa* (0.01-0.05 mg kg^{-1}). Our Co values are similar to those reported earlier [30]. The median Mo content was ranged from 0.040 to 0.887 mg kg^{-1} in our samples. Beryllium identified only in *U. diocia* (0.0047 mg kg^{-1}). On the other hand, Be contents of other wild species were not detectable levels. The nutritionally significant element Se was determined as the highest value in *U. diocia* (0.0498 mg kg^{-1}), followed by *O. umbellatum* (0.0102 mg kg^{-1}) and *T. orientalis* (0.0032 mg kg^{-1}) but the Se level *of S. excelsa* was not at the level of detection. The Ag content ranged between 0.01 and 0.16 as mg kg^{-1} fresh weight (Table 4).

Table 4. The micro-elements composition belonging to wild plant species and Duncan Multiple Comparison Test results [*].

Plant Species	Variation	Mineral Matters (mg kg^{-1} fresh weight)														
		Fe	Zn	Cu	Mn	Ba	Ni	Al	V	B	Cr	Co	Mo	Be	Se	Ag
U. diocia (Isırgan) n=10	Min	61.49	5.17	2.89	7.59	6.23	1.12	1.07	2.52	1.123	0.219	0.216	0.382	0.001	0.022	0.045
	Max.	160.53	10.61	6.61	18.21	30.42	6.11	3.87	8.52	2.611	0.928	0.502	1.798	0.009	0.076	0.121
	Mean	108.4a	7.59a	4.26a	10.55a	17.99b	3.45a	2.75b	4.78a	1.743a	0.538a	0.393a	0.887a	0.005a	0.05a	0.089b
	SD	31.91	1.59	1.15	3.14	6.77	1.64	1.01	2.25	0.481	0.268	0.086	0.517	0.003	0.018	0.021
	SE	10.09	0.50	0.36	0.99	2.14	0.52	0.32	0.71	0.152	0.085	0.027	0.164	0.001	0.006	0.007
	CV (%)	29.44	20.94	26.85	29.75	37.62	47.5	36.53	47.11	27.59	49.78	21.93	58.3	53.27	37.08	23.88
T. orientalis (Kaldırık) n=10	Min	4.89	2.58	1.4	5.05	1.9	0.54	2.98	3.97	0.297	0.112	0.021	0.021	0.000	0.000	0.011
	Max.	18.23	5.59	7.57	11.65	7.93	1.36	10.79	9.77	0.78	0.412	0.097	0.102	0.000	0.012	0.109
	Mean	11.62bc	3.8b	4.59a	7.5b	4.61b	0.87b	5.54a	6.21a	0.488c	0.275b	0.064c	0.046b	0.000b	0.003bc	0.062a
	SD	4.32	0.92	1.99	2.41	1.99	0.23	2.88	1.88	0.156	0.103	0.022	0.024	0.000	0.004	0.028
	SE	1.37	0.29	0.63	0.76	0.63	0.07	0.91	0.59	0.049	0.033	0.007	0.008	0.000	0.001	0.009
	CV (%)	37.14	24.32	43.45	32.19	43.21	26.77	52.01	30.2	32.04	37.64	34.52	53.08	0.00	138.61	46.11
S. excelsa (Melocan) n=10	Min	0.63	4.15	1.05	0.98	5.11	2.65	0.11	0.03	0.708	0.046	0.01	0.024	0.000	0.000	0.065
	Max.	3.36	8.96	3.25	1.66	14.51	4.74	0.3	0.15	1.791	0.126	0.045	0.11	0.000	0.000	0.129
	Mean	1.79c	6.08ab	2.2b	1.31c	8.48b	3.6a	0.2c	0.1b	1.145b	0.086c	0.023c	0.066b	0.000b	0.000c	0.095b
	SD	0.93	1.71	0.72	0.28	3.02	0.65	0.06	0.04	0.307	0.027	0.012	0.029	0.000	0.000	0.019
	SE	0.29	0.54	0.23	0.09	0.95	0.2	0.02	0.01	0.097	0.008	0.004	0.009	0.000	0.000	0.006
	CV (%)	52.12	28.06	32.8	21.67	35.59	17.93	31.62	35.75	26.77	30.7	52.72	43.4	0.00	0.00	19.46
O. umbellatum (Sakarca) n=10	Min	20.03	3.88	3.41	1.3	56.21	0.84	3.28	1.07	0.314	0.163	0.085	0.017	0.000	0.002	0.034
	Max.	46.73	12.47	9.98	3.49	130.33	3.01	8.03	7.94	1.064	0.483	0.302	0.071	0.000	0.029	0.161
	Mean	29.51b	8.39a	5.66a	2.26c	80.01a	1.48b	6.15a	4.51a	0.647c	0.329b	0.181b	0.040b	0.000b	0.01b	0.085b
	SD	8.82	2.99	2.04	0.67	21.13	0.67	1.48	2.33	0.213	0.099	0.079	0.015	0.000	0.008	0.041
	SE	2.79	0.94	0.65	0.21	6.68	0.21	0.47	0.74	0.067	0.031	0.025	0.005	0.000	0.003	0.013
	CV (%)	29.88	35.59	36.05	29.63	26.41	45.08	24.11	51.75	32.95	30.14	43.48	37.1	0.00	82.97	48.3

Notes: SD- Standard Deviation SE- Standard Error CV- Coefficient of Variation.[*] : Same letter marked as statistical averages are not different from each other ($P<0.05$).

The contents of Ca, Fe, Mn, Ni, B, Cr, Co, Mo, Be and Se of *U. diocia* were richer than in other plants. On other hand, K, Mg, Al, V and Ag in *T. orientalis*, Zn, Cu and Ba in *O. umbellatum* were taken the highest value. There was no significant difference between the Na contents of wild plants.

Table 5. The toxic-elements (heavy metals) composition belonging to wild plant species and Duncan Multiple Comparison Test results [*].

Plant Species	Variation	Mineral Matters (mg kg^{-1} fresh weight)				
		As	Hg	Tl	Cd	Pb
U. diocia (Isırgan) n=10	Min	0.169	0.167	0.271	0.011	0.378
	Max.	0.586	0.496	0.635	0.04	1.728
	Mean	0.366a	0.376ns	0.391a	0.026b	0.997a
	SD	0.146	0.104	0.11	0.009	0.416
	SE	0.046	0.033	0.035	0.003	0.132
	CV (%)	39.85	27.78	28.21	34	41.71
T. orientalis (Kaldırık) n=10	Min	0.058	0.143	0.087	0.002	0.225
	Max.	0.157	0.448	0.302	0.02	1.394
	Mean	0.116bc	0.313ns	0.21b	0.01b	0.539b
	SD	0.029	0.11	0.075	0.005	0.338
	SE	0.009	0.035	0.024	0.002	0.107
	CV (%)	25.07	35.05	35.72	49.72	62.79
S. excelsa (Melocan) n=10	Min	0.014	0.127	0.253	0.016	0.239
	Max.	0.054	0.425	0.419	0.053	1.233
	Mean	0.043c	0.282ns	0.327ab	0.032b	0.628ab
	SD	0.012	0.109	0.062	0.012	0.335
	SE	0.004	0.034	0.02	0.004	0.106
	CV (%)	29.38	38.64	18.97	38.07	53.31
O. umbellatum (Sakarca) n=10	Min	0.112	0.084	0.149	0.206	0.463
	Max.	0.204	0.605	0.594	0.771	2.673
	Mean	0.151b	0.267ns	0.321ab	0.418a	0.963a
	SD	0.033	0.144	0.149	0.193	0.637
	SE	0.011	0.045	0.047	0.061	0.201
	CV (%)	21.95	53.76	46.45	46.13	66.13

Notes: SD- Standard Deviation SE- Standard Error CV- Coefficient of Variation ns : not significant
[*] : Same letter marked as statistical averages are not different from each other ($P<0.05$).

The levels of As, Cd, Hg and Pb in the wild vegetable samples are presented in Table 5. The level of As that has toxic effects with trace amounts was observed between 0.014 and 0.586 mg kg^{-1} in 4 different edible wild plants. These values are in agreement with reported values [30]. Another element with toxic effects, Hg, was determined in *U. diocia, T. orientalis, S. excelsa* and *O. umbellatum* to be 0.376±0.104 mg kg^{-1}, 0.313±0.110 mg kg^{-1}, 0.282±0.109 mg kg^{-1} ve 0.267±0.144 mg kg^{-1}, respectively. Hg results are in agreement with those reports for leafly fresh vegetables [15]. Thallium (Tl) is caused by fossil fuels and cement production also it take part in the formulation of pesticides as the active ingredient of the poison [31]. The Tl contents of *U. diocia*, *T. orientalis*, *S. excelsa* and *O. umbellatum* ranged from 0.087 to 0.635 mg kg^{-1} according to plant species. The average Cd contents of *U. diocia*, *T. orientalis*, *S. excelsa* and *O. umbellatum* were 0.026, 0.010, 0.032 and 0.418 mg kg^{-1}, respectively. The amounts of Pb known as heavy or toxic elements, in *U. diocia, T. orientalis, S. excelsa* and *O. umbellatum* plants consumed as vegetables by local community were 0.997±0.416, 0.539±0.338, 0.628±0.335 and 0.963±637 mg kg^{-1}, respectively (Table 5). The Cd and Pb results are similar to those reported values [15, 24]. Our Pb results are lower than those reported in the literature [27]. The distribution of toxic elements in plants showed that the amount of As and Tl in *U. diocia*, the content of Cd in *O. umbellatum* roots, the amount of Pb in *U. diocia* and *O. umbellate* were higher than the other plants. Hg in all plants also varied within the same limits.

The fact that macro, micro and heavy metals varies according to plant species, this may have been occured from different plant parts (root, leaf, and stem) which are used for food. Indeed, local people are generally used the leaves of *U. diocia* plants, the stems of *T. orientalis*, the shoots of *S. excelsa* and the roots and leaves of *O. umbellatum* as food. The result of mineral differences can be expected because of plant edible parts were analyzed in this study. Mineral contents of our examples changed within broad limits according to both plant species and literature data on same plant species. This may be due to plant type, species, environmental conditions (soil mineral composition, soil type, contamination level, the industrial zone, use of pesticides and fertilizers, climate, irrigation, lighting, temperature, aeration, pH, nutrient type and concentration of these nutrients, the mutual effects with each other, etc.) [25, 30, 32], and the differences of minerals absorption capability of plants (root structure, young-old plants, etc.), differences of mineral deposition in plants parts (leaf, stem and roots) [24, 25], as well as sample preparation and the sensitivity of the apparatus used in the analysis [22].

In this study, most of plants were obtained from vegetation of hazelnut orchard. Therefore, fertilizers and agricultural laundering drugs (insecure, or more than the amount used in pesticides and fungicides) applied to hazelnut may have increased heavy metals in plants to be directly or indirectly. At the same time, the hazelnut orchard in the city center may be affected by heavy metal pollution causing sources. These sources are very diverse and are mainly small-scale industrial wastes (metal processing, metal-wire melting, coating, etc.), flue and exhaust gases (brick furnaces, diesel generators, and vehicle emissions, poor quality coal), the dust created during road construction. Moreover, other important factors of increase of heavy metals in growing plants in urban and rural areas are city garbage, sewage, industrial wastes, wastewater treatment facility sludge and contaminated water [32].

It has been reported that wild plants are richer in terms of macro and micro elements than cultured vegetables [8, 33, 34]. Indeed, in this study, the mineral content of 4 different wild plant compared with the mineral content of some culture vegetables such as *Spinacia oleracea* L., *Portulaca sativa* Haworth, *Lactuca sativa* L., *Allium porrum* L., *Petroselinum sativa* Hoffmann, *Brassica oleracea* L. var. Italica P., *Brassica oleracea* L. var. botrytis [23], the amounts of K, Ca, Mg, Zn, Na were dispersed in similar limits, but, some micro-elements in wild plants were found to be very high, such as Fe 4 folds, Cu 7 folds and Mn 2.5 folds. Finally, 100 g *U. diocia* can supply the majority of daily minerals needs as Cr (% 216) Mo (% 265), Fe (% 133), Mn (61%), Cu (60%), Ni (34%), V (27%), Mg (15%), Zn (11%) and Se (11%). Other hand, 100 g fresh plants of *T. orientalis* and *O. umbellatum* are rich resources to supply need of daily Cr (120-132%), Cu (66-81%), Fe (14-36%), V (34-25%), Mn (42-13%) and Mo (15-12%). *S. excelsa* are found to be adequate resources of Cr (36%), Ni (36%), Cu (31%) and Mo (21%) (Table 6).

Table 6. Evaluation of mineral contents of wild plants according to daily mineral requirements for humans.

Mineral	Daily requirement[a] (mg day^{-1})	Wild vegetables species							
		U. diocia		*T. orientalis*		*S. excelsa*		*O. umbellatum*	
		mg 100g^{-1}	Supply the requirement (%)	mg 100g^{-1}	Supply the requirement (%)	mg 100g^{-1}	Supply the requirement (%)	mg 100g^{-1}	Supply the requirement (%)
K	4700	434	9	485	10	35	0.7	219	5
Ca	1000	62	6	9	0.9	1.95	0.2	33.4	3
Mg	255	39	15	53	21	9.4	4	11.2	4
Na	2300	4.2	0.2	3.4	0.2	4.3	0.2	3.35	0.2
Fe	8.1	10.8	133	1.16	14	0.18	2	2.95	36
Zn	6.8	0.76	11	0.38	6	0.61	9	0.84	12
Cu	0.7	0.42	60	0.46	66	0.22	31	0.57	81
Mn	1.8-2.3	1.1	61	0.75	42	0.13	7	0.23	13
Ni	1.0	0.34	34	0.09	9	0.36	36	0.15	15
V	1.8	0.48	27	0.62	34	0.01	0.6	0.45	25
B	20	0.17	0.9	0.05	0.3	0.11	0.6	0.065	0.3
Cr	0.025	0.054	216	0.03	120	0.009	36	0.033	132
Co	25	0.04	0.2	0.006	0.02	0.002	0.01	0.018	0.07
Mo	0.034	0.09	265	0.005	15	0.007	21	0.004	12
Se	0.045	0.005	11	0.0003	0.7	0.000	0.0	0.001	2

Reference: [35].

The Al content received by an adult with daily diet varies in many countries (Australia (1.9-2.4), Finland (6.7), Germany (8-11), Japan (4.5), Netherlands (3.1), Sweden (13), Switzerland (4.4), UK (3.9) and USA (7.1-8.2)). The amounts of Ba can take daily from various food by adult have been reported to be 0.44-1.8 mg day^{-1}. In light of these data, the Al concentration of all plant species is not a health risk. Similarly, the high Ba content of *O. umbellatum* species (8 mg 100 g^{-1}) has no toxic effect. Because, it is emphasized that Ba taken up to 200 mg / body weight per day has no toxic effect on reproduction and development of human [36, 37].

Wild plants are used as vegetables for human nutrition. On the other hand, toxic compounds for human are absorbed with the consumption of these plants. The adverse effects of wild plants containing As, Cd, Hg, Tl and Pb has been reported by many researchers [8, 28, 30]. World Health Organization has determined limits and tolerable values to reduce negative effects on human health of heavy metals. Accordingly, the daily dose of the heavy metals can be tolerated for adults (70 kg) have been identified as 0.150 mg kg^{-1} for As, 0.070 mg kg^{-1} for Cd, 0.250 mg kg^{-1} for Pb, and 0016 mg kg^{-1} for Hg [38]. Thallium is more toxic to mammals than Hg, Pb and Cd. Its toxicity is more dependent on environmental source than food-borne, and the lethal dose of thallium and salts for adults is 10-15 mg per kilograms of body weight [31]. Consequently, contents of As, Cd, Tl and Pb of our examples (100 g) does not hazard for human health but the amount of Hg in samples supplied from near the city center reached up to 3.7 fold of daily tolerable limit values.

4. CONCLUSIONS

More demand for edible wild plants result from the idea of benefits on health. Research results show that, these plants are located in the vegetable group, is one of rich mineral resources that are effective on human nutrition and health. Therefore, wild plants can significantly contribute with the minerals composition especially for the diet of consumers with low purchasing power of the economic. Moreover, these plants can use for enrichment of diets with low mineral content. Other hand, excessive and continuous uptake of metals (As, Cd, Hg, Tl and Pb) by four plant species may produce toxicity in human nutrition. In order to ensure the sustainable use of wild plant resources as a food, the plant must not be damaged during the harvesting process. Wild plants should not be collected from areas affected by environmental pollution, and wild plants must be cleaned and washed very well before being used. If there is any doubt about the collected area, consumers should prefer the consumption of cooked rather than raw. In addition, if wild plants that are directly or indirectly affected by pesticides are used for consumption, care must be taken that a certain period of time passes between the last drug application time and the harvesting period before consumption. Most important of all, these plants must be cultured, the use of wild plants for human nutrition should be increased, and more detailed studies should be done about the composition of these plants.

Conflict of Interests

Authors declare that there is no conflict of interests.

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