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**Research Article**

# Investigation of carbonate addition on essential element concentrations in various teas

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## ABSTRACT

Daily consumption of various teas is a popular tradition in many countries especially in Turkey and although it shouldn't be in tea, carbonate can be added to obtain more brew from teas especially in local coffeehouses. In this study, the effect of carbonate addition on the essential element concentrations of some black teas (black, earl grey and green tea), herbal teas (fennel, mint and sage tea) and fruit teas (apple, lemon and rosehip) is analysed by inductively coupled plasma optical emission spectrometer (ICP-OES), after the infusion process of tea brewing with carbonate. Afterwards, the total element contents of the tea grains in are determined by again ICP-OES prior to microwave digestion process. Considering the data obtained from the experiments, carbonate addition increased or decreased some elements with respect to the tea types. According to the results obtained after the microwave digestion method, although the major elements in all types of teas are found as Ca, K, P, Mg and Mn, which do not reach 2% brewing from the tea grains, carbonated infusion is not recommended due to its increasing effect on the concentration of the major elements contained in teas.

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## INTRODUCTION

Tea is a rich source of essential nutritional elements made from the leaves of the *Camellia sinensis* plant [1]. It is a highly precious, non-alcoholic beverage mainly due to its pleasant aroma, flavor, health benefits and positive effects on cultural interactions [2]. *Camellia sinensis* plants consist of one apical bud, two subsequent leaves and other parts of fresh leaves, which cause the different chemical composition of the tea. This composition depends on fermentation amount in fresh leaves and the degree of oxidation of polyphenols. Correspondingly, there are three types of tea production techniques and these methods determine the type of tea produced. Green tea without fermentation, oolong tea with semi-fermentation and black tea with full fermentation are generated. Nowadays, consumption of herbal and fruit teas has gained popularity due to the increasing ecological awareness and interest in healthy lifestyle. Also, for the medical applications, a variety of teas are produced from herbs and fruits [1]. Most preferable teas can be classified as Black tea (*Camellia sinensis*), fennel *(F.*

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*vulgare* ssp. *piperitum*), mint or peppermint (*Mentha piperita* L.) and sage (*Salvia officinalis* L.) as herbal teas; apple (*Malus domestica* Borkh), lemon (*C. limon*), and rosehip (*Rosa canina* L.) as fruit teas [3]. Considering tea contents in terms of essential elements is important for deliberate consumption. Teas contain various necessary element to human body [4].

Elements can be classified into two groups: major (macro) elements and trace elements. Major elements such as calcium (Ca), phosphorus (P), potassium (K), sulphur (S), sodium (Na), chloride (Cl) and magnesium (Mg) are essential mineral nutrients attended in the human body in amounts higher than 5 g. Trace elements involve iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), iodine (I) and selenium (Se) that the body requires in little quantities relatively to macro elements [5]. They participate in separate jobs all over the body, each having special duties that only it can perform. Some essential minerals are active in all the body systems—gastrointestinal system, muscles, bones, cardiovascular system, blood and central nervous system—deficiencies can have wide-reaching effects and can influence people of all ages. Main functions, deficiency symptoms and sources of many essential minerals are explained in detail [6].

In terms of protecting human health, it is important to determine how much of the average elements that should be taken from the teas consumed daily. In the literature, there are numerous studies investigating the essential element contents of different teas [1]. Alnaimat et al. studied bioaccessibility of trace elements (Li, Be, Ti, Ga, Cu, Ag, Hg, Cd, Cs, Pt, Tl, Pb, As, Cr, Co, Ni, V, Se, Sn and Sb) and major elements (Rb, Ba, Al, Fe, Zn, Si, Ca, Mg, Mn, Mo, Sr, P and K) in tea infusions using an in vitro dialyzability protocol. They used ICP-MS, ICP-OES and FAES for elements determination in digested tea leaves, their infusions and the dialyzate fractions from tea infusions [7]. Shotyk et al. estimated the natural abundance of trace elements in the leaves of Labrador tea (Rhododendron groenlandicum), and the extent of their release during hot water extraction [8]. Pohl et al. carried out operationally defined chemical fractionation of Al, Ba, Ca, Cu, Fe, Mg, Mn, Ni, Sr and Zn in infusions of loose leaf and bagged black and green teas [9]. Długaszek and Kaszczuk determined the amounts of Ca (calcium), Cr (chromium), Cu (copper), Fe (iron), K (potassium), Mg (magnesium), Mn (manganese), Na (sodium), Ni (nickel) and Zn (zinc) elements in herbal teas infusions as well as yerba mate and rooibos by atomic absorption spectrometry method (AAS) [10]. Voica et al. investigated the metal content of 32 herbal plants for tea beverages from Romania and analyzed twelve elements representing toxic metals and essential mineral elements by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) [11]. Milani et al. determined Al, As, Ba, Cd, Cr, Fe, Pb, Se, Cu, Mn, Ni and Zn trace elements in herbal teas commercialized in Brazil such as Boldo, Chamomile, Mate and Peppermint [12]. Atasoy et al. determined the essential element contents and metal concentrations in Turkish black tea infusions and compared the composition of Turkish tea and others [13]. Dalipi et al. analysed total concentrations of thirteen elements K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Rb, Sr, Ba and Pb as well as their extraction efficiencies into infusion of teas, herbs and roots samples by total reflection X-ray fluorescence (TXRF) [14]. Erdemir reported total elemental contents, time-dependent extractabilities, and bioaccessibilities of Mg, Mn and Fe from black, earl grey, and green teas, using ICP-MS [15]. Domingo Martin et al. determined metallic elements (Hg, Pb, Cr and Cd), metalloids (As) and mineral compounds (Fe, Mn, Cu, and Zn) in twelve herbal teas; mentha (Mentha piperita); thyme (Thymus vulgaris); common sage (Salvia officinalis); chamomile (Matricaria chamomilla); lime flower (Tilia sp.); valerian (Valeriana officinalis); field horsetail (Equisetum arvense); senna (Cassia angustifolia); lemon verbena (Aloysia triphylla); rooibos (Aspalathus linearis); green tea (Camellia sinensis); and lime (Citrus aurantiifolia) [16]. Skowron et al. reported antioxidant activity, content of bioactive compounds (rutin, quercetin, phenolic acids including: gallic, chlorogenic, protocatechuic, p-coumaric, caffeic, ferrulic, syringic and sinapic as well as other selected organic acids) and trace element content such as Mn, heavy metal content such as Al; Cd; and Pb of white, green, black, lemon-flavored and Red Lapacho teas [17].

As can be seen in the literature, it is important to know the amount of elements contained in various teas that are frequently consumed daily in terms of human health and conscious consumption. So, there are many studies addressing essential element contents of several nutrients [1]. In coffeehouses, although it is known to be wrong, carbonate is added to obtain more brew from tea. Hence the novelty of this study is its determination of carbonate effect on essential element contents of black, herbal and fruit teas and comparison with pure infusions. For this scope, black, earl grey, green, fennel, mint, sage, apple, lemon and rosehip teas were supplied and eleven essential elements (Ca, Co, Cr, Fe, K, Mg, Mn, Na, P, Se and Zn) contents before and after carbonate addition were compared. Moreover, after the infusion and microwave digestion method in teas, the element contents were determined by ICP-OES which is the most preferred analysis technique in the literature and the element amounts of the selected teas were examined.

## EXPERIMENTAL PROCEDURE

Black (black, earl grey and green), herbal (fennel, mint and sage) and fruit (apple, lemon and rosehip) teas were purchased from a local market in Istanbul, Turkey in 2016. Pure water of 0.07 µs $cm^{-1}$ was obtained from a Human Power $I^+$ brand water purification system (HUMAN Corporation, Seoul, Korea). Sodium carbonate ($Na_2CO_3$) (Merck KgaA, Darmstadt, Germany) was purchased to study carbonate effect. The element content analysis was accomplished with a

**Figure 1.** Filtration process of tea samples.

**Figure 2.** Analysis of element concentration of teas by ICP-OES.


**Figure 3.** Microwave digestion system.

PerkinElmer Optima 2100 DV ICP-OES (PerkinElmer Inc., MA, USA) equipped with an AS-93 autosampler. Conditions of measuring were adjusted to a power of 1.45 kW, a plasma flow of 15.0 L min$^{-1}$, an auxiliary flow of 0.8 L min$^{-1}$, and a nebulizer flow of 1 L min$^{-1}$. Infusion process was carried out according to method applied in Gorgulu, et al. [1]. The same experimental procedure was applied to examine the carbonate effect on the essential element concentrations in all tea samples. 0.125 gram of carbonate was added to each tea sample then the same infusion method was conducted.

In the second step, microwave digestion method was carried out for the determination of essential element contents of teas in powder form by ICP-OES. 10 ml of 65% pure nitric acid ($HNO_3$) (Merck KgaA, Darmstadt, Germany) was added to the microwave digestion vessels by weighing 0.1 grams of tea samples. Samples were kept for 12 hours after nitric acid addition. At the end of the waiting period, the vessels, whose lids were closed, were placed into the microwave digestion analyzer and digested for 55 minutes. 5 specimens were processed at each time and temperatures ranging from 100-190°C were applied to samples along with 55 minutes. Microwave digestion process was carried out in four steps. In the first step, temperature was kept at 150°C and 10 minutes process was accomplished with 5 minutes waiting period. Then, the second step was carried out for 10 minutes at 160°C with 5 minutes waiting time. In the third step, temperature was adjusted to 190°C, process duration was kept in 10 minutes and waiting period was increased to 10 minutes. In the last step, temperature was kept at 200°C, 3 minutes duration and 2 minutes waiting period was adjusted and process was completed [18].

## RESULTS AND DISCUSSION

### Determining the Effect of Carbonate on Element Contents in Teas

Element concentrations obtained by normal infusion, which is combined from the literature studies, and carbonated infusion for tea groups are given in Table 1 and Table 2, respectively. Also, detection limits of the analysed elements are shown in Table 3. According to the obtained experimental data, there is a decrease in Ca, Cr, K, Mg, Mn, P and Se element concentrations in black, green and earl grey teas with the addition of carbonate. Both in the three types of teas, greatest decrease was seen in the Mn concentration. In addition, the concentration of the element Co in black, earl grey and green tea

**Table 1.** Normal infusion essential element concentrations of black, earl grey, green, fennel, mint, sage, apple, lemon and rosehip teas (ppm) [1, 18]

| Element | Black Tea | Earl Grey Tea | Green Tea | Fennel Tea | Mint Tea | Sage Tea | Apple Tea | Lemon Tea | Rosehip Tea |
|---|---|---|---|---|---|---|---|---|---|
| Ca | 2.528±0.003 | 2.636±0.047 | 9.271±0.083 | 24.34±0.354 | 61.86±3.132 | 33.98±0.003 | 34.62±0.912 | 67.62±3.210 | 53.41±1.181 |
| Co | b.d.l. | b.d.l. | b.d.l. | 0.052±0.004 | b.d.l. | 0.040±0.003 | 0.053±0.004 | 0.00113±0.00011 | 0.073±0.007 |
| Cr | 0.048±0.004 | 0.044±0.003 | 0.148±0.008 | 0.0014±0.0001 | 0.0014±0.0001 | 0.235±0.022 | 0.036±0.028 | 0.128±0.010 | 0.0084±0.0001 |
| Fe | 2.396±0.04 | 2.539±0.105 | b.d.l. | b.d.l. | 0.029±0.0001 | b.d.l. | 4.968±0.490 | 2.424±0.240 | 4.585±0.062 |
| K | 295.1±6.9 | 293.5±8.000 | 235.8±3.700 | 178.7±11.17 | 168.5±6.930 | 141.3±9.829 | 118.2±0.778 | 93.72±0.339 | 177.8±4.667 |
| Mg | 11.02±0.23 | 10.57±0.740 | 12.61±0.460 | 24.65±0.134 | 52.84±0.212 | 16.57±0.559 | 14.27±0.127 | 19.71±0.368 | 29.14±0.106 |
| Mn | 217.5±8.60 | 178.1±9.200 | 116.5±0.500 | 0.373±0.020 | 0.227±0.001 | 6.790±0.510 | 61.68±2.620 | 16.16±1.440 | 102.1±5.900 |
| Na | b.d.l. | b.d.l. | b.d.l. | b.d.l. | 17.33±0.1697 | 55.44±4.533 | b.d.l. | b.d.l. | b.d.l. |
| P | 21.92±0.28 | 20.95±0.760 | 14.55±0.520 | 11.93±0.438 | 17.05±0.269 | 8.660±0.130 | 7.444±0.138 | 8.192±0.077 | 10.52±0.389 |
| Se | 1.093±0.045 | 1.180±0.008 | 0.280±0.001 | 0.398±0.034 | 0.010±0.001 | 0.0044±0.0001 | 0.547±0.053 | 0.180±0.016 | 0.421±0.025 |
| Zn | b.d.l. | b.d.l. | 3.202±0.0264 | b.d.l. | 0.047±0.003 | 0.031±0.0014 | 0.383±0.001 | b.d.l. | 0.743±0.064 |

*b.d.l: Below detection limit

**Table 2.** Carbonate effect on essential element concentrations of black, earl grey, green, fennel, mint, sage, apple, lemon and rosehip teas (ppm)

| Element | Black Tea | Earl Grey Tea | Green Tea | Fennel Tea | Mint Tea | Sage Tea | Apple Tea | Lemon Tea | Rosehip Tea |
|---|---|---|---|---|---|---|---|---|---|
| Ca | 1.592±0.015 | 1.768±0.037 | 2.128±0.118 | 30.65±1.457 | 37.20±2.835 | 34.86±1.803 | 25.62±0.636 | 68.55±6.739 | 50.29±2.065 |
| Co | 0.001±0.0002 | 0.001±0.0002 | 0.002±0.0001 | 0.001±0.0002 | b.d.l. | 0.001±0.0002 | 0.001±0.0002 | b.d.l. | 0.003±0.0003 |
| Cr | 0.004±0.0004 | 0.003±0.0004 | 0.002±0.0001 | 0.002±0.0001 | 0.001±0.0002 | 0.001±0.0002 | 0.001±0.002 | 0.004±0.0003 | 0.002±0.0003 |
| Fe | 0.018±0.001 | 0.016±0.0003 | 0.024±0.001 | 0.017±0.001 | 0.030±0.002 | 0.024±0.0003 | 0.116±0.008 | 0.012±0.0003 | 0.126±0.002 |
| K | 119.9±2.758 | 116.9±4.950 | 91.96±0.806 | 191.1±5.162 | 200.0±1.414 | 132.4±9.192 | 93.79±4.504 | 94.44±0.120 | 193.4±3.536 |
| Mg | 10.01±0.058 | 8.494±0.454 | 8.118±0.281 | 27.00±1.167 | 44.52±2.807 | 21.97±0.933 | 11.94±0.339 | 18.28±0.636 | 31.53±1.308 |
| Mn | 1.273±0.042 | 1.280±0.021 | 1.682±0.076 | 0.027±0.001 | 0.048±0.004 | 0.044±0.002 | 1.367±0.046 | 0.430±0.017 | 1.626±0.069 |
| Na | 239.6±11.24 | 242.1±1.273 | 243.5±11.24 | 293.3±5.940 | 311.3±16.26 | 237.7±22.27 | 255.1±7.920 | 250.6±5.657 | 252.7±1.344 |
| P | 17.52±0.919 | 13.91±0.445 | 9.425±0.492 | 15.12±0.092 | 9.237±0.506 | 8.535±0.346 | 10.13±0.014 | 6.451±0.036 | 15.56±0.707 |
| Se | 0.016±0.001 | 0.014±0.001 | 0.023±0.0003 | b.d.l. | 0.015±0.001 | 0.028±0.001 | 0.007±0.0003 | 0.030±0.003 | 0.008±0.001 |
| Zn | 0.105±0.006 | 0.094±0.004 | 0.104±0.006 | 0.071±0.002 | 0.058±0.006 | 0.102±0.004 | 0.147±0.006 | 0.097±0.007 | 0.203±0.007 |

**Table 3.** Detection limits of analysed elements

| | Ca (ppm) | Co (ppm) | Cu (ppm) | Fe (ppm) | K (ppm) |
|---|---|---|---|---|---|
| LOD | 0.0063 | 0.0005 | 0.0004 | 0.0017 | 0.0015 |
| LOQ | 0.0209 | 0.0015 | 0.0013 | 0.0055 | 0.0049 |
| | **Mg (ppm)** | **Na (ppm)** | **P (ppm)** | **Se (ppm)** | **Zn (ppm)** |
| LOD | 0.0010 | 0.0029 | 0.0038 | 0.0019 | 0.0002 |
| LOQ | 0.0035 | 0.0096 | 0.0125 | 0.0065 | 0.0006 |

was below the detection limits but it was determined as 0.001 ppm, 0.001 ppm and 0.002 ppm, respectively, when brewed by adding carbonate. Similar to Co, because of the carbonate salt structure, the concentration of the element Na was determined as 239.6 ppm, 242.1 ppm and 243.5 ppm, respectively, when brewed by adding carbonate while the instrument was below the detection limits in black, earl grey and green tea. Concentration of Fe; while it decreased in black and earl grey tea, it increased to 0.024 ppm after carbonated infusion while the instrument was below detection limits in green tea. While the Zn element was below the instrument detection limits in black and earl grey tea, it was determined as 0.105 ppm and 0.094 ppm, respectively, after carbonated infusion. Zn element concentration decreased from 3.202 ppm to 0.104 ppm in green tea. Essential element concentrations except Na of black, early grey and green teas with carbonate addition are lower than lemon addition effect report of Derun [19].

In fennel tea, Ca, K, Mg and P elements concentrations increased while Co, Mn and Se elements concentrations decreased. Fe, Na, Zn element concentrations were also below the instrument detection limits, and were determined as 0.017 ppm, 293.3 ppm and 0.071 ppm, respectively, after infusion with carbonate addition. In mint tea, Fe, K, Se and Zn elements concentrations increased while concentrations of Ca, Mg, Mn and P elements decreased. The Na element concentration also increased from 17.33 ppm to 311.3 ppm in mint tea after carbonated infusion due to the Na content from the structure of the carbonate salt. Cr concentration in fennel and mint tea did not change with carbonated infusion. Co element is below the ICP-OES measurement limit in mint tea. In sage tea, Ca and Mg element concentrations increased when Co decreased from 0.04 ppm to 0.001 ppm, Cr decreased from 0.235 ppm to 0.001 ppm, K decreased from 141.3 ppm to 132.4 ppm, Mn decreased from 6.79 ppm to 0.044 ppm and P from 8.66 ppm to 8.54 ppm. While the Fe element concentration in sage tea was out of the device detection limits, it increased to 0.024 ppm after carbonated infusion. Na element concentration was increased from 55.44 ppm to 237.7 ppm and the concentration of Se element increased from 0.004 ppm to 0.028 ppm after carbonated infusion. Ca, Co, Fe, K, Mg, P, Se and Zn element concentrations of fennel and sage teas with carbonate addition are lower than lemon addition while Co element concentration in mint tea with carbonate addition and lemon addition results of Gorgulu et al. are below detection limit [1].

**Determination of Element Contents in Teas with Microwave Digestion Method**

Essential element contents of black, herbal and fruit teas in powder form were determined by ICP-OES using microwave digestion method and results are given in Table 4. The element concentrations obtained by ICP-OES as a result of normal infusion on previously selected teas were compared with the element concentrations obtained after microwave digestion and it was determined what percentage of the element concentration contained in the tea in powder form. Also, essential element percentages from powder forms of selected teas to brew are given in Table 5. The most elements that pass from the powder form of black tea are; Se (47.63 %) and Mn (45.42 %). However, the highest concentrations of elements in powder form are K, Ca, P, Mg and Mn, respectively, and those with the highest concentrations of elements in infused form are K, Mn and P, respectively. The prominent situation here is that although some of the element concentrations such as Ca and Mg of powdered tea are high, the percentage of infusion is low, so the concentration of the infused element is low. In earl grey tea, most common elements from the powdered form to the infusion are Se (40.85%) and Mn (39.10%), respectively. After microwave digestion, concentrations of K, Ca, P, Mg and Mn elements are prominent and after infusion, K, Mn and P elements concentrations are high in earl grey tea, respectively. In green tea, after microwave digestion, elements that have high concentrations are K, Ca, P, Mg and Mn, respectively while elements with high concentrations after infusion are K, Mn and P, respectively. After the microwave digestion method of fennel tea, the elements with the highest concentration are K, Ca, P and Mg, respectively. The element percentage range of mint tea passing from powder to brew is quite narrow and ranges from 0.021% to 2.166%. In mint tea, according to the teas examined so far, the element concentration order after microwave digestion is parallel to the element concentration order after normal infusion. This is due to the fact that the percentages are

**Table 4.** Microwave digestion results on essential elements concentrations of black, earl grey, green, fennel, mint, sage, apple, lemon and rosehip teas (ppm)

| Element | Black Tea | Earl Grey Tea | Green Tea | Fennel Tea | Mint Tea | Sage Tea | Apple Tea | Lemon Tea | Rosehip Tea |
|---|---|---|---|---|---|---|---|---|---|
| Ca | 2777.0±4.243 | 2772.5±7.778 | 3238.5±31.82 | 5580.0±210.7 | 7638.0±3.132 | 9674.0±87.68 | 2859.0±50.91 | 10320.0±381.8 | 5865.5±28.99 |
| Co | 0.106±0.005 | 0.079±0.003 | 0.109±0.006 | 0.179±0.013 | 0.065±0.005 | 0.169±0.006 | 0.074±0.003 | 0.075±0.003 | 0.107±0.006 |
| Cr | 0.606±0.003 | 0.726±0.019 | 0.316±0.022 | 0.376±0.024 | 0.140±0.113 | 1.291±0.110 | 0.649±0.007 | 0.517±0.023 | 0.189±0.004 |
| Fe | 79.17±0.092 | 113.8±4.596 | 99.64±0.502 | 99.28±0.912 | 138.90±9.051 | 478.8±0.141 | 140.9±1.273 | 100.4±2.821 | 72.94±1.223 |
| K | 16305.0±7.071 | 15575.0±261.6 | 12285.0±77.78 | 14670.0±721.3 | 14500.0±551.5 | 12360.0±70.71 | 7846.5±45.96 | 8505.5±201.5 | 12605.0±77.78 |
| Mg | 665.7±3.818 | 694.35±3.465 | 683.1±17.18 | 2878.0±46.67 | 3640.0±222.03 | 1777.0±2.828 | 736.4±5.091 | 1726.5±120.9 | 1478.5±19.09 |
| Mn | 478.8±12.02 | 455.55±15.91 | 557.4±9.617 | 4.182±0.008 | 25.61±0.354 | 28.97±0.057 | 100.1±0.382 | 94.10±0.771 | 115.45±3.182 |
| Na | 114.6±3.960 | 142.55±0.071 | 77.94±4.872 | 452.0±22.77 | 800.1±49.78 | 93.64±1.874 | 42.14±0.750 | 236.8±15.27 | 43.15±0.650 |
| P | 1283.5±19.09 | 1362.5±3.536 | 1506.5±102.5 | 3207.5±115.3 | 1847.5±62.93 | 771.4±8.627 | 544.1±1.626 | 1114.5±36.06 | 716.7±3.111 |
| Se | 2.293±0.224 | 2.879±0.002 | 1.947±0.002 | 1.723±0.020 | 1.391±0.095 | 0.290±0.001 | 1.378±0.004 | 1.283±0.083 | 1.546±0.043 |
| Zn | 2.534±0.041 | 2.774±0.038 | 3.410±0.084 | 3.079±0.024 | 6.646±0.410 | 2.521±0.249 | 3.847±0.075 | 13.00±0.636 | 4.709±0.080 |

**Table 5.** Essential element percentages (%) from powder forms of black, earl grey, green, fennel, mint, sage, apple, lemon and rosehip teas to brew

| Element | Black Tea | Earl Grey Tea | Green Tea | Fennel Tea | Mint Tea | Sage Tea | Apple Tea | Lemon Tea | Rosehip Tea |
|---|---|---|---|---|---|---|---|---|---|
| Ca | 0.091 | 0.095 | 0.286 | 0.436 | 0.810 | 0.351 | 1.211 | 0.655 | 0.910 |
| Co | b.d.l. | b.d.l. | 44.04 | 29.05 | b.d.l. | 23.67 | 71.62 | 1.507 | 68.22 |
| Cr | 7.921 | 6.065 | 46.91 | 0.372 | 1.000 | 18.21 | 51.77 | 24.78 | 4.444 |
| Fe | 3.027 | 2.232 | b.d.l. | b.d.l. | 0.021 | b.d.l. | 3.526 | 2.414 | 6.286 |
| K | 1.810 | 1.884 | 1.919 | 1.218 | 1.162 | 1.143 | 1.506 | 1.102 | 1.411 |
| Mg | 1.655 | 1.522 | 1.845 | 0.856 | 1.452 | 0.932 | 1.938 | 1.142 | 1.971 |
| Mn | 45.42 | 39.10 | 20.89 | 89.20 | 0.884 | 23.44 | 61.60 | 17.17 | 88.40 |
| Na | b.d.l. | b.d.l. | b.d.l. | b.d.l. | 2.166 | 59.20 | b.d.l. | b.d.l. | b.d.l. |
| P | 1.707 | 1.537 | 0.966 | 0.372 | 0.923 | 1.123 | 1.368 | 0.735 | 1.467 |
| Se | 47.63 | 40.85 | 14.38 | 23.10 | 0.683 | 1.382 | 39.71 | 14.04 | 27.24 |
| Zn | b.d.l. | b.d.l. | 93.91 | b.d.l. | 0.707 | 1.230 | 9.956 | b.d.l. | 15.78 |

close to each other and less. Among the element concentrations contained in sage tea after the microwave digestion method, the high elements are K, Ca, Mg, P and Fe, respectively. After infusion, this order is in the form of K, Na and Ca elements. As it is seen in Table 4, although the elements with the highest concentration of apple tea in powder form after K and Ca are Mg (736.4 ppm), P (544.1 ppm) and Fe (140.9 ppm), respectively, It is found in low concentrations in infused form compared to other elements due to the low percentage of infusion. When the concentration of the element of lemon tea in powdered and the infused form is compared; unlike the case with the eight other studied teas, the highest concentration in powdered lemon tea is not K, but Ca with 10,320.00 ppm. Ca, K and Mg elements are the first three elements with high concentration in lemon tea after microwave digestion. Sorting after infusion; has been changed to K, Ca and Mg, respectively, because of higher passing rate of the element K to the brew than the percentage of the element Ca. Finally, in rosehip tea; due to the high concentration of the elements of K, Ca and Mg in rosehip tea in powder form, although their passing percentages through brew are low, they are also in high concentrations in the infused form of rosehip tea compared to other elements.

## CONCLUSION

Eleven essential element content in various teas of black, earl grey, green, fennel, mint, sage apple, lemon and rosehip teas with ICP-OES after normal infusion was obtained firstly from literature, then with ICP-OES after carbonated infusion and with ICP-OES after microwave digestion to determine the amount of elements contained in the powder form of the selected teas by experimentally.

- According to the tables, after carbonate addition, the greatest decrease is seen in Mn element concentration in black tea, Cr and Mn concentrations in green tea, Fe concentration in earl grey tea, Se concentration in fennel tea, Mn concentration in mint tea, K concentration in sage tea, Se concentration in apple tea, Mn concentration in lemon and rosehip tea.
- After carbonate addition, in black, earl grey, green, fennel, apple, lemon and rosehip tea, due to the Na content from the structure of the carbonate salt, Na has the most increased element concentrations which are increased from below detection limits to 239.6 ppm, 242.1 ppm, 243.5 ppm, 293.3 ppm, 255.1 ppm, 250.6 ppm and 252.7 ppm, respectively.
- The Na element concentration also increased from 17.33 ppm to 311.3 ppm in mint tea and from 55.44 ppm to 237.7 ppm in sage tea. Also, there are some increases in P element concentration in fennel tea, Se concentration in mint tea, Mg concentration in sage tea.
- The highest essential element percentages of teas from powder form to brew are 47.63% of Se for black tea, 40.85% Se for earl grey tea, 93.91% of Zn for green tea, 89.20% of Mn for fennel tea, 2.166% of Na for mint tea, 59.20% of Na for sage tea, 71.62% of Co for apple tea, 24.78% of Cr for lemon tea and 88.40% of Mn for rosehip tea. Na element percentages of all teas except mint and sage tea from powder form to brew are below detection limit. Co element percentages of black, earl grey and mint teas, Fe element percentages of green, fennel and sage teas, Zn element percentages of black, earl grey, fennel and lemon teas are also below detection limit.
- As a result, since carbonated infusion reduces the concentration of the main elements in the tea, it is not recommended to add carbonate to obtain more brew from teas.


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## AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

## DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

## CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## ETHICS

There are no ethical issues with the publication of this manuscript.

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