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DETERMINATION OF LEAF NUTRIENT CONTENT IN BARBERRY GENOTYPES GROWN IN KAYSERI REGION

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Abstract
Barberry species' flowers, fruits, and leaves are widely consumed due to their rich nutritional content and positive effects on health. This study determined the leaf mineral content levels of Berberis crataegina DC. genotypes collected from Kayseri province in the center of Turkey. The study material consisted of 10 genotypes collected from the Alidağı region of Kayseri province. A total of 13 mineral substances (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, P, S, and Zn) were determined in the leaves of the genotypes. The mineral content of leaves differed among genotypes. The most abundant mineral substances in Barberry leaves were determined as Ca (906.32 - 3017.62 mg/kg), Mg (250.75 - 950. 50 mg/kg), K (240.50 - 850.50 mg/kg), P (150.50 -350.00 mg/kg), S (60.30 - 175.75 mg/kg) and Na (40.25 - 95.50 mg/kg). The leaves' lowest mineral substances were Ni (0.20 - 0.05 mg/kg) and Cu (0.85 - 1.95 mg/kg). As a result of the study, it was observed that barberry leaves growing naturally in the region have rich mineral content.

Keywords: Berberis crataegina DC, leaves, mineral contents.

1. INTRODUCTION

The *Berberidaceae* family, which is generally distributed in the northern hemisphere's temperate regions, consists of about 500 species, of which about 300 are found in Eurasia and 200 in South America (Sodagar et al., 2012). Four barberry species (*Berberis vulgaris L., Berberis integerrima Bunge, Berberis cretica L.* and *Berberis crataegina*) grow naturally in Türkiye (Davis, 1965-1988). *Berberis crataegina* DC. is one of the important wild fruit species in Türkiye, widely used for food and medicinal purposes. *Berberis crataegina* DC., which grows naturally in Türkiye, Iran and Turkmenistan, also grows in Asian and European regions (Kılıç and Yusufbeyoğlu, 2022).
Berberis crataegina DC., a drought and cold-resistant fruit species, can grow in mountainous areas where cold winters prevail (Alemardan et al., 2013). This shrub-shaped plant, reaching a height of approximately 2 m, generally grows in rocky areas at altitudes between 800 and 1500 m. Its leaves are yellow, small and oval-shaped. It blooms in late summer. The fruits, which initially appear red, turn from dark purple to black as they ripen in autumn (Kılıç and Yusufbeyoğlu, 2022).
The roots, leaves and fruits of *Berberis crataegina* DC. plants are traditionally used to treat rheumatic, gynecological, circulatory and diabetic disorders. Its fruits are used in the treatment of hypertension, stomach and intestinal disorders, and colds; its roots are used in the treatment of jaundice, bronchitis, and colds; and its leaves are used in the treatment of wounds and cuts in cases of intestinal disorders

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(Ercan, 2024). The growing demand for natural products with high bioactive compound content highlights the potential of using easily accessible leaves for isolating bioactive compounds. These compounds have significant potential for improving human health, preventing infections, and aiding disease recovery (Adamcová et al., 2022).
Barberry leaves are known to be rich in bioactive compounds such as antioxidants, phenolics and flavonoids compared to other plant parts (El-Zahar et al., 2022; Gul et al., 2023; Och et al., 2023). The leaves of barberry species have been used for medicinal purposes for years, thanks to their rich bioactive compounds. However, there is insufficient information about barberry leaves' macro and micronutrient contents. This study was carried out to determine the nutritional content of the *Berberis crataegina* DC leaves. species.

2. MATERIALS AND METHODS

The study was conducted on 10 genotypes of *B. crataegina* naturally growing in Kayseri province, located in central Türkiye. For correct sampling, a proper distance of at least 200 m between the genotypes was regarded so that the clone samples would not be collected. Leaf nutrient analysis was conducted with three replicates, each consisting of 100 leaves. Leaf samples were washed with water and distilled water as a preliminary step. It was then dried at 65-70 °C until the weight stabilized. The samples were ground to be less than 0.5 mm in size. The total nitrogen content of leaf samples burned by the Kjeldahl method was determined by steam distillation (Lees, 1971). To determine the amount of other nutrients, the samples were thawed by dry combustion method (Kaçar, 1972) and then macro and micro elements concentrations of the samples were read in the ICP-OES instrument (Kaçar and İnal, 2008).
Leaf nutrient content was analyzed using the statistical software package JMP Pro 17. The TUKEY multiple comparison test was used to analyze the results, and the results were presented at a significance level of %5 ($p < 0.05$) In addition, multivariate statistical methods (principal component analysis (PCA) and heat map analysis) were applied when comparing the data sets of leaf nutrient content, biochemical properties and antioxidant activity using the JMP Pro 17 statistical software package.

3. RESULTS AND DISCUSSIONS

Leaf mineral element contents of barberry genotypes varied according to genotypes. Al content varied between 3.70 (G10) – 7.40 (G5) mg/kg, B content varied between 10.11 (G7) – 16.03 (G1) mg/kg, Ca content varied between 960.32 (G3) – 3017.62 (G1) mg/kg, Fe content varied between 5.00 (G8) – 25.75 (G2) mg/kg, K content varied between 240.50 (G7) - 850.50 (G4) mg/kg, Mg content varied between 250.75 (G9) – 950.50 (G1) mg/kg, Mn content varied between 1.70 (G1) – 4.50 (G5) mg/kg, Na content varied between 40.25 (G7) – 95.50 (G3) mg/kg, Ni content varied between 0,05 (G5) – 0.20 (G4) mg/kg, P content varied between 150.50 (G8) – 350.00 (G6) mg/kg, S content varied between 60.30 (G7) – 175.75 (G2) mg/kg and Zn content varied between 1.50 (G1) – 5.50 (G6) mg/kg (Table 1). Our study findings are similar to the findings of Gulsoy et al. (2011), who studied the species *Berberis crataegina* DC., and were higher than the findings of Shah et al. (2003) and Gulfraz et al. (2004), who studied the species *Berberis lycium*. The observed differences between studies are due to ecological variations, genetic diversity of the genotypes examined (Toplu et al., 2009), and agricultural practices (Hernandez et al., 2016). According to the results obtained from leaf samples, berberis genotypes are rich in Ca, Mg, K, P, S and Fe. Minerals such as calcium, magnesium,

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potassium, and phosphorus are critical for bone health, cardiovascular function, and cellular metabolism (Ali, 2023; Yadav et al., 2024).

Table 1. Leaf nutrient contents of barberry genotypes

Genotype	Al	B	Ca	Fe	K	Mg	Mn	Na	Ni	P	S	Zn
G1	4.23 g	16.03 a	3017.62 a	23.98 b	313.08 ı	950.50 a	2.00 h	88.87 b	0.12 c	184.01 h	87.23 g	1.50 h
G2	5.43 d	13.72 e	1422.08 ı	25.75 a	388.75 h	549.04 d	1.70 ı	62.90 e	0.18 a	334.99 b	175.75 a	1.75 g
G3	6.21 c	14.05 d	960.32 j	22.28 c	416.66 g	740.02 b	2.82 e	95.50 a	0.07 e	312.35 c	104.40 e	1.61 gh
G4	4.69 f	15.13 c	1844.72 g	21.72 d	850.50 a	444.13 f	3.11 d	60.60 f	0.20 a	195.50 f	75.64 h	3.36 e
G5	7.40 a	11.20 ı	2032.48 e	16.32 f	699.15 b	378.81 g	4.50 a	77.60 c	0.05 f	254.89 d	93.61 f	2.83 f
G6	4.36 g	15.73 b	2575.76 c	18.79 e	613.77 d	500.84 e	2.44 g	58.72 fg	0.09 d	350.00 a	140.68 b	5.50 a
G7	5.07 e	10.11 j	1734.43 h	15.66 g	240.50 j	609.11 c	3.55 c	40.25 ı	0.15 b	189.89 g	60.30 ı	5.10 b
G8	6.15 c	13.51 f	2225.26 d	5.00 j	499.70 f	743.47 b	4.10 b	73.34 d	0.07 e	150.50 j	74.58 h	4.36 c
G9	6.70 b	12.49 g	2745.70 b	10.00 h	576.17 e	250.75 ı	3.55 c	58.36 g	0.16 b	240.72 e	131.48 c	4.05 d
G10	3.70 h	11.94 h	1881.81 f	7.59 ı	641.57 c	323.87 h	2.54 f	50.70 h	0.12 c	167.22 ı	114.23 d	3.55 e

In the study, the effect levels of mineral contents of berberis genotypes were determined by Principal Component Analysis (PCA). To ensure reliability in PCA analysis, components with eigenvalues greater than one were considered (Mohammadi and Prasanna, 2003). The eigenvalue of the first five components was greater than 1. The eigenvalue of the first five components was greater than 1. PCA1, PCA2 and PCA3 explained 33.60%, 19.61% and 15.18% of the total variation, respectively. If the component values of the features examined in the principal component analysis are 0.30 and above, it is accepted that they make a significant contribution to the main component (Brown, 1991). While Fe and B contents provided the highest positive contribution to the PCA1, Cu, Mn and Zn contents provided the highest negative effect. The contents that provided the highest positive contribution to the PCA2 were Na and Mg, while the contents that provided the highest negative contribution were Ni and S. In the PCA3, the highest negative contribution was detected in Mg and Ca contents, while the highest positive contribution was detected in Al, P and S contents (Table 2).

Table 2. PCA of barberry genotypes based on leaf nutrient contents

Traits	PCA1	PCA2	PCA3	PCA4	PCA5
Al	-0.12	0.33	0.49	0.01	0.07
B	0.36	-0.04	-0.18	0.44	0.05
Ca	-0.06	-0.05	-0.30	0.49	0.49
Cu	-0.42	-0.02	-0.07	-0.27	0.18
Fe	0.42	-0.01	0.05	-0.11	-0.22
K	-0.09	-0.17	0.26	0.60	-0.42
Mg	0.23	0.38	-0.39	-0.14	0.11

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Mn	-0.37	0.28	0.19	0.16	-0.12
Na	0.26	0.48	0.10	0.18	0.03
Ni	0.09	-0.48	-0.12	-0.13	-0.32
P	0.27	-0.13	0.46	-0.07	0.33
S	0.22	-0.32	0.35	-0.06	0.43
Zn	-0.32	-0.23	-0.09	0.15	0.28
Eigenvalue	4.36	2.54	1.97	1.50	1.00
Cumulative Variance	33.60	19.61	15.18	11.60	7.70
Total Variance	33.60	53.21	68.39	79.99	87.69

As a result of the heatmap hierarchical clustering analysis based on the nutritional contents of barberry genotypes, two main clusters were formed. The two main groups are further divided into two subgroups. While group A contains genotypes G5, G7, G8, G9 and G10, group B contains genotypes G1, G2, G3, G4 and G6. The genotypes in group B stood out in terms of Al, Mn, Cu and Zn contents. The genotypes in Group A varied according to the genotypes. The genotypes in Group A vary according to the genotypes in terms of mineral contents (except Al, Mn, Cu and Zn).

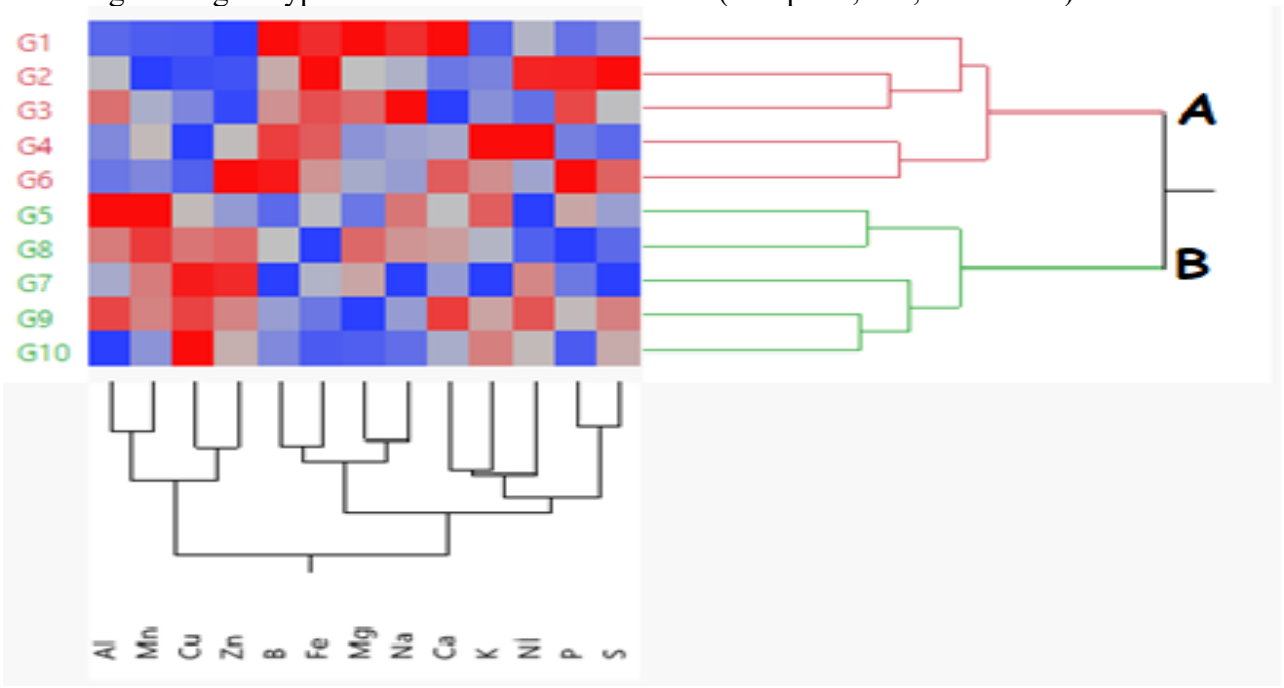

Figure 1. Heatmap hierarchical clustering analysis of nutrient contents of barberry genotypes

4. CONCLUSIONS

This study is the first to reveal the region's leaf nutrient contents of barberry genotypes. As a result of the study, it was determined that the barberry genotypes in the region had rich variation in terms of leaf mineral contents. As a result of the study, it was concluded that barberry leaves are a medicinally important plant species thanks to their rich mineral content.

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