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Mineral content of some herbs and herbal teas by infusion and decoction

Mehmet Musa Özcan [a,*], Ahmet Ünver [a], Tolga Uçar [b], Derya Arslan [a]

[a] Selcuk University, Faculty of Agriculture, Department of Food Engineering, Campus, Konya, Turkey
[b] Food Engineer, İzmir, Turkey

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Abstract

Sage (*Salvia fruticosa* L.), anise (*Pimpinella anisum* L.), Hawthorn (*Crataegus orientalis*), rosemary (*Rosmarinus officinalis* L.), mountain tea (*Sideritis* spp), basil (*Ocimum basilicum* L.), lime flower (*Tilia cordata*), nettle (*Urtica dioica* L.), thyme (*Thymbra spicata*), coriander (*Coriandrum sativum* L.), rosehip (*Rosa canina* L.), mentha (*Mentha piperita* L.), balm (*Melissa officinalis* L.), tea (*Camelia sinensis* L.) (Black and green), sena leaf (*Casia angustifolia*), camomile (*Matricaria chamomilla*), tarragon (*Artemisia dracunculus* L.), cinnamon (*Cinnamomum casia*) and fennel (*Foeniculum vulgare* L.) were used as plant material in this study. Decoction was applied to *R. canina*, *A. dracunculus* and *C. casia*, and infusion was applied to other plant materials. Ten, 15 and 20 min were used as a time parameter for both infusion and decoction. Inductive coupled plasma atomic emission spectrometry (ICP-AES) has been used for the determination of the elements in all infusions, decoctions and plant material.

The Fe (1295.65 ppm) and Mg (3178.74 ppm) of *M. officinalis*, P (12698.05 ppm) and Pb (3.85 ppm) of green tea, Ca (19685.70 ppm) of *C. orientalis*, K (29167.53 ppm), Cu (12.18 ppm) and Na (2563.86 ppm) of *C. casia*, Zn (26.00 ppm) of *M. chamomille* and Se (23.53 ppm) contents of *C. sativum* were higher than the other plant materials.

Ca (28.621 mg/100 ml) was the highest in concentration in the infusion of *C. angustifolia* for 10, 15 and 20 min. Ca could not be found in black and green teas. K (231.390 mg/100 ml) and P (24.857 mg/100 ml) contents were the highest in *A. dracunculus* tea. Mg (16.230 mg/100 ml) content of *O. basilicum* was determined as the highest.

In general, the minerals that difuse to the tea at higher concentrations at the 10th minute were Ag, B, Cu, Co, Fe, ln and Zn, at the 15th minute were Ag, B, Cu, Co, K, ln and Zn and at the 20th minute were Ag, B, Cu, Co, ln, Fe and K. As a result, 10 min was the optimum time for getting the minerals into the tea, and it is apparent that plants and teas are good sources of the minerals.

Keywords: Herbal tea; ICP-AES; Mineral; Infusion; Decoction

1. Introduction

It is estimated that there are 300 thousand plants species which have seeds. WHO reported that 20 thousand of these are used for medical purposes. Five hundred of these are cultivated and remaining are wild in nature (Usal & Özdeş, 2001).

By the development of technology and increase in the importance of time, people have started to consume more processed foods. As a result health problems have increased.

Başgel and Erdemoğlu (2005) reported the daily mineral intake by consuming herbal teas for a 70 kg person and the reported amounts of minerals per day are 500 mg Ca, 300 mg Mg, 15 mg Fe, 5 mg Al, 2.8 mg Mn, 15 mg Zn, 2.5 mg Cu, 1.6 mg Sr, 1.1 mg Ba, 0.025 mg Ni, 0.05–0,2 mg Cr, 0.04 mg Co, 0.415 mg Pb and 0.057 mg Cd.

Ca is the main component of bone and teeth, and its function, in cell membranes, in muscles, by regulation of endo- and exoenzymes and by regulation of blood pressure, has great importance (Kılıç & Köse, 2001).

* Corresponding author. Tel.: +90 332 241 0041; fax: +90 332 2410 108.
E-mail address: mozcan@selcuk.edu.tr (M. Musa Özcan).

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Na and K are of great importance for many regulation systems in the body. Na is excreted in sweat by the body. Diarrhoea and vomiting causes the loss of Na and K. Tea, fruits, vegetables and coffee are good sources of K and Na. The minimum daily intake of Na and K are 2.4 g and 3.5 g (Baysal, 2002).

Twenty-five elements (Al, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Ln, K, Li, Mg, Mn, Na, Ni, P, Pb, S, Sr, Ti, V, and Zn) were detected in both *S. aucheri* and its infusions. The ranges of mineral levels varied from Cd (1.6668 mg/kg) to K (13,570 mg/kg) and Ni (0.05273 mg/kg) to K (196.25 mg/kg) in herbs and their infusions, respectively (Özcan, 2004a).

The aim of this study is to establish the mineral content of some spices and to determine the optimum infusion or the decoction time for the diffusion of minerals to water.

2. Materials and methods

2.1. Material

Salvia fruticosa L., *Pimpinella anisum* L., *Crataegus orientalis*, *Rosmarinus officinalis* L., *Sideritis* spp, *Ocimum basilicum* L., *Tilia cordata*, *Urtica dioica* L., *Thymbra spicata*, *Coriandrum sativum* L., *Rosa canina* L., *Mentha piperita* L., *Melissa officinalis* L., *Camelia sinensis* L. (Black), *Casia angustifolia*, *Matricaria chamomilla*, *Artemisia dracunculus* L., *Cinnamomum casia*, *Camelia sinensis L.* (Green) and *Foeniculum vulgare* L. were provided by local bazaar. Plants were identified and authenticated by Dr. Yavuz Bağcı, a plant taxonomist. The plants were stored in a dry, dark and cool room.

2.2. Method

Approximately 0.5 g of the dried and ground fruit was put into a burning cup, and 15 mL of pure HNO_3 was added. The samples were incinerated in a MARS 5 microwave oven (Manufactured by, CEM corporation, USA) at a temperature of 200 °C, and the solution was diluted to 100 ml with water. Concentrations were determined with an Inductively Coupled Plasma Atomic Emission Spectrometer. While, decoction was applied to *R. canina*, *C. casia* and *A. dracunculus* and infusion to other plants.

2.2.1. Infusion

Dried aerial parts of the plant (2 g) were added in 98 mL distilled water and heated in a steel kettle, and were allowed to stay for a known interval (5, 10 and 15 min) after boiling. This was filtered with an ashless filter paper. The filtrate (25 mL) was diluted with 25 mL of distilled water.

2.2.2. Decoction

Decoction was applied to *R. canina*, *C. casia* and *A. dracunculus*. Dried aerial parts of the plant (2 g) were added to 98 mL distilled water in a steel ketle after boiling, and was allowed to stay for a known interval (5, 10 and 15 min). It was filtered with an ashless filter paper. The filtrate (25 mL) was diluted with 25 mL of distilled water.

Infusion and decoction waters were directly injected into ICP-AES instrument from Varian-Vista (Varian International, Zug, Switzerland). The instrument was operated with a radiofrequency power of 0.7–1.5 kW (1.2–1.3 kW for axial); plasma gas flow rate (Ar) of 10.5–15 L/min(radial), 15 L/min (axial); auxillary gas flow rate (Ar) of 1.5 L/min; viewing height of 5–12 mm; copy and reading time of 1–5 s (maximum of 60 s); and copy time of 3 s (maximum of 100 s) (Skujins, 1998).

2.3. Statistical analysis

Data were subjected to analysis of variance with mean separation by Duncan's multiple range test. Differences were considered statistically significant at the $P \leqslant 0.05$ level. Statistical analysis was performed using SPSS 10.0 for Windows. The statistical results were evaluated according to Düzgüneş, Kesici, Kavuncu, and Gürbüz (1987).

3. Results

3.1. Mineral contents of the herbs

The mineral contents of the dried herbs are listed in Table 1. Al content was high in *M. officinalis* (1694.60 ppm) and Ca content was high in *C. orientalis* (19685.70 ppm) and *C. angustifolia* (17592.00 ppm). While, Fe in *M. officinalis* (1295.65 ppm) was high, it was very low in green tea (2.94 ppm) and *C. sativum* (6.60 ppm). Cu content of *C. casia* (12.18 ppm) was high, but Cu content of *R. officinalis* (0.04 ppm) was very low. K content was very low in *T. spicata* (1200.99 ppm), *R. canina* (5316.84 ppm) and *C. angustifolia* (6728.64 ppm), but was very high in *M. chamomilla* (27497.81 ppm), *C. casia* (29167.53 ppm) and green tea (28890.93 ppm). Na in *C. sativum* (22.84 ppm), green tea (28.51 ppm), *R. officinalis* (43.82 ppm) and black tea (49.96) was very low with respect to *M. chamomilla* (2503.27 ppm) and *C. casia* (2563.86 ppm). *C. casia* (11733.96 ppm), *F. vulgare* (10145.48 ppm) and green tea (12698.05 ppm) was rich in P, but was poor in *R. canina* (856.22 ppm). The P contents of other herbs were generally lower than 5717.98 ppm. Li contents of *M. officinalis* (3.41 ppm) and *C. angustifolia* (3.41 ppm) were high, but the Li contents of the other herbs were lower than 1.68 ppm. The Zn contents of *T. spicata* (3.54 ppm) and *U. dioica* (3.32 ppm) were low, but high in *M. chamomilla* (26.00 ppm) and *M. officinalis* (21.74 ppm). Mn content of *A. dracunculus* (125.74 ppm) was high, while low in *C. sativum* (0.40 ppm). Mg content ranged between 58.36 and 3178.74 ppm. Cd (0.45 pm), Tl (10.95 ppm) and Ag (0.63 ppm) contents of *A. dracunculus* were very high. The Co (0.72 ppm) and In (1.96 ppm) contents of *F. vulgare* were high. *P. anisum* had the highest values of As (19.36 ppm) and Bi (0.28 ppm) among the other herbs. While B in *S. fruticosa* (46.73 ppm) and *C. sativum*

Table 1
Mineral content of the plants (ppm)[A]

Plants	n	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co
S. fruticosa	3	0.00 ± 0.00e[B]	547.8 ± 162.8b	2.7 ± 2.68bc	46.7 ± 4.67a	7.98 ± 2.13ef	0.00 ± 0.00b	7159.8 ± 2148.61bcd	0.41 ± 0.10a	0.28 ± 0.21bcde
P. anisum	3	0.01 ± 0.0002e	419.3 ± 152.3bcd	19.4 ± 6.15a	28.7 ± 2.34b	18.94 ± 5.39cd	0.28 ± 0.15a	2478.7 ± 946.78bcd	0.02 ± 0.02c	0.12 ± 0.03bcde
C. orientalis	3	0.17 ± 0.17cd	313.9 ± 20.6bcde	1.7 ± 0.783bc	27.6 ± 1.27b	56.05 ± 3.72a	0.00 ± 0.00b	19685.7 ± 429.04a	0.09 ± 0.07bc	0.14 ± 0.04bcde
R. officinalis	3	0.11 ± 0.11de	31.1 ± 16.1f	0.00 ± 0.00c	7.5 ± 3.45ef	1.75 ± 0.84f	0.23 ± 0.17a	224.1 ± 221.91d	0.05 ± 0.053bc	0.37 ± 0.20b
Sideritis spp.	3	0.00 ± 0.00e	81.5 ± 18.41ef	0.00 ± 0.00c	13.4 ± 1.15de	7.07 ± 1.71ef	0.00 ± 0.0b	4506.5 ± 1229.06bcd	0.07 ± 0.07bc	0.34 ± 0.13b
O. basilicum	3	0.01 ± 0.003e	38.3 ± 21.83ef	5.3 ± 5.19bc	0.64 ± 0.63f	1.23 ± 0.68f	0.19 ± 0.01ab	574.7 ± 569.13cd	0.08 ± 0.08bc	0.12 ± 0.06bcde
T. cordata	3	0.02 ± 0.02e	3.2 ± 0.086f	0.00 ± 0.00c	31.8 ± 5.35ab	0.49 ± 0.14f	0.00 ± 0.00b	3001.2 ± 412.43bcd	0.00 ± 0.00c	0.22 ± 0.08bcde
U. dioica	3	0.04 ± 0.01e	136.6 ± 62.58ef	3.5 ± 3.45bc	6.7 ± 5.61ef	9.33 ± 4.22ef	0.27 ± 0.065a	8654.2 ± 4213.07bc	0.14 ± 0.06bc	0.19 ± 0.05bcde
T. spicata	3	0.05 ± 0.01de	108.7 ± 45,99ef	7.6 ± 7.50b	1.03 ± 1.03f	4.78 ± 2.0ef	0.00 ± 0.0b	1925.7 ± 1250.99cd	0.05 ± 0.01bc	0.05 ± 0.04cde
C. sativum	3	0.00 ± 0.00e	6.5 ± 3.7f	1.6 ± 0.46bc	41.8 ± 3.24a	0.14 ± 0.07f	0.11 ± 0.11ab	6420.1 ± 2024.56bcd	0.04 ± 0.04c	0.24 ± 0.07bcde
R. canina	3	0.03 ± 0.01e	13.7 ± 11,24f	0.2 ± 0.18c	2.9 ± 2.96f	0.34 ± 0.28f	0.00 ± 0.0b	3479.3 ± 3445.40bcd	0.00 ± 0.00c	0.32 ± 0.32bc
M. piperita.	3	0.07 ± 0.01de	536.1 ± 114.14b	0.00 ± 0.00c	9.8 ± 1.93def	21.42 ± 1.59bcd	0.00 ± 0.0b	4200.0 ± 1435.87bcd	0.02 ± 0.02c	0.20 ± 0.003bcde
M. officinalis	3	0.06 ± 0.06de	1694.6 ± 555.29a	0.00 ± 0.00c	14.2 ± 3.19de	25.23 ± 3.26bc	0.19 ± 0.07ab	10155.5 ± 1855.76b	0.13 ± 0.12bc	0.31 ± 0.31bcd
C. sinensis (Black tea)	3	0.00 ± 0.00e	106.5 ± 42.94ef	5.1 ± 5.08bc	14.1 ± 1.90cd	2.04 ± 0.82f	0.19 ± 0.086ab	0.00 ± 0.00d	0.01 ± 0.01c	0.03 ± 0.03de
C. angustifolia	3	0.37 ± 0.09b	22771 ± 160.78def	5.4 ± 5.360bc	17.9 ± 17.23cd	28.63 ± 19.67b	0.00 ± 0.00b	17592.0 ± 16575.51a	0.05 ± 0.05bc	0.34 ± 0.13b
M. chamomilla	3	0.27 ± 0.06bc	266.8 ± 72.98cdef	16.4 ± 1.07a	23.6 ± 8.74bc	5.49 ± 1.42ef	0.17 ± 0.07ab	8186.5 ± 2830.86bcd	0.19 ± 0.01b	0.24 ± 0.08bcde
A. dracunculus	3	0.63 ± 0.11a	40.3 ± 20.80ef	2.6 ± 2.12bc	7.2 ± 1.70 ef	1.77 ± 0.78f	0.00 ± 0.00b	8163.4 ± 3704.27bcd	0.45 ± 0.17a	0.21 ± 0.14bcde
C. casia	3	0.33 ± 0.18b	515,9 ± 19.05bc	2.0 ± 1.76bc	6.8 ± 6.12ef	13.25 ± 0.24de	0.00 ± 0.00b	1211.7 ± 73.68cd	0.06 ± 0.06bc	0.27 ± 0.17bcde
C. sinensis (Green tea)	3	0.045 ± 0.01de	22.9 ± 7.9f	1.9 ± 1.97bc	24.6 ± 2.13bc	0.88 ± 0.31f	0.00 ± 0.0b	0.00 ± 0.00d	0.14 ± 0.14bc	0.29 ± 0.22bcde
F. vulgare	3	0.02 ± 0.01e	48.8 ± 25.5ef	5.2 ± 5.12bc	2.9 ± 2.57f	2.17 ± 1.10f	0.00 ± 0.00b	5118.2 ± 3102.90bcd	0.11 ± 0.10bc	0.72 ± 0.10a

Plants	n	Cr	Cu	Fe	Ga	In	K	Li	Mg
S. fruticosa	3	2.77 ± 0.17defgh	2.83 ± 0.90cd	352.2 ± 95.24bc	0.48 ± 0.48c	0.00 ± 0.00c	10967.3 ± 1948.60cd	1.68 ± 0.09b	2391.0 ± 417.77b
P. anisum	3	3.39 ± 1.36def[B]	3.27 ± 0.75cd	320.4 ± 122.37bcde	0.79 ± 0.79bc	0.44 ± 0.23bc	4411.9 ± 1948.60def	1.52 ± 0.08b	949.6 ± 224.75def
C. orientalis	3	5.24 ± 0.49bcd	3.66 ± 0.11c	213.6 ± 24.27bcdef	0.00 ± 0.00c	0.38 ± 0.37bc	10837.5 ± 770.83cd	1.51 ± 0.08b	2167,91 ± 113.32b
R. officinalis	3	0.31 ± 0.31gh	0.04 ± 0.041f	20.5 ± 12.59f	0.63 ± 0.63c	0.47 ± 0.46bc	11200.2 ± 547.35cd	1.15 ± 0.03b	230.0 ± 114.23fg
Sideritis spp.	3	7.79 ± 4.13b	1.63 ± 0.54def	55.7 ± 12.415ef	0.00 ± 0.00c	0.00 ± 0.00b	7116.7 ± 2592.76def	1.21 ± 0.03b	755.5 ± 148.42defg
O. basilicum	3	0.06 ± 0.062gh	0.64 ± 0.44f	44.7 ± 27.0679f	2.38 ± 1.11a	1.11 ± 1.10ab	11160.4 ± 1145.31cd	1.08 ± 0.02b	513.2 ± 280.93efg
T. cordata	3	5.08 ± 0.83bcd	0.31 ± 0.14f	39.2 ± 6.34f	0.00 ± 0.0c	0.399 ± 0.086bc	21389.5 ± 2345.35b	1.25 ± 0.11b	146.2 ± 20.70g
U. dioica	3	0.66 ± 0.03fgh	1.53 ± 1.10def	106.7 ± 46.21cdef	0.57 ± 0.56c	0.08 ± 0.08c	8080.2 ± 5440.31de	1.37 ± 0.08b	1319.1 ± 496.01cd
T. spicata	3	0.60 ± 0.04fgh	0.72 ± 0.48ef	79.2 ± 33.08def	0.00 ± 0.00c	0.45 ± 0.10bc	1200.9 ± 120.87ef	1.39 ± 0.07b	503.8 ± 197.83efg

C. sativum	3	5.97 ± 0.66bcd	0.38 ± 0.02f	6.60 ± 6.53f	2.14 ± 2.12ab	0.00 ± 0.00c	19865.7 ± 782.67b	1.23 ± 0.03b	132.6 ± 62.40g
R. canina	3	1.33 ± 1.14efgh	0.71 ± 0.71ef	8.85 ± 8.76f	1.19 ± 1.18abc	0.00 ± 0.00c	5316.8 ± 5264.99def	0.95 ± 0.05b	1018.2 ± 775.87de
M. piperita.	3	6.28 ± 1.61bc	6.47 ± 0.41b	451.4 ± 85.60b	0.00 ± 0.00c	0.43 ± 0.04bc	18496.2 ± 1169.53b	1.52 ± 0.16b	2316.6 ± 136.29b
M. officinalis	3	6.46 ± 1.062bc	7.88 ± 0.95b	1295.7 ± 583.46a	0.00 ± 0.00c	0.37 ± 0.08bc	20704.7 ± 2373.69b	3.41 ± 1.49a	3178.7 ± 227.40a
C. sinensis (Black tea)	3	0.40 ± 0.39gh	0.59 ± 0.11f	8.92 ± 6.22f	1.02 ± 1.01abc	0.00 ± 0.00c	25520.5 ± 2249.24ab	1.24 ± 0.09b	156.3 ± 68.50g
C. angustifolia	3	4.99 ± 1.83bcd	2.46 ± 1.80cde	199.5 ± 127.19bcdef	0.00 ± 0.00c	0.41 ± 0.07bc	6728.6 ± 663.02def	3.41 ± 1.98a	2001.7 ± 1035.70bc
M. chamomilla	3	11.19 ± 2.93a	7.40 ± 1.78b	244.5 ± 60.70bcdef	1.41 ± 1.40abc	0.00 ± 0.00c	27497.8 ± 7828.58a	1.40 ± 0.03b	2164,9 ± 270.93b
A. dracunculus	3	3.70 ± 0.13cde	1.76 ± 0.94def	26.5 ± 14.10f	0.00 ± 0.00c	0.39 ± 0.33bc	1890.8 ± 882.06ef	0.90 ± 0.07b	517.2 ± 206.70efg
C. casia	3	11.73 ± 2.94a	12.18 ± 1.22a	342.0 ± 14.48bcd	0.00 ± 0.00c	0.00 ± 0.00c	29167.5 ± 1100.72a	1.47 ± 0.15b	1841.1 ± 79.63bc
C. sinensis (Green tea)	3	0.448 ± 0.050gh	0.15 ± 0.134f	2.94 ± 2.91f	0.00 ± 0.00c	0.46 ± 0.46bc	28890.9 ± 992.32a	1.14 ± 0.12b	58.4 ± 31.17g
F. vulgare	3	3.03 ± 1.79defg	3.74 ± 2.03c	66.0 ± 36.36ef	0.00 ± 0.00c	1.96 ± 1.94a	17500.4 ± 10241.44bc	1.10 ± 0.25b	2432.6 ± 885.39b

Plants	*n*	Mn	Na	Ni	P	Pb	Se	Sr	Tl	V	Zn
S. fruticosa	3	22.50 ± 5.91cdef	886.02 ± 247.53bc	1.63 ± 0.31cde	2385.7 ± 860.40cd	1.15 ± 0.63b	0.00 ± 0.00d	8.62 ± 2.18b	1.25 ± 1.24bc	0.82 ± 0.30bc	12.35 ± 4.99c
P. anisum	3	20.62 ± 1.66cdef	325.23 ± 11.45de	2.53 ± 0.71bc	1948.7 ± 240.30d	0.83 ± 0.75b	2.64 ± 1.91 cd	11.66 ± 2.86b	0.66 ± 0.66c	0.98 ± 0.22bc	9.56 ± 3.42cd
C. orientalis	3	16.89 ± 1.31cdef	1259.82 ± 155.26b	1.89 ± 0.09cd	5227.4 ± 392.80bc	0.80 ± 0.79b	0.00 ± 0.00d	69.05 ± 1.93b	2.17 ± 1.48bc	0.86 ± 0.02bc	17.91 ± 0.37b
R. officinalis	3	1.65 ± 1.02f[B]	43.82 ± 20.89e	0.36 ± 0.10fgh	1465.9 ± 433.34d	0.34 ± 0.34b	4.32 ± 4.28cd	1.75 ± 0.84b	6.60 ± 4.37abc	0.06 ± 0.01d	7.43 ± 2.37cde
Sideritis spp.	3	7.52 ± 1.72ef	547.98 ± 179.3cde	0.71 ± 0.27efgh	1492.4 ± 731.31d	0.75 ± 0.25b	0.00 ± 0.00d	3.97 ± 0.92b	5.09 ± 3.19bc	0.22 ± 0.18d	12.24 ± 3.23c
O. basilicum	3	4.791 ± 3.01ef	65.24 ± 33.14e	0.08 ± 0.08h	5245.9 ± 643.45bc	0.66 ± 0.65b	6.99 ± 6.92cd	12.90 ± 7.35b	0.91 ± 0.91bc	0.07 ± 0.02d	23.25 ± 5.49ab
T. cordata	3	4.88 ± 0.70ef	33.11 ± 3.87e	0.30 ± 0.04gh	1654.9 ± 324.23d	1.56 ± 0.32b	16.56 ± 9.97b	1.62 ± 0.37b	1.93 ± 0.81bc	0.04 ± 0.04d	8.26 ± 2.61cd
U. dioica	3	10.57 ± 4.58def	227.44 ± 135.72de	0.72 ± 0.21efgh	1418.1 ± 1169.88d	0.88 ± 0.87b	1.97 ± 0.95 cd	36.94 ± 15.95b	3.10 ± 2.07bc	0.47 ± 0.26cd	3.32 ± 3.28e
T. spicata	3	5.72 ± 2.58ef	119.04 ± 37.59de	1.34 ± 0.10defg	1150.2 ± 232.43d	0.27 ± 0.27b	2.98 ± 0.975cd	9.71 ± 3.80b	4.30 ± 0.31bc	0.23 ± 0.05d	3.54 ± 2.87e
C. sativum	3	0.40 ± 0.40f	22.84 ± 3.86e	0.539 ± 0.18fgh	3270.8 ± 463.34bcd	0.02 ± 0.02b	23.53 ± 0.98a	0.64 ± 0.28b	1.32 ± 0.03bc	0.17 ± 0.05d	14.13 ± 4.23bc
R. canina	3	13.93 ± 11.71def	280.10 ± 233.95de	0.67 ± 0.15efgh	856.2 ± 847.875d	0.17 ± 0.10b	0.00 ± 0.00d	4.05 ± 3,20b	5.56 ± 3.44abc	0.15 ± 0.10d	3.96 ± 0.67de
M. piperita.	3	43.50 ± 3.09c	916.23 ± 76.53bc	3.52 ± 0.27a	3073.3 ± 240.57bcd	0.00 ± 0.00b	1.65 ± 0.54 cd	49.57 ± 6,26b	1.04 ± 0.53bc	1.41 ± 0.13b	10.79 ± 0.19c
M. officinalis	3	36.33 ± 8.59cd	1270.17 ± 42.66b	2.91 ± 0.93ab	5700.7 ± 461.6152b	1.65 ± 0.97b	0.00 ± 0.00d	16.72 ± 1,25b	0.48 ± 0.11c	2.66 ± 0.67a	21.74 ± 3.94ab
C. sinensis (Black tea)	3	90.82 ± 36.00b	46.96 ± 18.73e	0.76 ± 0.12efgh	2890.4 ± 234.23cd	1.07 ± 1.06b	6.55 ± 6.48cd	1.41 ± 0,54b	7.06 ± 3.62ab	0.20 ± 0.16d	8.71 ± 2.34cd
C. angustifolia	3	16.66 ± 11.2cdef	1328.62 ± 993.96b	0.87 ± 0.84efgh	1854.6 ± 1774.10d	1.43 ± 0.43b	0.00 ± 0.00d	210.9 ± 162,9a	1.55 ± 0.58bc	1.02 ± 1.01bc	6.34 ± 6.28cde
M. chamomilla	3	24.30 ± 5.64cdef	2503.27 ± 661.44a	3.71 ± 0.91a	5717.9 ± 1666.69b	1.31 ± 1.29b	0.00 ± 0.00d	22.69 ± 6,15b	1.88 ± 1.27bc	0.84 ± 0.41bc	26.00 ± 6.28a
A. dracunculus	3	125.74 ± 49.49a	447.62 ± 233.4cde	1.39 ± 0.24def	1315.8 ± 997.00d	1.07 ± 0.23b	0.00 ± 0.00d	3.29 ± 1,20b	10.95 ± 10.85a	0.24 ± 0.07d	4.01 ± 3.04de
C. casia	3	31.43 ± 1.75cde	2563.86 ± 231.73a	1.30 ± 0.16defg	11733.9 ± 6225.97a	0.71 ± 0.46b	0.00 ± 0.00d	20.22 ± 0,74b	2.13 ± 0.34bc	1.35 ± 0.10b	10.29 ± 1.88c
C. sinensis (Green tea)	3	20.25 ± 7.83cdef	28.51 ± 5.10e	0.46 ± 0.20fgh	12698.1 ± 3090.24a	3.85 ± 3.07a	8.99 ± 7.39c	0.28 ± 0,12b	3.27 ± 3.24bc	0.05 ± 0.05d	17.55 ± 2.34b
F. vulgare	3	13.61 ± 7.29def	675.84 ± 323.60cd	3.05 ± 1.52ab	10145.48 ± 2330.568a	0.56 ± 0.56b	2.87 ± 1.63 cd	25.44 ± 13,15b	1.29 ± 1.274bc	0.14 ± 0.12d	10.87 ± 7.53c

[A] Dry matter.

[B] Different letters means the statistical difference.

Table 2
Duncan test of the mineral content of the teas vs. plants (mg/100 ml)

Plants	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co
S. fruticosa	0.0000b[A]	0.014c	0.0021bc	0.154abcde	0.013h	0.000d	15.855de	0.0004ab	0.002defgh
R. canina	0.0016b	0.015c	0.0099abc	0.139bcdef	0.0039I	0.000d	7.889g	0.0000d	0.002efghı
C. sinensis (Black tea)	0.000b	6.017a	0.0161a	0.035h	0.017gh	0.0046abc	0.000i	0.0002bcd	0.003bcdef
C. sinensis (Green tea)	0.0034b	1.204b	0.0036bc	0.078fgh	0.007I	0.0000d	0.000i	0.0004abc	0.005a
C. sativum	0.0000b	0.010c	0.0152ab	0.139bcdef	0.005I	0.0005bcd	5.463ghı	0.0004 abc	0.002ghıi
M. chamomilla	0.0080ab	0.008c	0.0107abc	0.214ab	0.005I	0.0009bcd	6.110gh	0.0003bcd	0.002efghı
Sideritis spp.	0.0000b	0.014c	0.0000c	0.059gh	0.007I	0.000d	3.962hı	0.0003bcd	0.001hıi
C. orientalis	0.0035b	0.015c	0.011abc	0.135bcdef	0.052b	0.000d	20.291c	0.0005ab	0.004abc
C. cassia	0.0207a	0.013c	0.0214a	0.134bcdef	0.007I	0.0000d	0.382i	0.0003bcd	0.001i
A. dracunculus	0.099ab	0.097c	0.0149ab	0.126bcdefg	0.022fg	0.000d	3.703ı	0.0006a	0.003abcd
R. officinalis.	0.001b	0.012c	0.000c	0.131cdefg	0.036cd	0.0050abc	25.171ab	0.0001d	0.002fghıi
F. vulgare	0.0011b	0.009c	0.0079abc	0.178abcd	0.0023I	0.000d	18.426cd	0.00001d	0.003bcde
P. anisum	0.001b	0.014c	0.0105abc	0.188abc	0.025ef	0.0065a	13.321ef	0.0001d	0.002efghı
O. basilicum	0.0018b	0.021c	0.0056bc	0.142bcdef	0.020fg	0.0030abcd	24.428b	0.0001d	0.004abc
M. officinalis	0.0011b	0.019c	0.000c	0.157abcde	0.020fg	0.0023abcd	20.116c	0.0001d	0.003bcde
T. spicata	0.0012b	0.015c	0.0007bc	0.142bcdef	0.040c	0.000d	24.352b	0.0001d	0.003bcdef
M. piperita	0.0011b	0.014c	0.000c	0.109defg	0.032de	0.000d	20.886c	0.0001d	0.004ab
C. angustifolia	0.0011b	0.020c	0.0065bc	0.236a	0.139a	0.0000d	28.621a	0.0001d	0.002efghı
T. cordata	0.0007b	0.013c	0.000c	0.099efgh	0.0053I	0.0000d	11.475f	0.000d	0.001ıi
U. dioica	0.0010b	0.011c	0.0112abc	0.155defgh	0.021fg	0.0055ab	27.611ab	0.0001d	0.002cdefg

Plants	Cr	Cu	Fe	In	K	Li	Mg	Mn
S. fruticosa	0.020bcd[A]	0.017def	0.668c	0.000b	127.611defgh	0.004ef	7.825hı	0.044zde
R. canina	0.047a	0.005ghıi	1.076ab	0.000b	99.819hıijk	0.004ef	8.286hı	0.117bcde
C. sinensis (Black tea)	0.015bcd	0.025bcd	0.8675bc	0.000b	143.887cde	0.004cdef	4.423kl	1.558a
C. sinensis (Green tea)	0.022abcd	0.019cde	0.2216de	0.003ab	141.134def	0.004def	6.541i	1.754a
C. sativum	0.012bcd	0.026bc	0.2119de	0.000b	107.192ghıij	0.004cdef	4.756jk	0.016de
M. chamomilla	0.036ab	0.029b	0.3633cd	0.000b	203.2384bc	0.004cdef	7.340ıi	0.041cde
Sideritis spp.	0.029abc	0.024bcd	0.0330ef	0.000b	117.227efghıi	0.004f	3.588lm	0.011e
C. orientalis	0.017bcd	0.011efg	0.9290b	0.004ab	86.682ijk	0.005bcd	8.377h	0.045cde
C. cassia	0.010bc	0.005hıi	0.8628bc	0.000b	30.622l	0.005bcde	1.569n	0.122bcd
A. dracunculus	0.012bcd	0.1588a	0.1220de	0.001ab	231.390a	0.004cdef	10.918ef	0.159b
R. officinalis.	0.006cd	0.002hıi	0.0472ef	0.007ab	90.248ıijk	0.006b	10.135fg	0.072bcde
F. vulgare	0.011cd	0.001ıi	0.671c	0.007ab	120.697defghı	0.004cdef	12.459cd	0.019de
P. anisum	0.007cd	0.031b	0.0782ef	0.006ab	75.572k	0.004cdef	3.215m	0.016de
O. basilicum	0.011cd	0.007ghı	0.0054f	0.010ab	218.352ab	0.004cdef	16.230a	0.141bc
M. officinalis	0.007cd	0.009fgh	1.0041ab	0.006ab	135.031defg	0.004def	11.877cde	0.046bcde
T. spicata	0.005d	0.003hıi	0.0074f	0.007ab	78.983jk	0.005bcd	9.701g	0.082bcde
M. piperita	0.016bcd	0.008ghı	1.1389a	0.007ab	153.230cd	0.006b	11.334de	0.094bcde
C. angustifolia	0.009cd	0.085ab	0.9418b	0.011a	82.625jk	0.025a	14.320ab	0.085bcde
T. cordata	0.024abcd	0.004hıi	0.882bc	0.005ab	109.105fghıij	0.004cdef	5.393j	0.099bcde
U. dioica	0.024abcd	0.007ghıi	0.0229ef	0.008ab	226.832ab	0.005bc	12.781bc	0.048bcde

Plants	Na	Ni	P	Pb	Se	Sr	Ti	V	Zn
S. fruticosa	3.008bc[A]	0.003fgh	3.468def	0.0028ab	0.000c	0.020ıi	0.006b	0.001bc	0.053bc
R. canina	0.496def	0.002gh	1.522fgh	0.0017abcd	0.000c	0.018ıi	0.005b	0.001c	0.023c
C. sinensis (Black tea)	0.466def	0.039a	4.612d	0.0011bcd	0.0537ab	0.008i	0.007b	0.001bc	0.043c
C. sinensis (Green tea)	1.232 de	0.046a	3.298defg	0.0013bcd	0.0437b	0.009i	0.004b	0.001bc	0.157abc
C. sativum	1.841cd	0.005defgh	1.935efgh	0.0008bcd	0.0755a	0.024hıi	0.005b	0.001bc	0.051c
M. chamomilla	14.626a	0.011bc	16.178b	0.0008bcd	0.000c	0.019ıi	0.006b	0.001bc	0.062bc
Sideritis spp.	0.706def	0.003gh	3.275defg	0.0010bcd	0.0000c	0.006i	0.008b	0.001abc	0.047c
C. orientalis	3.625b	0.008bcde	4.519d	0.0034a	0.000c	0.063efg	0.005b	0.001bc	0.051c
C. cassia	4.631b	0.003gh	0.343h	0.0018abcd	0.0000c	0.009i	0.039a	0.001c	0.074bc
A. dracunculus	15.966a	0.008bcde	24.857a	0.0025abc	0.000c	0.074e	0.005b	0.003a	0.204ab
R. officinalis	0.051ef	0.005efgh	0.060h	0.0004cd	0.0017c	0.045fgh	0.001b	0.001bc	0.037c
F. vulgare	0.031ef	0.009bcd	4.672d	0.0014bcd	0.0022c	0.065ef	0.0001b	0.001bc	0.046c
P. anisum	0.006f	0.005defg	1.767efgh	0.0029ab	0.0028c	0.037ghı	0.001b	0.001bc	0.099bc
O. basilicum	0.150ef	0.003gh	8.496c	0.0021abc	0.0012c	0.340b	0.001b	0.001abc	0.056bc
M. officinalis	0.020f	0.003gh	8.398c	0.0037a	0.000c	0.029hıi	0.001b	0.001bc	0.059bc
T. spicata	0.031ef	0.012b	3.303defg	0.0025abc	0.0011c	0.083e	0.001b	0.001abc	0.087bc
M. piperita	0.094ef	0.011bc	3.191defg	0.0000d	0.0031c	0.146d	0.001b	0.0001c	0.093bc
C. angustifolia	0.297ef	0.002h	1.125fgh	0.0006cd	0.0000c	0.893a	0.001b	0.003ab	0.135 abc
T. cordata	0.049ef	0.007cdef	5.763cd	0.0030ab	0.0019c	0.022hıi	0.003b	0.0002c	0.319a
U. dioica	0.035ef	0.002gh	4.291de	0.0014bcd	0.0022c	0.206c	0.005b	0.003ab	0.151abc

[A] Different letters means the statistical difference.

(41.83 ppm) was very high, it was very low in *O. basilicum* (0.64 ppm) and *T. vulgaris* (1.03 ppm). Ba content of *C. orientalis* (56.05 ppm) was the highest, but was low in *C. sativum* (0.64 ppm), *T. cordata* (0.49 ppm) and *R. canina* (0.34 ppm). Se content of *C. sativum* was 23.53 ppm. While, Se content of *P. anisum, R. officinalis, O. basilicum, T. cordata, U. dioica, T. vulgaris, M. piperita*, *Camelia sinensis* (green tea and black tea) and *F. vulgare* ranged between 1.65 and 16.56 ppm, there was no Se in the other samples. Sr content of the samples ranged between 0.28 and 210.90 ppm.

Limited studies were carried out on the mineral contents of spices and herbs (Akgül, 1993; Arslan & Toğrul, 1995; Başgel & Erdemoğlu, 2005; Claudia, Peter, & Antonia, 1998; Gürses, 1984; Kaçar et al., 1979; Nas, 1990; Özcan, 2004a; Özcan, 2004b; Poyrazoğlu & Gürses, 2004; Zengin, Gezgin, Özcan, & Çetin, 2004). In general, the mineral content of the herbs that we studied were similar to the literature values. Some discrepencies may be due to the differences in the species, locations, soil properties, harvesting times, geographic parameters and analytical processes.

3.2. The mineral contents of teas

The mineral contents of the teas are listed in Table 2. While the Al contents of black tea and green tea were 6.017 mg/100 ml and 1.204 mg/100 ml, respectively, the Al content of other samples was lower than 0.021 mg/100 ml. Ca content of *C. angustifolia* was high (28.621 mg/100 ml), but Ca content of *C. casia* was low (0.382 mg/100 ml). There was no Ca in green tea and black tea. Fe in *M. piperita* and *O. basilicum* was found to be 1.1389 mg/100 ml and 0.0054 mg/100 ml, the highest and the lowest values, respectively. K contents of the teas ranged between 30.622 mg/100 ml and 231.390 mg/100 ml. Na in *P. anisum* (0.006 mg/100 ml) and *M. officinalis* (0.020 mg/100 ml) teas was low, but was high in *A. dracunculus* (15.966 mg/100 ml) and *M. chamomilla* (14.626 mg/100 ml) teas. *A. dracunculus* (24.857 mg/100 ml) and *M. chamomilla* (16.178 mg/100 ml) teas were rich in P, but *R. officinalis* (0.060 mg/100 ml) tea was poor in P. Zn in *R. canina*, black tea, *R. officinalis*, *F. vulgare* and *Sideritis* teas was very low and its amounts were 0.023, 0.043, 0.037, 0.046 and 0.047 mg/100 ml, respectively. But Zn in *A. dracunculus* (0.204 mg/100 ml) and *T. cordata* (0.319 mg/100 ml) was very high. *O. basilicum* tea was found to be the richest in Mg (16.230 mg/100 ml). Mn in black tea (1.558 mg/100 ml) and green tea (1.754 mg/100 ml) was high, but was low in *Sideritis* spp. (0.011 mg/100 ml).

Fernandez, Pablos, Martın, and Gonzalez (2002), Zengin et al. (2004), Özcan (2004a) and Başgel and Erdemoğlu (2005) studied the mineral content of teas, spices and herbs. Comparison of 10 min infusion of the plants with the results of Zengin et al. (2004): Ca, Cu, Fe, K, Mg, Mn and P contents in S. *fruticosa* teas were low but Na and Zn contents in *S. fruticosa* were similar. Mineral content of *O. basilicum* and *M. piperita* teas were lower than the results of Zengin et al. (2004). Ca, Cu, K, Li, Mg, Mn, P and Zn contents in *T. cordata* were low but were similar in Fe and Zn with respect to Zengin et al. (2004). Ca, Cu, Fe, K and P contents in *T. vulgaris* were low, but Zn content was similar to their results. Fe and Na contents in *R. canina* were similar, while, Ca, Cu, K, Mg, Mn, P and Zn contents were lower. Fe, Na and Mg contents in *M. chamomilla* were similar with their results. Ca, Cu, K, Mn, Na, P and Zn contents in *F. vulgare* were lower but in accordance with Fe and Mg. Fe content in black tea and Cu, Fe, Na and Zn content in green tea were similar with their result. According to Özcan (2004a), our result for 10 min infusion was similar in *S. fruticosa* for Fe, K and P contents, but Ca, Cu, Mg, Mn, Na and Zn contents were low. Comparison of 30 min infusion of the results of Başgel and Erdemoğlu (2005) with our results for 20 min infusion: Ca content in *S. fruticosa*, *R. canina* and *M. chamomilla* teas was high. Cu, Mg, Mn and Zn content in *T. cordata* tea were low, while, Ca and Fe contents were similar. Mineral contents of *F. vulgare* were lower than the results of Başgel and Erdemoğlu (2005).

The discrepencies of the mineral content of the teas may be due to the differences in the species, harvesting times, soil properties and climates.

Zn content was statistically significant ($p < 0.05$) according to the analysis of the variance of the infusion or decoction times of the plants, but other minerals were not significant according to the analysis of the variance of the infusion or decoction times. Zn content was maximum in 10 min infusions and was not changed too much after 15 and 20 min infusions (Table 3).

3.3. Percentages of the mineral transportation

Maximum transportation of Fe was in 10 and 20 min infusion of *R. canina*. Ag transportation was maximum in 15 min infusion of *R. canina.* By increasing the infusion time, Fe, Cu, Na, Pb, Sr, Tl and V transportations were increased for *R. canina.* There was no Ga in 10 min infusions, but it was detected in 15 and 20 min infusions of *R. canina*.

The transportation rates of Fe and Co were the best for black tea. Transportation rates of Al, Ni, Cd, Cr and Cu were also high. Transportation rates of other minerals were lower than 3%. It was found that the transportation rate was increased by the increase of the infusion time for Al, B, Bi, Cu, Fe, K, Mg, Mn, Na, Ni, Sr, Tl, V and Zn.

Ten and twenty minute infusion times were the best for the transportation percentage for Cu, while 15 min was the best for Ag, for the preparation of green tea. Transporta-

Table 3
Duncan test of the mineral content of the teas versus time

Time (minute)	Zn (mg/100 ml)
10	0.126a[A]
15	0.073b
20	0.077b

[A] Different letters means the statistical difference.

tion rate was between 3.2 and 6.4% for Mg, Ni, Mn and Fe. Ten minute infusion was optimum for Al, B, Cd, Co, Cu, P, Mg, Mn, Na, Ni, Sr, Tl and Zn transportation.

Na, Cu and Pb had the highest rates to transport to *C. sativum* tea at 10 and 15 min. At 20 min infusion the transportation percentage of Pb was decreased while the percentage of Cu and Na was increased. The transportation percentages of Mn, Ba, Sr, Fe and Mg were also high.

While 10 min found to be the optimum decoction time for transportation of Ag, 15 and 20 min was optimum for K for *A. dracunculus* tea. The percentage of transportation of Cu, Zn, Mg, Sr and Na was also high. While 10 min was optimum for Ag, Ar, Cr, Cu, Tl and Zn transportation rate, 20 min was the best for Al, Br, B, Ca, Cd, Co, Fe, In, K, Li, Mg, Mn, Na, Ni, P, Pb, Sr and V for the preparation of *A. dracunculus* tea.

Ca was found to be the most transported mineral to the *R. officinalis* tea in terms of percentage. Other minerals transported at high rates were Cu, Mn, Mg and Bi. The transportation rate of Ba, B, Bi, Ca, Co, Cr, Li, Mn, Na, Pb, Sr, V and Zn were high at 10 min infusion of *R. officinalis*; 15 min was optimum for Ag, Al, Ni and Se.

Ten and fifteen minutes was optimum for the transportation of B and Cr to *O. basilicum* tea. But 20 min was the best infusion time for the transportation of Ag to *O. basilicum* tea. Transportation rate was also high for Ca, Mg and Ni. Fifteen minute infusion was found to be optimum for transportation of Ba, B, Ca, Co, Cr, Cu, In, K, Mg, Mn, Na, Ni, P, Sr and V, while 15 min was the best for Ag, Bi, Cd, Ga, Pb, Se and Zn.

Ag, Co and In were the best minerals to be transported to the *M. piperita* tea at all infusion times. Ba, K and Zn were also transported at high rates. Ar, Bi, Ga, Pb and Se were not detected in *M. piperita* tea. Ten minute was optimum for transportation rate of Ag and Cu, while 20 min was the best for Ba, B, Co, In, Tl and V. The transportation percentage of the other minerals was not changed much.

In had the highest transportation rate for *U. dioica* tea. Other high rates were for Zn, Ag, K and Cr for the preparation of *U. dioica* tea. The transportation rate was high for B, Co, Cu, Fe, K, Mg, Na, P and Zn at 15 min, while it was high at 10 min for Ar, Bi, Ca, Cr, In and V.

4. Discussion

Except for *A. dracunculus*, the transportation rate of Ag was not affected by the increase of infusion time. Amount of Al was the highest, as detected in black and green teas. Amount of B detected was as high at 10, 15 and 20 min, in *C. angustifolis*, *P. anisum* and *C. angustifolis* teas, respectively. The transportation of Ca was high in *C. angustifolia* and *U. dioica* teas. Cu content was high in *A. dracunculus* and *C. angustifolia* teas at 10, 15 and 20 min infusions. Amount of Fe was high in *M. piperita* and *R. canina* teas at 10, 15 and 20 min infusions.

Amount of K was found to be high in *U. dioica* and *O. basilicum* teas at 10 and 15 min infusions, while it was high in *A. dracunculus* tea at 20 min infusion. Transportation of Na and P was the best at 10, 15 and 20 min infusions of *A. dracunculus* and *M. chamomilla* teas and the highest Zn transportation levels were obtained by 10, 15 and 20 min infusions of *T. cordata*, green tea and *U. dioica*.

According to the transportation percentages of the minerals, by the infusion of *S. fruticosa*, Cr at 10 min and Co at 15 and 20 min were found to be high in teas. Fe was transported at high levels at 10 and 15 min, while Ag was transported at 15 min of infusion of *R. canina*. Fe and Co transportation rates were high in black tea. The Cu transportation was high at 10 and 20 min infusions and Ag was high at 15 min infusion of green tea.

The minerals transported to the teas at high amounts at 10, 15 and 20 min infusions were Ag in *M. chamomilla* tea, Cu and K in *Sideritis* tea, Ag in *C. casia* tea, Ca in *R. officinalis* tea, B in *C. orientalis* tea, Ag in *P. anisum* tea, Ag and In in *M. officinalis* tea, B in *T. spicata* tea, Cu, In and Zn in *C. angustifolia* tea and In in *U. dioica* tea.

In conclusion, it was an advantage that the heavy metal contents were very low in the plants and in the teas. The 10 min infusion or decoction was enough for the most efficient minerals, and 10 min was generally found to be enough to prepare a mineral rich tea. As a result, plants and teas were found to be good sources of minerals.

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