Mineral Contents and Bioactive Properties of *Centaura* spp. Leave and Seeds

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ABSTRACT: *The mineral contents of Centaura leave and seeds were determined by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES). Macro element concentrations (P, K, Ca, Mg and S) of samples were found at high levels. K was established at high level in both leave and seed samples of Centaurea. While K contents of leaves changes between 7254.10 mg/kg (Centaurea lycaonica) and 26396.36 mg/kg (Centaurea pterocaula), it ranged from 6242.22 mg/kg (Centaurea salicifolia) to 15182.07 mg/kg (Centaurea cariensis). Ca contents of leaves changed between 6268.70 mg/kg (Centaurea derderiifolia) and 23471.24 mg/kg (Centaurea stapfiana). The same element was found between 1963.45 mg/kg (Centaurea salicifolia) and 12470.46 mg/kg (Centaurea stapfiana). Fe contents of leaves changed between 55.52 mg/kg (Centaurea cariensis Boiss. subsp. longipapposa) and 502.47 mg/kg (Centaurea salicifolia). Na content ranged from 324.27 mg/kg (Centaurea cariensis) to 4938.52 mg/kg (Centaurea cariensis). Anthocyanin contents of leaves ranged from 16.3 µmol/g (Centaurea kizildaghensis) to 109.3 µmol/g (Centaurea stapfiana). While total phenolic contents of leaves change between 693.5 mg gallic acid/g extract and 826.3 mg gallic acid/g extract, total phenolic content of seeds ranged from 655.1 mg gallic acid/g extract (Centaurea derderiifolia) to 1342.0 mg gallic acid/g extract (Centaurea cariensis Boiss. subsp. longipapposa). Total flavonoid contents of Centaurea leaves changed between 49.2 mg catechol/g (Centaurea nigrofimbria) to 157.5 mg catechol/g (Centaurea pterocaula).*

KEY WORDS: *Centaura, Leave and seeds, Mineral, Anthocyanin, Total phenol, Flavonoid, ICP- AES.*

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INTRODUCTION

The genus *Centaurea* L.(Asteraceae) is represented by a very large number of species, distributed in particular in southwest, central and east of the Turkey [1] (*Kılıç*, 2013). They are herbaceous perennial herbs grown in mountain slopes and dry lands [2] (*Wagenitz*, 1975). The aerial parts of the plant are known as peygamber çiçeği, zerdali dikeni, çoban kaldıran, Timur dikeni in Turkey [3] (*Baytop*, 1999). For centuries edible plants have been an integral part of human nutrition and were already described in detail in ancient literature. Nowadays, sales of fresh, top-quality flowers for human consumption are increasing world wide [4,5] (*Kopec*, 2004; *Mlcek & Rop*, 2011). Aerial parts of *Centaurea cyanus* have an incontestable source of many phenolic compounds and polysaccharides [6-8] (*Turcan et al.* 2011; *Pirvu et al.* 2008; *Pirvu et al.* 2012). Centaurea species are Eurasian native (*Reed & Hughes*, 1970). Livestock consumption of spotted knapweed has been considered minimal, especially mature plants because of their high fiber content and low nutritive value [9-11] (*Watson & Renney*, 1974; *Strang et al.* 1979; *Kelsey & Mihalovich*, 1987). Pharmacological studies pointed out strong gastroprotective effect of the Cyani herba selective extracts [8] (*Pirvu et al.* 2012). Many members of the genus Centaurea have been long used in Anatolian folk [3,12] (*Baytop*, 1999; *Sezik et al.* 2001). Various Centaurea species have certain biological properties, such as antimicrobial [13] (*Karamenderes et al.* 2006), antifungal [14] (*Koukoulitsa et al.* 2005) and antioxidant [15] (*Severino et al.* 2007) properties. Chemical compositions of the members of Centaurea were also reported by some studies [16] (*Dural et al.* 2003). It was not randomized to the study on mineral contents and bioactive properties of *Centaura* spp. leave and seeds.

The aim of this study was to determine to the mineral contents and some bioactive properties of *Centaura* leave and seeds obtained from different locations in Southern Turkey.

EXPERIMENTAL SECTION

Materials

Materials collected from several locations of Turkey are given in Table 1. Materials were brought in PVC containers. Samples were kept in sealed containers at -18^{o}C during study. The specimens are kept in the KNYA herbarium of the Department of Biology, Selçuk University, and identified by Dr. Duran.

Determination of ash and mineral contents

Ash was determined according to the standard AOAC [17] (1990) method. *Centaura* samples were dried at 50 ^{o}C in a drying cabinet with air-circulation until reached constant weight. Later, about 0.5 g dried and ground sample was digested by using 5ml of 65% HNO_3 and 2 mL of 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress). The volumes of the digested samples were completed to 20 mL with ultra-deionized water and mineral concentrations were determined by inductively coupled plasma-optical emission spectroscopy (ICP-AES; (Varian-Vista, Australia). Measurements of mineral concentrations were checked using the certified values of the related minerals in the reference samples received from the National Institute of Standards and Technology (NIST; Gaithersburg, MD, USA) [18] (*Skujins*, 1998).

Working conditions of ICP-AES are : Instrument: ICP-AES (Varian-Vista), RF Power: 0.7-1.5 kW (1.2-1.3 kW for Axial), Plasma gas flow rate (Ar) : 10.5-15 L/min. (radial) 15 " (axial), Auxilary gas flow rate (Ar) :1.5 ", Viewing height : 5-12 mm, Copy and reading time :1-5 s (max.60 s), Copy time : 3 s (max. 100 s).

Determination of Anthocyanins, Total Phenolic Contents and Flavonoids

Anthocyanins were analyzed according to the method of *Ticconi et al.* [19] (2001). 0.5 g Fresh Weight (FW) were homogenized in a solution containing propanol, chlorhydric acid, and water (18 : 1 : 81). The resulting homogenates were boiled in a water bath for 3 min and then left in darkness for 24 h at room temperature. 3 mL of the supernatants were centrifuged at 6500 rpm for 40 min. Finally, the absorbencies of the samples were measured at 535 and 650 nm. The absorbance value was calculated and corrected by the following formula:

$$A = A_{535} - A_{650}$$

The phenols of the plant material were extracted with MeOH. Total phenolic content was assayed quantitatively by absorbance at 765 nm with Folin-Ciocalteau reagent according to the method of *Madaan et al.* [20] (2011). Firstly, a standard curve of known concentrations of

Table 1: Plants used in experiment.

No	Plant	Family	Localities	Voucher no
1	*Centaurea derderiifolia* Wagenitz	Asteraceae (Compositae)	B6 Sivas: Divriği entrance, 1120 m, 21.08.2013, 39°22'17"N, 38°05'53"E	A.Duran 9804 & M.Öztürk, Ş.Atiker
2	*Centaurea salicifolia* M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	Asteraceae	A8 Rize: İkizdere, Cimil road, 11. km, 1100 m, 18.08.2013, road side, Forest area	A.Duran 9747 & M.Öztürk, Ş.Atiker
3	*Centaurea nigrofimbria* (K.Koch) Sosn.	Asteraceae	A8 Rize: Cimil, Ortaköy-Başköy between, valey deep, 1950-2000 m, 18.08.2013, rock place, 40°44'00"N, 40°46'38"E	A.Duran 9759 & M.Öztürk, Ş.Atiker
4	*Centaurea stapfiana* (Rand.-Mazz.) Wagenitz	Asteraceae	C8 Mardin: Derik-Mazıdağ road, 2. Km, 922 m, 15.06.2013, Quercus area, 37°22'50"N, 40°17'02"E	A.Duran 9605 & C.Sağlam, Y.Gürbüz
5	*Centaurea lycaonica* Boiss. & Heldr.	Asteraceae	C4 Konya: Konya-Beyşehir between, 1317 m, 31.05.2013, andezit road place, 37°53'11"N, 31°59'44"E	A.Duran 9571 & Ş.Atiker, Y.Gürbüz
6	*Centaurea cariensis* Boiss. subsp. *longipapposa* Wagenitz	Asteraceae	C3 Isparta: Gelendost-Eğridir between, 944 m, 31.05.2013, kalker rock çatlakları, 37°57'13"N, 30°56'41"E	A.Duran 9572 & Ş.Atiker, Y.Gürbüz
7	*Centaurea kizildaghensis* Uzunh., E.Dogan & H.Duman	Asteraceae	C4 Konya: Derebucak, Çamlık, Kızıldağ vericiler road, 1930 m, 23.06.2013, step, *Pinus nigra* açıklığı, 37°20'59"N, 31°40'46"E	A.Duran 9627 & C.Sağlam, B.Tosun
8	*Centaurea* regia Boiss. subsp. *cynarocephala* (Wagenitz) Wagenitz	Asteraceae	C8 Mardin: Derik-Mazıdağ yolu, 2. Km, 922 m, 15.06.2013, quercus place, rock place, 37°22'50"N, 40°17'02" E	A.Duran 9606 & C.Sağlam, Y.Gürbüz
9	*Centaurea helenioides* Boiss.	Asteraceae	A8 Rize: Cimil, Ortaköy-Başköy arası, valey deep, 1950-2000 m, 18.08.2013, rocky place, 40°44'00"N, 40°46'38" E	A.Duran 9760 & M.Öztürk, Ş.Atiker
10	*Centaurea cariensis* Boiss. subsp. *microlepis* (Boiss.) Wagenitz	Asteraceae	C3 Antalya: Elmalı, Çığlıkara forest area, 1868 m, 25.08.2013, road side, 36°31'35"N, 25°51'31"E	A.Duran 9838 & Ö.Çetin, M.Çelik
11	*Centaurea pterocaula* Trautv.	Asteraceae	C4 Konya: Cihanbeyli-Gölyazı, through to the lake from Gölyazı, 9. km, 926 m, 08.07.2013, salty step, 38°32'28"N, 33°20'30"E	A.Duran 9682 & M.Öztürk, Ş.Atiker

gallic acid was prepared to calculate the total phenolic content to be expressed as gallic Acid Equivalent (GAE). 10 mg of gallic acid was dissolved in 100 mL of 50% methanol (100 µg/mL) and then diluted to 12.5, 25, 50 or 100 µg/mL. 0.076 mL aliquot of each dilution was taken in a test tube and diluted to 0.76 mL of distilled water. Then 0.12 mL Folin Ciocalteu's reagent (1 N) was added and allowed to incubate at room temperature for 5 min. 0.32 mL of 20% (w/w) Na_2CO_3 was added in each test tube, adjusted with distilled water up to the mark of 2 mL, vortexed and left to stand for 30 min at room temperature. Absorbance of the standard was measured at 765 nm using UV/Vis spectrophotometer (Schimadzu, Japan) against blank, i.e., distilled water. For measurement of plant samples, appropriately diluted methanolic extracts of 0.76 mL were taken in test tubes and then similar procedure was followed with the standards.

Total flavonoids content was estimated according to *Dewanto et al.* [21] (2002). Methanol extracts were properly diluted with distilled water. 5% $NaNO_2$ solution was added to each test tube; after five minutes, 10% $AlCl_3$ solution was added and then after 6 minutes 1.0 M NaOH was added. Finally total volume was filled up to 5 mL with water and the test tubes were mixed well. Absorbance of the resulting pink-colored solution was measured at 510 nm versus blank. Calibration curve was prepared using Catechol as standard. The flavonoid content was expressed as mg Catechol Equivalents (CE) per g of dry weight (mg CE/g DW).

Statistical analyses

Results of the research were analysed for statistical significance by analysis of variance (*Püskülcü & İkiz*, 1989) [22].

RESULTS AND DISCUSSION

Mineral contents of leaves and seeds of *Centraurea* genus are presented in Table 2. Generally, macro element concentrations (P, K, Ca, Mg and S) of samples were found high. K was established at high level in both leave and seed samples of *Centaurea*. While K contents of leaves changes between 7254.10 mg/kg (*Centaurea lycaonica*) and 26396.36 mg/kg (*Centaurea pterocaula*), it ranged from 6242.22 mg/kg (*Centaurea salicifolia*) to 15182.07 mg/kg (*Centaurea cariensis* Boiss. subsp. *microlepis*). Ca contents of leaves changed between 6268.70 mg/kg (*Centaurea derderiifolia*) and 23471.24 mg/kg (*Centaurea stapfiana*). The same element was found between 1963.45 mg/kg (*Centaurea salicifolia* M.Bieb. ex Willd., subsp. *abreviata*) and 12470.46 mg/kg (*Centaurea stapfiana*). While Mg contents of Centaurea leaves ranged from 845.0 mg/kg (*Centaurea cariensis* Boiss. subsp. *microlepis*) to 4411.54 mg/kg (*Centaurea kizildaghensis*), Mg contents of seeds were found between 817.74 mg/kg (*Centaurea lycaonica*) to 2259.14 mg/kg (*Centaurea cariensis* Boiss. subsp. *longipapposa*). As seen in Table 1, K, Ca, Mg and S contents of leaves were found high compared with results of seed samples.

Microelement and heavy metal contents of *Centura* leave and seeds are given in Table 3. Fe and Na contents of leaves were found high when compared with results of other microelement of leaves. While Fe contents of leaves changes between 55.52 mg/kg (*Centaurea cariensis* Boiss. subsp. *longipapposa*) and 502.47 mg/kg (*Centaurea salicifolia*), Na content ranged from 324.27 mg/kg (*Centaurea cariensis* Boiss. subsp. *microlepis*) to 4938.52 mg/kg (*Centaurea cariensis* Boiss. subsp. *longipapposa*). In addition, Fe and Na contents of seeds changed between 76.34 mg/kg (*Centaurea pterocaula*) to 537.66 mg/kg (*Centaurea stapfiana*) and 332.14 mg/kg (*Centaurea pterocaula*) to 1265.05 mg/kg (*Centaurea lycaonica*), respectively. While Zn contents of leaves determines between 4.28 mg/kg (*Centaurea cariensis* Boiss. subsp. *longipapposa*) to 44.99 mg/kg (*Centaurea kizildaghensis*), the same element in seeds was found between 12.58 mg/kg (*Centaurea* regia) to 32.74 mg/kg (*Centaurea helenioides*).

While Mn contents of leaves change between 12.05 mg/kg (*Centaurea cariensis* Boiss. subsp. *longipapposa*) to 32.64 mg/kg (*Centaurea pterocaula*), Mn contents in seeds ranged from 6.97 mg/kg (*Centaurea pterocaula*) to 39.21 mg/kg (*Centaurea cariensis* Boiss. subsp. *microlepis*). As seen in Table 3, Mn contents of *Centaurea pterocaula* leave was found higher than result of *Centaurea pterocaula* seed. Cu contents of leaves changed between 5.90 mg/kg (*Centaurea cariensis* Boiss. subsp. *microlepis*) and 16.33 mg/kg (*Centaurea derderiifolia*). In seed, Cu content ranged from 6.43 mg/kg (*Centaurea nigrofimbria*) to 14.0 mg/kg (*Centaurea salicifolia*). Cd and Cr contents of leaves were found at low levels. While Ni contents of leaves change between 1.52 mg/kg (*Centaurea pterocaula*) to 18.60 mg/kg (*Centaurea nigrofimbria*), the same element in seeds ranged from 1.05 mg/kg (*Centaurea pterocaula*) to 10.59 mg/kg (*Centaurea* regia). Generally, microelement and heavy metal contents of leaves were determined at partly high level. These differences may be probably due to contamination of leave with environment factors.

The ash, anthocyanin, total phenolic and total flavonoid contents of leave and seeds of *Centaurea* genus are presented in Table 4. While ash contents of Centaurea leaves change between 0.14% (*Centaurea nigrofimbria*) and 1.74% (*Centaurea derderiifolia*), this parameter ranged from 0.23% (*Centaurea cariensis* Boiss. subsp. *microlepis*) to 7.40% (*Centaurea nigrofimbria*) in seeds. Ash content of *Centaurea salicifolia* was found very close to result of *Centaurea nigrofimbria*. Generally, ash contents of seeds (except *Centaurea stapfiana*, *Centaurea lycaonica*, *Centaurea helenioides*, *Centaurea cariensis* Boiss. subsp. *microlepis*) were found higher than those of results of leaves. But ash contents of *Centaurea stapfiana*, *Centaurea lycaonica*, *Centaurea helenioides* and *Centaurea cariensis* Boiss. subsp. *microlepis* were found very close to results of the same plant leaves. Anthocyanin contents of leaves ranged from 16.3 µmol/g (*Centaurea kizildaghensis*) to 109.3 µmol/g (*Centaurea nigrofimbria*). In seeds, anthocyanin contents were found between 24.1 µmol/g (*Centaurea derderiifolia*) to 508.4 µmol/g (*Centaurea salicifolia*). Anthocyanin content of *Centaurea helenioides* (492.8 Mmol/g) was found very close to result of *Centaurea salicifolia*. While total phenolic contents of leaves change between 693.5 mg

Table 2: Macro element contents of leave and seeds of Centaurea species (mg/kg).

Samples					
Leaves	P	K	Ca	Mg	S
Centaurea derderiifolia Wagenitz	751.00±132.56*	9424.48 ± 1036.80	6268.70 ± 1659.26	2336.83 ± 483.51	1536.27 ± 262.77
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	935.33 ± 65.06	5967.66 ±1075.86	9075.36 ± 1008.63	1458.66 ± 518.02	886.57 ± 138.24
Centaurea nigrofimbria (K.Koch) Sosn.	609.65 ± 382.05	11146.53 ± 1711.83	6558.57 ± 1119.94	1305.76 ± 276.70	874.00 ± 194.64
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	204.05 ± 18.95	16466.81 ± 1771.88	23471.24 ± 4655.68	2846.83 ± 296.81	1852.22 ± 159.56
Centaurea lycaonica Boiss. & Heldr.	842.42 ± 81.83	7254.10 ± 231.82	9098.64 ± 1094.89	2267.55 ± 216.59	1025.66 ± 66.15
Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	869.33 ± 119.78	7917.85 ± 161.23	7162.68 ± 418.37	3106.55 ± 256.62	2270.60 ± 102.67
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	356.74 ± 25.84	15812.79 ± 3715.47	6678.68 ± 924.14	4411.54 ± 494.04	1727.86 ± 344.98
Centaurea regia Boiss. subsp. *cynarocephala* (Wagenitz) Wagenitz	126.58 ± 23.21	19686.33 ± 1415.17	11487.82 ± 2068.86	1586.03 ± 327.64	983.31 ± 192.78
Centaurea helenioides Boiss.	651.57 ± 76.82	12426.30± 1063.55	11252.87 ± 475.51	1786.44 ± 27.50	1489.66 ± 56.55
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	250.88 ± 37.05	12764.25 ± 1866.03	6418.05 ± 915.10	845.00 ± 114.16	969.20 ± 168.44
Centaurea pterocaula Trautv.	523.19 ± 73.35	26396.36 ± 2631.80	14277.35 ± 1974.61	1923.44 ± 278.99	879.17 ± 96.72
Seeds	P	K	Ca	Mg	S
Centaurea derderiifolia Wagenitz	1272.01 ± 180.00	9703.22 ± 1259.81	6521.26 ± 946.74	2008.37 ± 256.76	1305.55 ± 145.51
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	3312.54 ± 1362.58	6242.22 ± 1804.21	1963.45 ± 452.90	1927.36 ± 535.98	1979.46 ± 556.98
Centaurea nigrofimbria (K.Koch) Sosn.	612.86 ± 170.80	10797.75 ± 816.78	4593.20 ± 358.66	1738.75 ± 89.15	1061.18 ± 41.07
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	142.32 ± 29.24	8720.98 ± 532.61	12470.46 ± 387.10	1315.99 ± 53.25	1082.47 ± 49.86
Centaurea lycaonica Boiss. & Heldr.	1783.55 ± 131.00	9128.28 ± 1035.01	5514.81 ± 783.67	1724.27 ± 154.85	1473.61 ± 187.20
Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	1374.04 ± 201.08	10892.14 ± 427.11	6600.08 ± 195.06	2259.14 ± 47.53	1608.00 ± 53.58
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	684.99 ± 66.14	8302.64 ± 1109.08	7021.65 ± 498.94	1340.43 ± 104.59	1252.57 ± 150.57
Centaurea regia Boiss.subsp. *cynarocephala* (Wagenitz) Wagenitz	983.73 ± 239.60	9452.07 ± 1237.73	4185.99 ± 618.85	817.74 ± 43.44	889.09 ± 106.63
Centaurea helenioides Boiss.	2017.79 ± 863.81	8198.35 ± 772.60	3462.91 ± 230.83	1836.61 ± 451.56	1347.35 ± 517.81
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	2088.34 ± 173.42	15182.07 ± 797.05	6021.35 ± 415.03	1662.58 ± 48.88	1619.21 ± 22.72
Centaurea pterocaula Trautv.	442.78 ± 94.53	7618.54 ± 1285.48	5275.59 ± 543.56	1215.67 ± 96.74	838.14 ± 103.91

Table 3: Micro element and heavy metal contents of leave and seeds of Centaurea species (mg/kg).

Samples										
Leaves	Fe	Zn	Mn	B	Cu	Mo	Na	Cd	Cr	Ni
Centaurea derderiifolia Wagenitz	165.28 ± 25.85	28.88 ± 9.59	22.16 ± 2.85	19.08 ± 1.53	16.33 ± 2.00	1.13 ± 0.32	915.46 ± 168.04	0.16 ± 0.07	0.46 ± 0.60	10.15 ± 1.11
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	502.47 ± 63.19	9.93 ± 2.93	21.28 ± 3.35	20.94 ± 5.78	9.28 ± 0.80	0.70± 0.17	666.87 ± 42.84	0.16 ± 0.04	1.47 ± 1.36	5.75 ± 1.17
Centaurea nigrofimbria (K.Koch) Sosn.	115.53 ± 33.23	9.58 ± 1.42	19.40 ± 5.69	26.29 ± 5.65	8.29 ± 0.76	0.26 ± 0.08	634.47 ± 145.97	0.11 ± 0.02	0.42 ± 0.65	18.60 ± 3.52
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	198.33 ± 3.27	19.55 ± 6.63	12.49 ± 2.46	23.30 ± 8.94	8.59 ± 0.99	0.99 ± 0.17	954.00 ± 96.30	0.14 ± 0.04	0.25 ± 0.04	6.77 ± 2.53
Centaurea lycaonica Boiss. & Heldr.	173.41 ± 27.17	14.06 ± 1.82	10.84 ± 0.85	27.10 ± 5.45	10.00 ± 0.86	0.14 ± 0.02	586.13 ± 100.67	0.13 ± 0.02	0.27 ± 0.07	4.28 ± 0.99
Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	55.52 ± 7.77	4.28 ± 0.29	12.05 ± 0.20	42.79 ± 2.99	6.39 ± 1.34	0.49 ± 0.12	4938.52 ± 322.15	0.08 ± 0.06	0.00 ± 0.001	2.96 ± 0.24
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	85.64 ± 8.93	44.99 ± 4.41	19.20 ± 2.33	28.07 ± 4.91	6.73 ± 2.24	0.23 ± 0.12	410.13 ± 77.64	0.16 ± 0.08	0.07 ± 0.07	3.52 ± 0.13
Centaurea regia Boiss. subsp. *cynarocephala* (Wagenitz) Wagenitz	315.14 ± 85.45	13.49 ± 2.16	27.07 ± 7.29	28.98 ± 2.70	10.73 ± 0.91	1.43 ± 0.42	893.27 ± 115.23	0.31 ± 0.14	0.26 ± 0.09	17.00 ± 2.89
Centaurea helenioides Boiss.	184.89 ± 32.48	11.71 ± 0.77	18.02 ± 0.92	22.75 ± 6.41	9.88 ± 0.60	0.46 ± 0.21	550.65 ± 114.32	0.16 ± 0.03	0.30 ± 0.06	3.31 ± 0.52
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	119.69 ± 18.79	8.96 ± 1.03	19.09 ± 2.88	21.34 ± 5.11	5.90 ±0.85	0.15 ± 0.05	324.27 ± 59.01	0.10 ± 0.03	0.18 ± 0.01	1.52 ± 0.10
Centaurea pterocaula Trautv.	286.90 ± 25.84	8.59 ± 0.58	32.64 ± 4.34	23.23 ± 2.10	9.65 ± 0.51	2.59 ± 0.49	359.77 ± 53.05	0.21 ±0.07	0.77 ± 0.15	2.61 ± 1.19
Seeds	Fe	Zn	Mn	B	Cu	Mo	Na	Cd	Cr	Ni
Centaurea derderiifolia Wagenitz	77.96 ± 15.00	15.87 ± 2.01	8.99 ± 1.47	23.83 ± 4.42	10.94 ± 1.31	0.53 ± 0.08	341.24 ± 51.95	0.17 ± 0.00	0.04 ± 0.04	2.50 ± 0.36
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	102.75 ± 12.81	15.66 ± 0.55	11.20 ± 2.92	13.07 ± 1.10	14.00 ± 3.15	3.25 ± 1.17	455.20 ± 136.35	0.11 ± 0.01	0.06 ± 0.06	1.46 ± 0.63
Centaurea nigrofimbria (K.Koch) Sosn.	77.33 ± 3.76	20.74 ± 3.48	12.68 ± 1.92	15.99 ± 4.01	6.43 ± 1.23	0.21 ± 0.07	506.62 ± 180.10	0.27 ± 0.27	0.17 ± 0.15	5.55 ± 1.00
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	537.66 ± 122.00	13.29 ± 0.68	25.53 ± 0.56	30.45 ± 7.23	7.62 ± 0.91	0.80 ± 0.19	545.54 ± 118.10	0.21 ± 0.03	1.13 ± 0.12	3.43 ± 0.83
Centaurea lycaonica Boiss. & Heldr.	103.93 ± 23.50	23.23 ± 1.31	12.84 ± 1.61	15.12 ± 4.64	13.09 ± 1.36	0.56 ± 0.22	1265.05 ± 145.34	0.15 ± 0.01	0.12 ± 0.18	4.17 ± 0.97

Table 3: Micro element and heavy metal contents of leave and seeds of Centaurea species (mg/kg). (Continued)

Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	145.40 ± 23.98	22.16 ± 1.42	18.06 ± 0.90	21.00 ± 8.13	12.98 ± 0.40	0.80 ± 0.24	509.72 ± 35.38	0.17 ± 0.01	0.34 ± 0.45	2.15 ± 0.47
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	124.27 ± 39.08	14.18 ± 1.05	14.24 ± 1.49	15.66 ± 2.37	8.99 ± 0.76	0.31 ± 0.05	403.70 ± 46.17	0.11 ± 0.01	0.12 ± 0.06	1.77 ± 0.72
Centaurea regia Boiss.subsp. *cynarocephala* (Wagenitz) Wagenitz	85.56 ± 20.55	12.58 ± 1.75	11.89 ± 1.26	18.24 ± 2.17	10.60 ± 2.28	0.30 ± 0.16	395.42 ± 133.70	0.11 ± 0.11	0.19 ± 0.06	10.59 ± 2.10
Centaurea helenioides Boiss.	81.99 ± 43.86	32.74 ± 6.23	9.47 ± 2.70	12.22 ± 1.55	10.47 ± 3.06	0.51 ± 0.24	388.18 ± 43.04	0.13 ± 0.06	16.17 ± 1.26	5.44 ± 1.03
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	99.64 ± 10.99	29.93 ± 3.80	39.21 ± 2.04	31.51 ± 2.17	11.29 ± 0.81	0.47 ± 0.19	702.87 ± 133.15	0.19 ± 0.03	0.09 ± 0.01	2.32 ± 0.77
Centaurea pterocaula Trautv.	76.34 ± 5.26	12.90 ± 3.13	6.97 ± 0.57	10.48 ± 1.05	8.83 ± 0.76	0.25 ± 0.11	332.14 ± 74.02	0.18 ± 0.07	0.22 ± 0.24	1.05 ± 0.47

gallic acid/g extract and 826.3 mg gallic acid/g extract, total phenolic content of seeds ranged from 655.1 mg gallic acid/g extract (*Centaurea derderiifolia*) to 1342.0 mg gallic acid/g extract (*Centaurea cariensis* Boiss. subsp. *longipapposa*). Generally, total phenolic contents of seeds were found hig (except *Centaurea derderiifolia*, *Centaurea salicifolia*, *Centaurea cariensis* Boiss. subsp. *microlepis*). Total phenolic contents of *Centaurea cariensis* Boiss. subsp. *longipapposa*, *Centaurea kizildaghensis*, *Centaurea* regia and *Centaurea derderiifolia* (1342.0, 1173.1, 1285.9, 1179.8 and 1230.1 mg gallic acid/g extract, respectively). A seen in Table 4, total phenolic contents of leaves were found partly similar. Total flavonoid contents of *Centaurea* leaves changed between 49.2 mg catechol/g (*Centaurea nigrofimbria*) to 157.5 mg catechol/g (*Centaurea pterocaula*). In addition, total flavonoid content of seeds ranged from 43.3 mg catechol/g (*Centaurea helenioides*) to 205.8 mg costechol/ g (*Centaurea cariensis* Boiss. subsp. *longipapposa*). Generally, total flavonoid contents of seeds were found higher compared with results of leaves (except *Centaurea salicifolia*, *Centaurea helenioides* and *Centaurea pterocaula*). These differences are probably due to plant part and structure, genetic, growing conditions, climatic factors, species differences and analytic conditions. *Er et al.* [23] (2013) reported that while the highest total phenol was established in *Salvia tomentosa* Mil. (13.316 mg GAE/100 mL), the lowest level was found in Salvia halophila Hedge 16.168 mg GAE/100 mL). *Miliauskas et al.* [24] (2004) have determined the total phenolic substance amount of methanol extracts in *S. pratensis* samples as 22.6, 24.0, 17.1 and 9.7 mg GAE/g extract. The total contents of phenolic substances ranged from 2.53 to 5.11 g of gallic acid/kg of fresh mass of same plant species [25] (*Rop et al*. 2012). *Rop et al.* [25] (2012) reported that *Centaurea cyanus* contained 4.76 g gallic acid/kg total phenolic and 1.81 g Rutin/kg (fw) total flavonoid. *Bimova & Pokluda* [26] (2009) determined 2.36-2.95 gallic acid/kg in cabbage. In another study, *Ibrahim et al.* [27] (2010) reported that fresh cucumber contained 0.56 g gallic acid/kg.

Ash contents of Centaurea maculosa ranged from 5.2% to 9.3% [11] (*Kelsey & Mihalovich*, 1987). *Kelsey & Mihalovich* [11] (1987) reported that aerial parts of *Centaurea maculosa* contained 0.84-1.13% Ca, 0.14-0.18% Mg, 0.17-0.21% P, 1.88-2.18 K, 92-165 ppm Al, 28-29.7 ppm B, 7.0-8.3 ppm Cu, 121.5-183.4 ppm Fe, 19.1-48.9 ppm Mn, 0.4-1.2 ppm Mo, 318-457 ppm Si, 17-25 ppm Na, 4.0-7.8 ppm Ti and 13.5-15.9 ppm Zn. Rop et al.[25] (2012) determined 534.48 mg/kg P, 3568.77 mg/kg K, 246.18 mg/kg Ca, 138.49 mg/kg Mg, 74.28 mg/kg Na, 6.89 mg/kg Fe, 2.29 mg/kg Mn, 0.89 mg/kg Cu, 7.59 mg/kg Zn and 0.49 mg/kg Mo in edible flowers of *Centaurea cyanus*. Especially, in today, consumers more take attention to the quality of food stuffs and to contents of individual compounds and food compoments. So, minerals and bioactive properties of plants have been discussed for a long time.

Table 4: Anthocyanin, total phenolic and total flavonoid contents of leave and seeds of Centaurea species.

Leaves	Ash (%)	Anthocyanin (μmol/g)	Total phenol (5 mg gallic acid/g extract)	Total flavonoid (mg catechol/g)
Centaurea derderiifolia Wagenitz	1.74 ± 1.08	41.1 ± 10.3	783.7 ± 37.8	97.1 ± 6.9
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	0.63 ± 0.01	18.5 ± 0.8	780.1 ± 38.0	65.6 ± 1.3
Centaurea nigrofimbria (K.Koch) Sosn.	0.14 ± 0.03	109.3 ± 4.6	693.5 ± 15.3	49.2 ± 2.5
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	0.42 ± 0.07	32.5 ± 2.9	734.6 ± 8.1	72.8 ± 0.3
Centaurea lycaonica Boiss. & Heldr.	0.82 ± 0.22	101.5 ± 17.2	697.2 ± 1.1	81.8 ± 7.3
Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	0.43 ± 0.14	32.4 ± 2.9	763.7 ± 11.2	53.2 ± 0.5
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	0.64 ± 0.07	16.3 ± 2.1	734.6 ± 8.1	71.4 ± 3.4
Centaurea regia Boiss. subsp. *cynarocephala* (Wagenitz) Wagenitz	0.85 ± 0.06	23.2 ± 4.0	812.7 ± 19.4	60.7 ± 5.3
Centaurea helenioides Boiss.	0.62 ± 0.09	67.2 ± 4.6	792.7 ± 30.4	92.1 ± 3.3
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	0.67 ± 0.20	27.3 ± 2.3	826.3 ± 24.4	59.9 ± 4.4
Centaurea pterocaula Trautv.	0.72 ± 0.20	75.5 ± 4.4	720.4 ± 14.0	157.5 ± 5.3
Seeds	Ash (%)	Anthocyanin (μmol/g)	Total phenol (5 mg gallic acid/g extract)	Total flavonoid (mg catechol/g)
Centaurea derderiifolia Wagenitz	1.88 ± 0.79	24.1 ± 0.4	655.1 ± 51.7	114.3 ± 14.1
Centaurea salicifolia M.Bieb. ex Willd., subsp. *abreviata* K.Koch,	5.17 ± 3.60	508.4 ± 50.2	740.4 ± 24.9	50.9 ± 0.4
Centaurea nigrofimbria (K.Koch) Sosn.	7.40 ± 5.42	47.5 ± 5.3	743.7 ± 2.6	110.0 ± 8.0
Centaurea stapfiana (Rand.-Mazz.) Wagenitz	0.37 ±0.17	62.5 ± 2.6	763.7 ± 11.2	72.8 ± 4.0
Centaurea lycaonica Boiss. & Heldr.	0.70 ± 0.19	178.2 ± 14.9	743.7 ± 2.6	91.4 ± 7.9
Centaurea cariensis Boiss. subsp. *longipapposa* Wagenitz	0.46 ± 0.15	205.5 ± 12.0	1342.0 ± 4.7	205.8 ± 2.0
Centaurea kizildaghensis Uzunh., E.Dogan & H.Duman	1.00 ± 1.02	95.7 ± 7.3	1173.1 ± 82.3	86.7 ± 2.2
Centaurea regia Boiss. subsp. *cynarocephala* (Wagenitz) Wagenitz	1.11 ±0.60	51.8 ± 5.9	1285.9 ± 19.3	101.5 ± 7.5
Centaurea helenioides Boiss.	0.54 ± 0.11	492.8 ± 29.9	1179.8 ± 11.1	43.3 ± 2.4
Centaurea cariensis Boiss. subsp. *microlepis* (Boiss.) Wagenitz	0.23 ± 0.13	59.0 ± 11.5	763.7 ± 11.2	75.2 ± 6.5
Centaurea pterocaula Trautv.	0.88 ± 0.63	153.0 ± 15.2	1230.1 ± 28.9	64.8 ± 2.7

The most of researchers emphasize their nutritional qualities and technological properties of horticulture and edible wild crops. The content of mineral elements and bioactive properties are a few of the most essential aspect that influence the use of edible flowers in human nutrition.

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