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ORIGINAL ARTICLE

# Determination of trace element contaminants in herbal teas using ICP-MS by different sample preparation method

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**Abstract** In recent years, the consumption rate of herbal teas has increased rapidly. In this study, 28 different plants (fennel, linden, roots, chamomile, green tea, thyme, sage, rosemary, rosehip, ginger, balm, echinacea, blue tea etc.) used as herbal tea bags and leaves/flowers. Different types of herbal tea were prepared keeping boiling water in contact for ten min with herbal teas and were digested with $HNO_3$ and $H_2O_2$ in a microwave oven. In these samples, trace element concentrations (As, Ba, Cd, Co, Cu, Cr, Ni, Pb, Se, V, Zn) were determined by Inductively Coupled Plasma Mass Spectrometry. The analytical performances were assessed as linearity, the limit of detection, limit of quantification, specificity/selectivity and recovery (%). The recovery values changed between 88 and 112%.

**Keywords** Herbal teas · Inductively coupled plasma mass spectrometry (ICP-MS) · Sample preparation · Trace element determination

## Introduction

Herbs have been used throughout history to protect people from diseases in the Far East for healing purposes. These are defined as plants that are used as medicines to prevent diseases, maintain health, or cure diseases. In recent years, other natural plant has increased because of the belief that they could be more effective than synthetic pharmaceuticals for preventing or treating diseases (Aliu et al. 2013; Martin-Domingo et al. 2017). Among the most commonly used plants are fennel, linden, roots, chamomile, green tea, thyme, sage, rosemary, rosehip, ginger, balm, echinacea.

The components of herbal teas include essential or non-essential minerals/metals such as As, Ba, Cd, Co, Cu, Cr, Ni, Pb, Se, V and Zn. Since herbal teas are often produced in non-environment friendly areas, ıts may be contaminated with non-essential elements (Karak et al. 2011). Herbals readily absorb these elements through their roots. For example, sources of environmental pollution are varied, ranging from batteries containing cadmium to use of lead arsenate as insecticide and these can do toxic effects in humans (Gomez et al. 2007; Oyediran and Aladejana 2011).

Elements are determined by techniques, such as atomic absorption spectrometry (AAS) (Ahmad et al. 2019; Demirel et al. 2008; Divrikli et al. 2006; Jalbani et al. 2007; Soliman 2015; Soylak et al. 2012), inductively coupled plasma optical emission spectrometry (ICP-OES) (Altundag et al. 2019; Polh et al. 2018) and inductively coupled plasma mass spectrometry (ICP-MS) (Lozak et al. 2002; Milani et al. 2015). In addition, studies of elements have been conducted analyzing herbal beverages (bags and leaves/flowers) by disruptive methods such as microwave-assisted digestion or acidification with $HNO_3$ or direct analysis after sample dilution bags and leaves/flowers (Flaten and Lund 1997; Milani et al. 2015).

The aim of this work is to compare the applicability of the direct analysis method and the ones prepared by brewing the bag, leaves/flowers and applied for herbal tea beverages for the determination of constituents by ICP-MS.

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## Materials and methods

### Sampling

Twenty-eight plant teas having different brands (fennel, linden, roots, chamomile, green tea, thyme, sage, rosemary, rosehip, ginger, balm, echinacea, blue tea etc.) were purchased from different herbalists in Turkey. 13 of the samples (bags) were selected from the herbalist, where they were sold without packaging, while the other 15 (leaves) were industrial products in sealed food packs.

### Chemicals and apparatus

Elemental calibration standard were prepared from 10 μg $mL^{-1}$ of a multi-element stock standard solution. $HNO_3$ (Suprapure® grade, 65%) and $H_2O_2$ (30%) were bought from Merck. Ultrapure water was used from 18.2 MΩ cm at 25 °C a Millipore ultrapure water purification system (Bedford).

### Sample preparation analysis with microwave digestion

Just about 0.2 g of the sample was weighed and transferred to the digestion vessel of a Milestone microwave digestion system. 6 mL of concentrated $HNO_3$ and 2 mL of $H_2O_2$ were added to the pots, then which was closed and placed in the microwave. The microwave oven heating program was carried out in three running steps. The microwave oven was at specific power and pressure programmed (from 80 to 150 °C ramp time 5 min; linearly increased again 225 °C hold time 15 min; 70 °C cooling time 10 min). After, the digested samples were diluted to a final volume of 25 mL with ultrapure water. Reagent blanks were tested for possible interferences in each set of samples (Kilic et al. 2018).

### Sample preparation analysis with acid dilution

The samples are prepared from different brands tea which are brewed with 10 min boiling drinking water to get a tea infusion (Fernandez et al. 2002; Jalbani et al. 2007; Milani et al. 2015; Szymczycha-Madeja et al. 2012). The steeped tea beverages were filtered and 2% $HNO_3$ were added to each sample. Three replicates from each sample were analyzed.

### Instrumentation

A Perkin-Elmer ELAN DRC-e model ICP-MS system was used for simultaneous multi-element detection of As, Ba, Cd, Co, Cu, Cr, Ni, Pb, Se, V, and Zn. The ICP-MS operational conditions are summarized in Table 1.

### Analytical methods

The performance of the analytical method was appreciated in linearity, limit of detection (LOD), limit of quantification (LOQ) and recovery. LOQ and LOD were calculated separately (Eurachem 2014). The digested NIST 1640a natural water was used in the calculation of LOQ and LOD. Results were shown in Table 2.

### Statistical analysis

All analyses were measured in triplicate and the data were reported as means ± standard deviations. To identify the relationships between various trace elements analysis in the samples, statistical analyses (variance and multiple comparison) were performed using SPSS V. 23 software (SPSS Inc., Chicago, IL, U.S.A.).

## Results and discussion

### Data analytical methods results

The assay analytical method developed was subjected to validation by performing specificity, linearity, limit of detection and quantification, precision and accuracy. As a result, the analytical curves showed good linearity within working range (0.5–100 μg $L^{-1}$), with $R^2$ of determination higher than 0.9970. The LOD for all the elements investigated were found to be in the range of 0.50 and 5.55 μg $L^{-1}$. The recoveries ranged from 88 to 112%. Repeatability of the method was calculated as the relative standard deviation of 10 replicates of the NIST 1640A. The relative standard deviation was ranged between 1.2 and 4.7%. The mean data were given in Table 2.

### Trace element analysis of samples

Twenty-eight samples (herbal teas) sold in Antalya/Turkey from the herbalist were analyzed using the infusion-prepared samples and in the digested samples by ICP-MS. Results were shown in Tables 3 and 4. As, Cd, Pb, Se and V not detected (< LOD) in the samples after infusion by ICP-MS. Trace elements, "Ba, Co, Cr and Ni" were presented in the lower concentration. Concentrations of Cr, Co, Ba and Ni ranged from 3 to 51 μg $kg^{-1}$, LOD-7.0 μg $kg^{-1}$, < LOD-913 μg $kg^{-1}$ and 3–114 μg $kg^{-1}$, in all samples respectively. These elements, in their study using herbal teas were determined in high concentrations (Özcan et al. 2008). Ni is the common cause of metal

**Table 1** ICP-MS operating conditions

| Spectrometer | Elan DRC-e (Perkin Elmer SCIEX, Norwalk, CT, USA) |
|---|---|
| Sample Introduction | Scott spray chamber |
| RF Power | 1000 |
| Skimmer cone | Nickel |
| Sampler cone | Nickel |
| Gas flow rates (L $min^{-1}$) | Nebulizer gas flow: 0.81, Auxillary gas flow: 1.20 Plasma gas flow: 19 |
| Scannig mode | Peak hopping |
| Analytical masses (amu) | Standart mode $^{138}Ba$, $^{208}Pb$, $^{111}Cd$, $^{52}Cr$,$^{75}As$,$^{60}Ni$, $^{59}Co$, $^{51}V$, $^{66}Zn$, $^{63}Cu$, $^{82}Se$ |
| Number of sweeps/reading | 20 |
| Number of readings/replicate | 1 |
| Number of replicates | 3 |
| Auto sampler | CETAX ASX-520 |
| Dwell time per AMU (ms) | 50 |
| Sample flush | Time (50), speed (± rpm)-48 |
| Read delay | Time (15), speed (± rpm)-20 |
| Internal standart | Tb |

**Table 2** Analytical methods results

| Elements | $R^2$ values | Regression equation | LOD (μg $L^{-1}$) | LOQ (μg $L^{-1}$) | Recovery (1640 A) | %RSD |
|---|---|---|---|---|---|---|
| Cu | 0.9988 | y = 2444.2x − 631.23 | 3.73 | 12.43 | 102 ± 1.5 | 1.4 |
| Cr | 0.9978 | y = 3894.5x − 5738 | 2.73 | 9.11 | 90 ± 2.3 | 2.5 |
| Co | 0.9996 | y = 4473.2x + 185.23 | 1.01 | 3.37 | 112 ± 1.7 | 1.5 |
| Ni | 0.9994 | y = 1096.7x − 1376.3 | 2.05 | 6.84 | 89 ± 2.7 | 3.1 |
| Ba | 0.9992 | y = 8644.9x − 14,357 | 5.55 | 18.50 | 99 ± 1.2 | 1.2 |
| Se | 0.9996 | y = 61.135x + 9.8266 | 2.53 | 8.44 | 101 ± 4.2 | 4.2 |
| As | 0.9995 | y = 585.76x − 32.089 | 1.05 | 3.51 | 106 ± 4.4 | 4.1 |
| Pb | 0.9991 | y = 9078.3x − 4555 | 1.13 | 3.78 | 100 ± 3.2 | 3.1 |
| Cd | 0.9970 | y = 743.53x − 77.149 | 0.50 | 1.68 | 88 ± 4.3 | 4.7 |
| V | 0.9995 | y = 3996.1x + 350.98 | 1.25 | 4.15 | 105 ± 2.8 | 2.6 |
| Zn | 0.9990 | y = 398.72x − 346.63 | 2.68 | 8.94 | 93 ± 1.6 | 1.7 |

*LOD* limit of derection; *LOQ* limit of quantification; *%RSD* relative standard deviation

allergy among the people. Careful selection of drink with relatively low nickel concentration can help to control nickel dermatitis. The Ba concentration levels reported in other papers are slightly higher (Haidu et al. 2017). Zn and Cu are essential components of enzymatic in human (Salgueiro et al. 2002; Silva et al. 2009). The concentration of Zn in teas varied from 25 to 642 μg $kg^{-1}$. Cu was determined range 5–181 μg $kg^{-1}$. Zn and Cu were determined in high concentrations according to the (Haidu et al. 2017). The observed change in the elements content of herbal tea was probably due to the plant species. Also, its absorbability of the element, mineral composition of the soil in which the plant was grown as well as and its climatic conditions.

In this study, the Table 4 shows that the amounts of trace elements (including toxic elements) are higher in the samples treated with microwave digestion in comparison with acid dilution. Therefore, the microwave digestion preparation of the samples was found to be more effective in terms of trace elements extraction In general, the levels found in this study were obtained lower those described by Szymczycha-Madeja et al. (2014) who evaluated determination of inorganic constituents in herbal beverages on the market. However, differences between values found in the samples from this study and data available in the literature may result from the use of different procedures of the beverages preparation or even the origin of the herbal leaves used.

**Table 3** The amount of the elements in the sample after infusion

| Brand/sample | | As | Ba | Cd | Co | Cr | Cu | Ni | Pb | Se | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bag* | | | | | | | | | | | | |
| 1 | Fennel | < LOD | 23.0 ± 2.0 | < LOD | 5.0 ± 0.2 | 23.0 ± 1.2 | 181 ± 10 | 69.0 ± 4.0 | < LOD | < LOD | < LOD | 230 ± 11 |
| 1 | Linden | < LOD | 10.0 ± 0.2 | < LOD | < LOD | 3.0 ± 0.1 | 26.0 ± 0.4 | 8.0 ± 0.1 | < LOD | < LOD | < LOD | 42.0 ± 0.7 |
| 1 | Lavandula stoechas | < LOD | 18.0 ± 0.4 | < LOD | < LOD | 13.0 ± 0.2 | 32.0 ± 0.5 | 28.0 ± 0.4 | < LOD | < LOD | < LOD | 137 ± 2 |
| 1 | Camomile | < LOD | 8.0 ± 0.4 | < LOD | < LOD | 3.0 ± 0.1 | 20.0 ± 0.5 | 3.0 ± 0.1 | < LOD | < LOD | < LOD | 34.0 ± 1.6 |
| 1 | Green tea | < LOD | 81.0 ± 1.6 | < LOD | 7.0 ± 0.1 | 17.0 ± 0.5 | 97.0 ± 1 | 94.0 ± 1.7 | 5.0 ± 0.1 | < LOD | < LOD | 143 ± 3 |
| 1 | Thyme | < LOD | 108 ± 2 | < LOD | 3.0 ± 0.1 | 23.0 ± 0.5 | 61.0 ± 0.7 | 29.0 ± 0.6 | < LOD | < LOD | < LOD | 225 ± 6 |
| 1 | Sage | < LOD | 30.0 ± 0.8 | < LOD | 2.0 ± 0.2 | 16.0 ± 0.3 | 32.0 ± 0.6 | 72.0 ± 1.0 | 7.0 ± 0.2 | < LOD | < LOD | 218 ± 4 |
| 1 | Rosemary | < LOD | 65.0 ± 0.5 | < LOD | < LOD | 13.0 ± 0.1 | 48.0 ± 0.5 | 20.0 ± 0.1 | 13.0 ± 0.2 | < LOD | < LOD | 642 ± 4 |
| 1 | Rosehip | < LOD | 648 ± 30 | < LOD | 4.0 ± 0.2 | 32.0 ± 1.0 | 42.0 ± 1.4 | 36.0 ± 1.2 | < LOD | < LOD | < LOD | 273 ± 10 |
| 1 | Ginger | 8.1 ± 0.3 | 14.0 ± 0.4 | < LOD | 3.0 ± 0.2 | 6.0 ± 0.1 | 51.0 ± 0.6 | 17.0 ± 0.3 | < LOD | < LOD | < LOD | 163 ± 4 |
| 2 | Rosehip | < LOD | 913 ± 26 | < LOD | 4.0 ± 0.1 | 51.0 ± 1.5 | 69.0 ± 1.3 | 63.0 ± 1.0 | < LOD | < LOD | < LOD | 489 ± 13 |
| 2 | Linden | < LOD | 15.0 ± 0.2 | < LOD | < LOD | 8.0 ± 0.1 | 77.0 ± 0.8 | 19.0 ± 0.2 | < LOD | < LOD | < LOD | 107 ± 1 |
| 2 | Rosemary | < LOD | 31.0 ± 0.8 | < LOD | < LOD | 12.0 ± 0.3 | 38.0 ± 1.0 | 28.0 ± 0.7 | < LOD | < LOD | < LOD | 242 ± 6 |
| *Leaves/flowers* | | | | | | | | | | | | |
| 3 | Camomile | < LOD | < LOD | < LOD | < LOD | 4.0 ± 0.5 | 27.0 ± 2.4 | 7.0 ± 1 | < LOD | < LOD | < LOD | 65.0 ± 7.1 |
| 4 | Echinacea | < LOD | 89.0 ± 1.2 | 14.0 ± 0.2 | 2.0 ± 0.1 | 10.0 ± 0.1 | 50.0 ± 1.0 | 12.0 ± 0.2 | < LOD | < LOD | < LOD | 66.0 ± 1.0 |
| 5 | Linden | < LOD | < LOD | < LOD | < LOD | 3.0 ± 0.2 | 14.0 ± 0.6 | 3.0 ± 0.2 | < LOD | < LOD | < LOD | 25.0 ± 1.2 |
| 5 | Thyme | < LOD | < LOD | < LOD | < LOD | 4.0 ± 0.2 | 9.0 ± 0.2 | 3.0 ± 0.1 | < LOD | < LOD | < LOD | 34.0 ± 1.4 |
| 5 | Sage | < LOD | < LOD | < LOD | < LOD | 6.0 ± 3 | 13.0 ± 0.1 | < LOD | < LOD | < LOD | < LOD | 42.0 ± 1.2 |
| 5 | Blue tea | < LOD | < LOD | < LOD | < LOD | 10.0 ± 0.3 | 28.0 ± 0.7 | 7.0 ± 0.2 | < LOD | < LOD | < LOD | 93.0 ± 2.5 |
| 6 | Linden | < LOD | < LOD | < LOD | < LOD | 3.0 ± 0.1 | 12.0 ± 0.1 | < LOD | < LOD | < LOD | < LOD | 29.0 ± 0.4 |
| 6 | Balm | < LOD | 31.0 ± 1.2 | < LOD | < LOD | 9.0 ± 0.3 | 42.0 ± 1.3 | 6.0 ± 0.3 | < LOD | < LOD | < LOD | 82.0 ± 3.8 |
| 6 | Sage | < LOD | < LOD | < LOD | < LOD | 5.0 ± 0.1 | 5.0 ± 0.1 | 4.0 ± 0.1 | < LOD | < LOD | < LOD | 20.0 ± 0.3 |
| 7 | Sage | < LOD | < LOD | < LOD | < LOD | 5.0 ± 0.08 | 19.0 ± 0.5 | < LOD | < LOD | < LOD | < LOD | 27.0 ± 0.6 |
| 6 | Lavandula stoechas | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD | < LOD |
| 6 | Camomile | < LOD | 24.0 ± 0.3 | < LOD | < LOD | 7.0 ± 0.1 | 27.0 ± 0.3 | < LOD | < LOD | < LOD | < LOD | 53.0 ± 1.5 |
| 6 | Green tea | < LOD | 41.0 ± 2 | < LOD | 7.0 ± 0.1 | 23.0 ± 0.7 | 180 ± 5.3 | 114 ± 4.0 | < LOD | < LOD | < LOD | 177 ± 5 |
| 6 | Rosemary | < LOD | 13.0 ± 0.4 | < LOD | < LOD | 5.0 ± 0.2 | 16.0 ± 0.4 | 5.0 ± 0.2 | < LOD | < LOD | < LOD | 59.0 ± 0.1 |
| 7 | Fennel | < LOD | 15.0 ± 0.4 | < LOD | 2.0 ± 0.1 | 13.0 ± 0.4 | 55.0 ± 1.6 | 24.0 ± 0.7 | < LOD | < LOD | < LOD | 120 ± 3 |

**Table 4** The amount of the elements in the sample after microwave digestion

| Brand/sample | | As | Ba | Cd | Co | Cr | Cu | Ni | Pb | Se | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bag* | | | | | | | | | | | | |
| 1 | Fennel | 68.0 ± 0.8 | 1251 ± 77 | < LOD | 355 ± 8 | 675 ± 21 | 10,587 ± 137 | 2864 ± 44 | < LOD | 525 ± 27 | 580 ± 11 | 17,529 ± 30 |
| 1 | Linden | 116 ± 5 | 24,035 ± 368 | 29.0 ± 0.1 | 255 ± 4 | 143 ± 14 | 10,582 ± 84 | < LOD | 698 ± 15 | 281 ± 10 | 669 ± 9 | 8804 ± 18 |
| 1 | Lavandula stoechas | 115 ± 6 | 4854 ± 92 | < LOD | 394 ± 8 | 2238 ± 27 | 3849 ± 33 | 3210 ± 56 | 1049 ± 16 | 333 ± 13 | 1089 ± 14 | 15,776 ± 14 |
| 1 | Camomile | 176 ± 5 | 1562 ± 48 | 50.0 ± 0.1 | 356 ± 2 | 484 ± 18 | 10,608 ± 128 | < LOD | 215 ± 9 | 428 ± 34 | 1700 ± 17 | 18,155 ± 19 |
| 1 | Green tea | 119 ± 2 | 44,706 ± 407 | 55.0 ± 0.1 | 773 ± 10 | < LOD | 11,125 ± 142 | 2553 ± 32 | 811 ± 9 | 226 ± 12 | 157 ± 2 | 11,417 ± 8 |
| 1 | Thyme | 83.0 ± 6 | 28,302 ± 204 | < LOD | 298 ± 7 | 632 ± 12 | 7090 ± 64 | 167 ± 10 | 578 ± 7 | 146 ± 10 | 1286 ± 23 | 18,345 ± 2 |
| 1 | Sage | 83.0 ± 4 | 8469 ± 85 | < LOD | 327 ± 2 | 1411 ± 26 | 4989 ± 52 | 4740 ± 65 | 522 ± 1 | 130 ± 4 | 1102 ± 15 | 28,021 ± 14 |
| 1 | Rosemary | 225 ± 3 | 22,657 ± 151 | 204 ± 1 | 1747 ± 8 | 4006 ± 82 | 8464 ± 65 | 5329 ± 81 | 10,790 ± 71 | 166 ± 13 | 1994 ± 28 | 86,330 ± 54 |
| 1 | Rosehip | 18.0 ± 3 | 64,569 ± 519 | 25.0 ± 0.2 | 278 ± 4 | 5648 ± 98 | 4560 ± 50 | 1328 ± 24 | < LOD | 247 ± 11 | 147 ± 2 | 16,314 ± 7 |
| 1 | Ginger | 702 ± 18 | 12,783 ± 52 | 358 ± 1 | 507 ± 10 | < LOD | 6157 ± 56 | < LOD | 727 ± 5 | 800 ± 11 | 299 ± 3 | 16,049 ± 7 |
| 2 | Rosehip | 39.0 ± 2 | 71,335 ± 141 | 25.0 ± 0.1 | 291 ± 8 | < LOD | 4592 ± 41 | 277 ± 43 | 29.0 ± 0.1 | 227 ± 1 | 691 ± 11 | 19,085 ± 14 |
| 2 | Linden | 312 ± 4 | 19,117 ± 27 | 51.0 ± 0.3 | 402 ± 1 | 2811 ± 29 | 17,279 ± 54 | < LOD | 7119 ± 10 | 66.0 ± 2 | 1423 ± 6 | 15,107 ± 4 |
| 2 | Rosemary | 99.0 ± 4 | 14,880 ± 122 | 83.0 ± 0.1 | 232 ± 3 | 2041 ± 28 | 6529 ± 18 | 806 ± 13 | 2893 ± 1 | 111 ± 1 | 748 ± 6 | 34,111 ± 20 |
| *Leaves/ flowers* | | | | | | | | | | | | |
| 3 | Camomile | 208 ± 3 | 6335 ± 47 | 48.0 ± 0.2 | 216 ± 1 | 2543 ± 26 | 13,312 ± 98 | 3167 ± 12 | 361 ± 3 | 425 ± 24 | 623 ± 2 | 22,355 ± 18 |
| 4 | Echinacea | 84.0 ± 2 | 36,713 ± 135 | < LOD | 402 ± 2 | 2109 ± 13 | 9274 ± 19 | 2865 ± 16 | < LOD | 87.0 ± 0.8 | 232 ± 2 | 14,151 ± 4 |
| 5 | Linden | 81.0 ± 4 | 39,319 ± 153 | < LOD | 58.0 ± 0.6 | 2245 ± 33 | 7772 ± 54 | 1932 ± 8 | < LOD | 64.0 ± 0.5 | 203 ± 4 | 10,045 ± 2 |
| 5 | Thyme | 88.0 ± 1 | 8618 ± 15 | < LOD | 153 ± 2 | 2266 ± 15 | 5096 ± 47 | 1623 ± 18 | < LOD | 98.0 ± 13 | 331 ± 5 | 20,176 ± 13 |
| 5 | Sage | 65.0 ± 2 | 1286 ± 11 | < LOD | 79.0 ± 2.4 | 3065 ± 30 | 7861 ± 32 | 956 ± 10 | 50.0 ± 3 | 173 ± 1 | 325 ± 3 | 15,634 ± 4 |
| 5 | Blue tea | 178 ± 2 | 19,767 ± 320 | < LOD | 165 ± 1 | 3004 ± 32 | 15,609 ± 39 | 4086 ± 41 | 171 ± 7 | 61.0 ± 11 | 403 ± 5 | 34,017 ± 14 |
| 6 | Linden | 39.0 ± 0.6 | 2238 ± 18 | 27.0 ± 0.3 | 55.0 ± 0.4 | 2793 ± 27 | 9088 ± 84 | 1092 ± 10 | < LOD | 92.0 ± 13 | 110 ± 1 | 17,023 ± 5 |
| 6 | Balm | 126 ± 7 | 47,561 ± 605 | < LOD | 537 ± 3 | 3420 ± 31 | 12,275 ± 127 | 3789 ± 15 | < LOD | 796 ± 7 | 1469 ± 12 | 17,263 ± 5 |
| 6 | Sage | 103 ± 1 | 18,114 ± 26 | < LOD | 1338 ± 6 | 3231 ± 26 | 4527 ± 21 | 3317 ± 16 | 63.0 ± 0.7 | 125 ± 1 | 823 ± 6 | 8310 ± 0.4 |
| 7 | Sage | 53.0 ± 3.0 | 4310 ± 16 | < LOD | 63.0 ± 1.0 | 1800 ± 20 | 7445 ± 46 | 753 ± 9 | < LOD | 169 ± 1 | 176 ± 1 | 10,537 ± 1 |
| 6 | Lavandula stoechas | 187 ± 5 | 28,861 ± 208 | < LOD | 151 ± 2 | 2969 ± 25 | 12,651 ± 55 | 2300 ± 9 | < LOD | 77.0 ± 0.6 | 535 ± 3 | 17,668 ± 4 |
| 6 | Camomile | 156 ± 2 | 38,407 ± 334 | 131 ± 0.3 | 241 ± 4 | 3723 ± 42 | 8358 ± 59 | 1380 ± 13 | 220 ± 4 | 143 ± 1 | 880 ± 10 | 20,477 ± 6 |
| 6 | Green tea | 103 ± 1 | 56,346 ± 194 | 36.0 ± 0.2 | 591 ± 7 | 3013 ± 44 | 13,555 ± 112 | 5678 ± 26 | 681 ± 3 | 124 ± 1 | 509 ± 1 | 16,341 ± 4 |
| 6 | Rosemary | 300 ± 5 | 17,719 ± 114 | < LOD | 149 ± 3 | 3879 ± 24 | 10,659 ± 54 | 7209 ± 65 | 1067 ± 11 | 1375 ± 24 | 573 ± 2 | 27,604 ± 18 |
| 7 | Fennel | 122 ± 4 | 9118 ± 7 | 17.0 ± 0.1 | 381 ± 8 | 3143 ± 47 | 12,638 ± 147 | 23,409 ± 192 | 502 ± 3 | 232 ± 13 | 206 ± 4 | 32,133 ± 26 |

Motivated by the increasing consumption of herbal beverages and considering all the aspects reported above, the main purpose of this study is to verify the applicability of the direct analysis and ICP-MS for the determination of inorganic constituents in herbal beverages sold.

## Conclusion

In this study, seven different brands of herbal tea (bags and leaves) were characterized in of the mass concentration of trace elements by different sample preparation methods. The linearity, LOD, LOQ, recovery and trueness were proved. Recovery values were determined to be over 85% for trace elements, indicating adequate precision and accuracy of the analyses. The trueness of the method and the performance of NIST 1640A natural water were to be considered satisfactory. The RSD ranged between 1.2 and 4.7%. A simple and fast sample preparation procedure, based on a partial decomposition by means of the solubilisation in, was developed, and its suitability prior to the multi-element analysis of slim teas by ICP-MS was assessed. Boiling water (10 min contact time) and microwave digestion between were evaluated. The results showed that the concentration of this element were higher in microwave digestion than in infusion-prepared. Based on our results, might be considered which determination of food content with accurate and sensitive analytical methods is important. Again according to the results, it is seen that leaves is more useful than tea bags.

#### Compliance with ethical standards

**Conflict of interest** The authors have no conflicts of interests to report.

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