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SOME ELEMENTAL CONCENTRATIONS IN THE ACORNS OF TURKISH *QUERCUS* L. (FAGACEAE) TAXA

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Abstract

Quercus acorns from 16 taxa grown naturally in different regions of Turkey were studied to detect some elemental concentrations in order to observe different accumulation levels. Total concentrations of K, Fe, Zn, Cu, Cr, Ni and Co in the acorns were determined in acid digests by atomic absorption spectrophotometry. No significant differences in section level were observed, but differences at specific and infraspecific levels were significant ($P<0.001$) for all examined elements. Fe concentrations were positively correlated with Zn and Cu ($P<0.02$) in Section *Quercus*, but only with Zn ($P<0.05$) in Section *Cerris*. Remarkable distinctions of Fe, Zn, Cu and Ni concentrations in spesific and subspesific levels were observed. Fe and Zn concentrations were detected high in the acorns of *Q. robur* subsp. *robur, Q. petraea* subsp. *petraea, Q. infectoria* subsp. *boissieri* and *Q. cerris* var. *cerris*. In general, Cu, Cr, Ni and Co concentrations were low, but the concentrations of Cu in *Q. petraea* subsp. *petraea* and *Q. libani*; Ni in *Q. pubescens*, *Q. cerris* var. *austriaca* and *Q. ilex*; Co in *Q. frainetto* and *Q. coccifera* and Cr in *Q. robur* subsp. *robur, Q. frainetto, Q. vulcanica* were found in higher levels. Considerably different concentrations of Fe, Zn and Cu especially in the related taxa may be evaluated for the taxonomic delimitation additionally as a characteristic tool reflecting the constant genetical tolerance of accumulation.

Introduction

Oaks include a wide range of about 500 species of trees and shrubs in the N. Hemisphere, exclusive of the Arctic and about half of these are in the New World. *Quercus* as an extremely important genus for phytogeographer, forester and ecologist is one of the most problematical groups in the Turkish flora since widespread hybridisation and introgression have much obscured specific limits (Hedge & Yaltırık, 1982). About 18 species native for Turkey make large forests of 6.5 million ha. in the Thrace and Anatolia totally with its subspecies, varieties and natural hybrids. They are divided into 3 distinct categories viz., white oaks (Sect. Quercus), red oaks (Sect. Cerris) and evergreen oaks (Sect. Ilex) according to anatomical structures of their woods, maturing period of the fruits and the features of leaf and cork (Yaltırık, 1984). Apart from hardwood for use in furniture and manufacturing, fuelwood, cork for insulation, erosion control; acorns and leaves of *Quercus* additionally provide fodder for animals, food for wildlife and wildstock (Cypert & Burton, 1948). Acorns have been used as food by human beings for thousands of years virtually everywhere oaks are found (Bainbridge , 1986; Lieutaghi, 1998). They occur in the early town sites in the Zagross Mountains in Iran and at Catal Huyuk in Turkey (6000 BC) and were a staple food for many people until after 1900 AD (Bainbridge , 1986) in Europe, Asia, North Africa, the Middle-East, and North America (Loudon, 1844; Bishop, 1891; Lefvebre, 1900; Merriam, 1918; Hedrick, 1919; Brandis, 1972). Acorns supply many trace elements and the acorn food is a good source of Ca and

Mg (Bainbridge, 1986; Leigh & Fredric, 1988). Duncan & Clawson, 1980, have reported the nutritional value of the acorns including Ca and P content for *Q. kelloggii* from California. In a few study on *Q. alba* acorns, high level of Ca and lower levels of Si and P were reported (Vogt & Cox, 1970; Vogel, 1990). Some macro- and microelement concentrations of the acorns of *Q. brantii* from different localities of Zagross mountain in Iran has also been reported (Saffarzadeh *et al*., 1999).

Elemental concentrations of different plant tissues are also important from taxonomical point of view. Thompson *et al*., (1997) reported general taxonomic differences in leaf concentrations of N, K, Mg and Ca from 83 taxa collected from field-sites and large taxonomical effect on leaf Ca and Mg concentrations with much of the variations occurring at the level of the subclass i.e., between monocots and dicots. Sixteen elements apart from other characters in determining phenetic relationships within *Ophioglossum* were analysed and reported that the relations based on chemical attributes differ from those based on morphological characteristics which are more plastic (Khandelwal, 1989). Significant variations in higher taxonomic categories (family or above) of 136 taxa were found in shoot Cs concentrations among flowering plants (Broadley *et al*., 1989). Cs accumulation is also reported to be influenced by inherent correlation with ecological specialism.

Variations in cation uptake selectivity occurs between taxa of different ecological habits (Marschner, 1995) and elemental concentrations of plant materials strongly depend on genotypic character of uptake in addition to the soil properties (Ernst, 1995). The variation among plants in their ability to absorb different elements is not always consistent and is affected by changing conditions of soil and climate and by the stages of plant growth (Kabata-Pendias & Pendias, 1986). Where an element is easily soluble, plants may take up very large amounts. The less concentration variability of multi-elemental patterns were detected in four vascular plants implying greater selectivity during elemental accumulation process compared to lichen and moss species which are non-spesific accumulators of metals (Chiarenzelli *et al*., 2001). *Haumaniastrum* species occurring over phytotoxic mineralisations as geographical indicators of Cu and Co have hyperaccumulation potential for these elements (Paton & Brooks, 1996). It has been reported that taxa within the Chenopodiaceae accumulate more shoot Cs than taxa in other families and that they are therefore of potential use in phytoremediation (Broadley & Willey, 1997). Many complex interactions between different elements are observed within plant tissues and also external root media particularly in the uptake, for example an excesss of Zn leads to a marked reduction in Fe concentration in plants and it interferes more with the absorption and translocation of Fe than it did with Cu and Mn (Kabata-Pendias & Pendias, 1986).

Elemental analysis of *Quercus* acorns from different species were carried out from nutritional point of view, but their taxonomical utility as an additional parameter in delineation of some taxonomic categories were not assessed. On the other hand, no report on mineral compositions of *Quercus* taxa from Turkey has been made. The present report gives an account on the accumulation and concentration of seven elements in the mature acorns of 16 *Quercus* taxa collected from their naturally growing area which have different climatic and soil conditions. The taxonomical value of the elemental concentrations and its relations at section, species and subspecific levels is also presented.

Materials and Methods

Plant sampling: The twigs bearing mature acorns of 16 *Quercus* taxon viz., *Q. robur* L. subsp. *robur, Q. hartwissiana* Steven., *Q. frainetto* Ten., *Q. petraea* (Mattuschka) Lieb. subsp. *petraea*, *Q. vulcanica* (Boiss.& Heldr. ex) Kotschy, *Q. infectoria* Olivier subsp. *infectoria*, *Q. infectoria* Olivier subsp. *boissieri* (Reuter) O.Schwarz, *Q. pubescens* Willd., *Q. cerris* L. var. *cerris, Q. cerris* L. var. *austriaca* (Willd.) Loudon, *Q. brantii* Lindl., *Q. libani* Olivier, *Q. trojana* P.B. Webb., *Q. ilex* L., *Q. aucheri* Jaub.& Spach, *Q. coccifera* L., were collected from their natural distribution areas in Marmara, North Anatolia, Aegean and Mediterranean region and South-East Anatolia of Turkey between July and October 2001. The herbarium material prepared were determined after reference to the Flora of Turkey (Hedge & Yaltırık, 1982) and comparing with the identified specimens from ISTF and ISTO herbarium.

Chemical analysis: Mature acorns (3-4) from each taxon were dried at 90°C (Heraeus, Germany) in aluminium foil for 3 days and ground with mortar and pestle. Three hundred mg DW of each sample were then wet-digested on a hot-plate using % 65 HNO_3 for 5 days. K, Zn, Fe, Cu, Cr, Ni and Co content of the cleared solutions were filtered through ashless filter paper and diluted with deionized water. Mineral analysis were carried out by Atomic Absorption Spectrophotometer (Shimadzu AA-680, Japan) according to Baumhardt & Welch (1972) and Bayçu & Önal (1993). Total concentrations were measured at 766.5 nm for K (emission mode), 213.9 nm for Zn, 324.8 nm for Cu, 248.3 nm for Fe, 232 nm for Ni, 357.9 nm for Cr, and 240.7 nm for Co (absorption mode). All reagents were of analytical grade and all analyses were conducted in triplicate. Results were calculated as µg/g on dry weight basis.

Statistical analysis: Mean values and standard deviations of elemental concentrations in the acorn samples were subjected to analysis of variance (two-way ANOVA) and correlation by means of Excel software (Excel, 2000).

Results

The results evaluated on the basis of section, species and infraspecific level showed some differences and similarities in each taxonomic categories. Mineral compositions of acorns are given in the Table 1. Average values of the elements in the acorns of all taxa can be ordered with their decreasing concentrations as K, Fe, Zn, Cu, Cr, Ni and Co respectively. All taxa examined for K concentrations have the highest levels, as a macroelement, comparing with the other elements. Distributional margin of the K levels were found between 7849 and 15935 (µg/g DW). The highest concentrations of K were detected in *Q. coccifera* and *Q. aucheri* from section Ilex and the lowest levels were found in *Q. petraea* subsp. *petraea* and *Q. infectoria* subsp. *infectoria* from section Quercus. Fe concentrations in the acorns of *Q. infectoria* subsp. *boissieri* (2071,1 µg/g), *Q. petraea* subsp. *petraea* (2020,1 µg/g) and *Q. robur* subsp. *robur* (1453,7 µg/g) were in considerable amounts. The lowest levels of Fe were observed in *Q. hartwissiana* (19 µg/g) and *Q. infectoria* subsp. *infectoria* (19,3 µg/g) from section Quercus.The striking differences of Fe concentrations between two subspecies of *Q. infectoria* (19,3 and 2071 µg/g) and two varieties of *Q .cerris* (40,2 and 584,2 µg/g) were detected. Largest

Table 1. Concentrations of the elements for each taxa (µg/g DW).

	K	Fe	Zn	Cu	Cr	Ni	Co
Section Quercus							
Q. robur subsp. *robur*	11512±877	1454±257	160,2±14	32,1±4,2	27,3±4.9	0	0,75±0,22
Q. hartwissiana	12158±673	19±2,9	6,9±1,2	9,9±1,6	14,3±1,9	1±0,25	0
Q. frainetto	10236±512	51,8±6,8	9,7±1,6	10,9 ±1,3	25,6±3,5	7,2±1,2	2,66±0,53
Q. petraea subsp. *petraea*	7849±826	2020±367	204,7±27	104,9±14	23,8±3,2	0	0
Q. vulcanica	8509±686	128±18,8	8,3±1,5	10,1±1,5	27,5±2,6	42,4±7,2	1,24±0,26
Q. infectoria subsp. *infectoria*	8326±749	19,3±3,1	10,3±1,3	9±1,4	9,8±2,1	2,98±0,6	0
Q. infectoria subsp. *boissieri*	9659±911	2071±182	367,5±33	36,5±3,58	12,6±2,4	17,4±3,1	0
Q. pubescens	8973±727	56,7±7,4	8,9±0,78	11,6±1,96	7,2±1,4	30,1±4,6	0,94±0,24
Mean values	9652±1451	727,4	97	28,1	18,5	12,6	0,58
Section Cerris							
Q. cerris var. *cerris*	12316±1120	584,2±67	338,6±39	43,3±6.1	19,2±3,5	0	0
Q. cerris var. *austriaca*	10257±744	40,2±6,4	11,4±2,1	17,1±2,1	18,2±1,9	43,5±7,1	0
Q. brantii	11886±1045	77,3±13,6	11,9±2,6	10,4±1.7	7,27±1.3	7,3±1,3	1,16±0,27
Q. libani	10543±663	102,9±14	49,2±6,4	52,5±8.5	0	22,6±3,1	0,88±0,17
Q. trojana	9882±674	229,5±33	11,7±2,2	11,8±2,25	117,5±16	5,3±0,93	0,37±0,06
Mean values	10976±951	206,8	84,5	27	32,4	15,7	0,48
Section Ilex							
Q. ilex	9854±559	66,4±10,5	11,1±0,95	13,5±1,82	0,31±0.06	37,1±3,6	0,16±0,04
Q. aucheri	14912±1224	138,8±18	48,9±37,5	32,4±5,1	14,5±2,7	0	0,97±0,13
Q. coccifera	15935±1187	26,3±3,4	9,2±2,7	9,1±0,15	15,7±24,4	1,8±0,4	1,51±0,26
Mean values	**13567±2658**	**77,1**	**23**	**18,3**	**10,1**	**12,9**	**0,55**

Each value is a mean ± standart deviation of three determinations.

variations of Zn concentrations in Section Quercus and extremely different values in subspecies and variety levels were found. The highest level of Zn concentration was detected in *Q. infectoria* subsp. *boissieri* (367,5 µg/g), while the lowest value was observed in *Q. hartwissiana* (6,9 µg/g). In addition to the differences among species and subspecies, varieties can also be distinguished from each other as can be seen in two subspecies of *Q. infectoria* (10,3 and 367,5 µg/g) and two varieties of *Q. cerris* (11,4 and 338,6 µg/g) for Zn. Cu concentration of *Q. petraea* subsp. *petraea* makes a peak (104,9 µg/g) in terms of others which have remarkably low levels, while *Q. libani* and *Q.cerris* var. *cerris* have relatively higher levels. The lowest level of Cu was observed in *Q. infectoria* subsp. *infectoria* (9 µg/g). Cr concentrations were found between 0-27,51 µg/g, but *Q. trojana* from section Cerris showed an evident increase with 117,5 µg/g. Cr has not correlated significantly with all examined elements. We have found no significant differences in section level, but some significant values among species and only a negative correlation with the other elements in Section Cerris were determined. Considerable variations of this element in specific and subspecific levels were observed. Ni concentrations among taxa were generally found low (0,95-5,3 µg/g), but remarkably high values were measured in *Q. vulcanica* (42,4 µg/g), *Q. cerris* var. *austriaca* (43,5 µg/g) and *Q. ilex* (37,1 µg/g). On the other hand, this element was not detected at all in some taxa, such as *Q. robur* subsp. *robur*, *Q. petraea* subsp. *petraea*, *Q. cerris* subsp. *cerris* and *Q. aucheri.* We have also detected very low concentrations of Co (0-1,51 µg/g) from almost all of the samples except *Q. frainetto* with a slightly higher value (2,66 µg/g). Ni showed negative correlation with the other elements. When our experimental data are grouped in section level which covers related species, concentrations of Fe, Zn and Cu are tend to be higher in the same species from section Quercus, namely *Q. robur* subsp. *robur*, *Q. petraea* subsp. *petraea*, *Q. infectoria* subsp. *boissieri* collected from regionally different localities. Generally speaking, this section have the highest concentrations of all elements detected except for K. However, section Ilex have the lowest values for all elements out of K. According to the values obtained for three section basis, concentrations of all examined elements have no significant differences. But, striking fluctuations and significantly differences among species, subspecies and variety from each sections were found ($p<0,001$). Correlation analysis of the samples were also carried out for all taxa totally and it was found that Fe was positively correlated with Zn ($p<0,001$) and Cu ($p<0,01$); and Zn was positively correlated with Cu ($p<0,02$) significantly. All other correlation coefficients were generally negative and nonsignificant. On the other hand, when the correlation of the elemental concentrations in section levels were examined, some differences were also observed. There are positively significant correlation between Fe and Zn ($p<0,001$; $p<0,05$) in Section Quercus and Section Cerris respectively. Besides, Fe and Cu concentrations have significant positive correlation ($p<0,02$) only in Section Quercus. No significant correlations were observed within Section Ilex, but some positively and negatively higher correlation values were determined. Zn and Cu for all examined species are positively significantly correlated ($p<0,02$), but they are nonsignificant at intersectional level. However, negative nonsignificant correlation between Ni, Co and the other elements in each section were also calculated.

Discussion

Quercus acorn has been a staple food in countries from Iran to Japan. They are still eaten regularly in Korea and North Africa (Kim & Shin, 1975; Bainbridge, 1991). It was also documented that *Quercus* have the best range of mineral concentrations having pro-oxidant activity and health benefits (Parcerisa *et al*., 1995) for man and animal feeding during the autumn (Alonso & Garciaolalla, 1997). Some elemental concentrations of the acorns examined here proved higher than that of some valuable foodstuff such as corn, sorghum, wheat, barley, oat and rye.

On the other hand, the various species of *Quercus* can tolerate a very wide range of climatic and soil conditions, including very hot or cold climates, highly saline or alkaline soil, and wet or intermittently flooded ground. We have collected *Quercus* acorns from the different regions of Turkey with different climate and soil conditions. Some macro- and microelement concentrations of the acorns of *Q. brantii* from Zagross mountain chain in Iran were reported to change slightly according to different climatic regions (Saffarzadeh *et al*., 1999). K content of *Q. brantii* has been found as 6800 µg/g for the above study, but in our investigation K level for this species has almost 2-fold higher value (11886 µg/g). According to our results obtained, we have observed higher concentrations of K in *Quercus* taxa than *Corylus avellana* from Turkey (Açkurt *et al*., 1999) and *Juglans regia*, but lower concentrations than *Castanea sativa* (Jenkins, & Ebeling, 1985; Sundriyal & Sundriyal, 2001). No significant correlation with any other microelements for all examined taxa was determined for K. However, significant relations between K and Zn were reported in *Corylus* from Turkey (Ackurt *et al*., 1999). Mineral accumulations in acorns of the different species may be effected with climate, soil factors and controlled genetically. According to Schleppi *et al*., (2000), environmental conditions such as chemism, the physical properties of soil, insolation, altitude, and physiological factors caused by season or age of some tissues may considerably influence the chemical composition of plants. On the other hand, it is known that nutrients are taken up selectively, often independently from their concentration in soil, and these processes are regulated physiologically. For instance, Fe-Zn, Fe-Cu and Zn-Cu are known to have antagonistic interactions within plant, and high levels of Fe compounds in soil greatly decrease trace metal uptake depending on the same absorption mechanism (Kabata-Pendias & Pendias, 1986). Accumulation in high concentrations of an element in any plant tissue without toxic effects may be a genetic characteristic and may include tolerance mechanisms. Though these elements are essential, they are also potentially toxic, so plants possess complex biochemistry to control them. For having different potential of taxa examined to accumulate concerning elements in different levels, the measurement values in mature acorns collected from well-developed oak trees in their natural environments may be used as a parameter in understanding the relations among taxa in taxonomical and ecophysiological point of view. But the knowing of the margin of concentrations for each element in any taxon of *Quercus* in naturally growing area is required for observing the relation much strictly among taxa and so it is needed to compare the results taken from same species of *Quercus* growing in different regions. In a study on elemental composition of *Abies alba* seedlings from four different populations in eastern Poland, it was reported that the significant difference between the experimental populations in the average content of most elements in shoots (Fe, Mn, Mg and Ca) except for Zn and suggested genetically conditioned variability between the populations

(Szymura, 2003). Variations in element concentrations among taxa may reflect different genetical dispositions for the accumulations. It may suggest genetically consolidated variability between individuals and populations for features responsible for receiving, distribution and accumulation of nutrients and other chemical compounds. These differences were also found in the case of *Betula pendula* to Al (Kidd & Proctor, 2000) and *Picea abies*, *Pinus sylvestris* and *B. pendula* to Zn (Österås *et al*., 2000). At the same time, these results may be assessed as an indicator for the species growing optimal and healthy in their natural environmental conditions.

In this study Fe, Zn and Cu concentrations in some *Quercus* taxa were observed remarkably high with positive significant correlations in contrary to the general interaction properties of these elements within plant. While the two varieties of *Q. cerris* from the nearest localities have quite different levels of Fe, Zn, Cu and Ni; two different species like *Q. trojana* and *Q. vulcanica* which are found in close localities had similar values of Zn and Cu but quite different concentrations of other elements implying genetical characteristics of accumulation. Natural Fe content of fodder plants ranges from 18 to about 1000 µg/g, and various cereal grains do not differ much in their concentrations and the common average Fe content of different cereals ranges from 25 to around 80 µg/g (Kabata-Pendias & Pendias, 1986). In our investigation, wide range of Fe concentrations between 19-2071 µg/g were determined. The highest values especially in *Q. infectoria* subsp. *boissieri* (2071 µg/g), *Q. petreae* subsp. *petreae* (2020 µg/g) and *Q. robur* subsp. *robur* (1453 µg/g) implying the potential of Fe accumulation can be compared with the grasses contained Fe within the range of 2127 to 3850 µg/g growing in soils derived from serpentine (Jhonston & Proctor, 1977). Meanwhile, Fe concentrations of 30-50 µg/g for *Castanea sativa* and *Juglans regia* (Jenkins & Ebeling, 1985; Sundriyal & Sundriyal, 2001) and 23,2 µg/g in *Corylus avellana* from Turkey (Açkurt *et al*.,1999) have been observed. We have also found approximately 3-fold Fe content in *Q. brantii* from Turkey (77,3 µg/g) compared to *Q. brantii* (25 µg/g) from Iran (Saffarzadeh *et al.*,1999). In the study on Turkish hazelnut, no significant differences observed in the levels of Fe between the geographical regions, apart from other elements (Açkurt *et al.,* 1999). Although no significance was found among section for Fe, dissimilar mean values in section level, extremely high amounts of Fe concentration in Section Quercus, and striking differences in species, subspecies and variety levels may be useful characteristics in the delineations of these taxonomic categories. It was declared that the absence of a significant difference between the concentrations of Fe in roots and presence in shoots is probably the result of various ways of effective transport and distribution of this element in different populations (Szymura, 2003). Especially different values of this element in taxonomically lower levels may imply the susceptibility to the genetical distinctions for the accumulation. Contrary to the results from *Corylus* (Açkurt *et al.,* 1999), Fe concentrations are positively and significantly correlated with Zn and Cu in *Quercus*. These correlations at section level are also different. Positive correlation between Zn and Fe is also reported for *Abies alba* parallely with our findings (Szymura, 2003). In plants, a proper proportion of Fe/Mn is required for the equilibrium of enzymatic processes. When this ratio is lower than 1.5, it causes toxicity of manganese and shortage of iron, when higher than 2.5 it causes Fe toxicity, which is accompanied by a shortage of Mn (Kabata-Pendias and Pendias, 1999). It was reported a wide optimum range for the Fe/Mn ratio in genus *Betulaceae* and *Fagaceae*, where it is lower than 1 (Strack, 1998).

Mean values for Zn in wheat grains were reported to range from 22 to 33 µg/g showing no clear differences in country of origin. Background content of Zn in grass and clover throughout the world is also relatively stable ranging from 12 to 47 µg/g (Kabata-Pendias & Pendias, 1986), however large variation of Zn were measured among examined taxa (6,9–367,5 µg/g). The highest values for this element in *Q. infectoria* subsp. *boissieri* and *Q. cerris* var. *cerris* may reflect strong accumulation characteristics. Zn concentration here was determined slightly higher than the results of Saffarzadeh *et al*., (1999), for *Q. brantii*. But similar accumulation levels for this element from very different habitats may imply its consistent characteristic which is less effected by other ecological parameters. Additionally, Zn is positively and significantly correlated with Cu for all taxa, as reported in Turkish *Corylus* (Açkurt *et al*., 1999). It was declared that Cu content, as an essential microelement for plant nutrition in most plants tend to be internally rather than externally regulated, so that concentrations in plants remain low and relatively constant, irrespective of the critical levels in the soil (Pavlova, 2000). On the other hand, Anke *et al.*, 1975, reported a significant variation in Cu uptake by red clover from different soils, while Kähäri, J. and H. Nissinen, 1978, found fairly uniform Cu levels in timothy from different soils. Cu concentrations were reported for grains as 3-58 µg/g. In our samples, this element has the values of 9-52,5 µg/g similarly, except for *Q. petraea* subsp. *petraea* which shows a 2-fold high value as 104,9 µg/g. While *Q. brantii* from Iran contains 4,63 µg/g Cu, *Q.brantii* from Turkey contained 10,4 µg/g as a higher value again most probably showing the ecological variations. Besides, Cu content was found as 4,2-7 µg/g in two species of *Pistacia* from Zagros mountains (Saffarzadeh *et al.,*1999), 6,5 µg/g in *Corylus avellana* (Ackurt *et al.,* 1999), 3 µg/g in *Juglans regia* (Jenkins & Ebeling, 1985; Sundriyal & Sundriyal, 2001) which indicate lower levels than *Quercus* acorns examined here. Relatively limited variations in Cu concentrations were detected in this examination comparing with K, Fe and Zn. The similar levels of Cu and Zn from *Q. vulcanica* and *Q. trojana* growing in the very close locations may depend on some environmental conditions as much as internal factors. It was reported that Cu and Zn levels are effected from geographical regions in *Corylus avellana* from Turkey (Açkurt *et al*., 1999). Contrarly, detection of different values for the other elements in these species may be explained with different ecological responses of two species to the same field conditions. Significantly different results in subspesific and variety level for Cu concentrations and the significant positive correlation with Fe in Section Quercus only may imply the usable characteristics of this parameter in additional taxonomic delimitations. In addition to the antagonistic or synergistic effects resulting internal equilibrium of the concentrations, different correlation characteristics of the examined elements may be due to the different plant parts and taxonomical groups.

Common levels of Cr found in plant materials are usually in the order of 0,02-0,2 µg/g (Kabata-Pendias & Pendias, 1986). In our observation, large variations in Cr concentrations were detected. The extremely high value of Cr was observed in *Q. trojana* (117,5 µg/g) from section Cerris. The second top value was obtained from *Q. vulcanica* (27,5 µg/g, section Quercus), which is an endemic species collected from the close localities with *Q. trojana*. These different results observed in two species from the same field may explain the different accumulation potentials. Such high concentration was declared in a grass near city streets to be as high as 17 µg/g which probably comes from pollution (Czarnowska, 1974). Native vegetation of serpentine soils was reported to contain up to 19 000 ppm (AW) Ni (Lyon *et al*., 1968). In a study on Ni accumulators from the serpentine flora of Turkey, it was discovered the new instance of Ni hyperaccumulation exceeding 0,1 % of the dry weight of some plant species and reported the worldwide interest in exploiting the property of hyperaccumulation, both for remediation of metal-contaminated soils and for economic selective extraction of metal compounds by cropping hyperaccumulators (Reeves & Adıgüzel, 2002). The Ni concentrations in certain foodstuff, cereal grains, and pasture herbage from different countries do not differ widely. Comparing with the results obtained from some plant foodstuff from different families changing between 0,06 and 3,7 µg/g (Ozoliniya & Zariniya, 1975), wide variations in *Quercus* acorns (0-43,5 µg/g) were observed in this study. The values measured in *Q. vulcanica* (42,4 µg/g) and *Q. cerris* var. *austriaca* (43,5 µg/g) may imply the accumulator characteristics in terms of other *Quercus* species and different soil conditions. Besides, *Q. vulcanica* and *Q. trojana* from very close localities have showed completely different values for Ni as two different species. On the other hand, Prasad M.N.V. and H. Freitas, 2000, have detected Ni, Cu, Cr concentrations in the stem, leaf and root of *Q. ilex* and they have found lower levels of Ni and Cu, but higher Cr concentrations in all organs. These results disagree with our findings on this species. Contrarily, higher level of Ni and Cu, and lower level of Cr were detected in the acorns. The Co content of some plant foodstuffs was reported to vary from around 8 to 100 µg/g (Kabata-Pendias & Pendias, 1986). The elemental concentrations of Co in *Quercus* acorns examined here were obtained as 0-2,66 µg/g. These results can be compared generally with the Co contents of clover and grasses ranging from 0,03 to 0,57 µg/g in different countries (Kabata-Pendias & Pendias, 1986). Non-existence or lower levels of this element are less informative in order to observe the differences among taxa. Significantly different concentrations of K, Fe, Zn and Cu especially in addition to Cr and Ni among distinct species and related taxa from each section, different significant correlation and high variation characteristics of these elements at intersectional level may be evaluated for the taxonomic delimitation additionally as a characteristic tool reflecting the constant genetical tolerance of accumulation. But beside the plant species and their genetical difference, changing conditions of soil and climate should also be kept in mind.

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