Determination of lead, cadmium and arsenic in infusion tea cultivated in north of Iran

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Abstract

Tea is one of the most common drinks in all over the world. Rapid urbanization and industrialization in recent decades has increased heavy metals in tea and other foods. In this research, heavy metal contents such as lead (Pb), cadmium (Cd) and arsenic (As) were determined in 105 black tea samples cultivated in Guilan and Mazandaran Provinces in north of Iran and their tea infusions. The amount of heavy metals in black tea infusions were analyzed using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP - AES).

The mean ± SD level of Pb in 5, 15 and 60 min in infusion tea samples were 0.802 ± 0.633, 0.993 ± 0.667 and 1.367 ± 1.06 mg/kg of tea dry weight, respectively. The mean level of Cd in 5, 15 and 60 min in infusion tea samples were 0.135 ± 0.274, 0.244 ± 0.46 and 0.343 ± 0.473 mg/kg of tea dry weight, respectively. The mean level of As in 5, 15 and 60 min in infusion tea samples were 0.277 ± 0.272, 0.426 ± 0.402 and 0.563 ± 0.454 mg/kg of tea dry weight, respectively. Also, the results showed that the locations and the infusion times influenced upon the amount of these metals (P < 0.05).

Keywords: Heavy metals, Lead, Cadmium, Arsenic, Tea

Introduction

Tea is one of the most common drinks in all over the world, which is produced from the leaves of a shrub Camellia sinensis [1]. About 98% of people drink tea as the first among all beverages available to use [2]. The 75% of the estimated 2.5 million metric tons of desiccated tea that are produced annually is processed as black tea which is used by many countries [3]. About 18–20 billion cups of tea are consumed daily in the world [4].

Iran is a tea-producing country and relies on substantial imports to supplement its production to satisfy the considerable consumption needs. Iranians hold one of the highest per capita rates in tea consumption in the world, (about1.6 kg per capita consumption in the period of 2005–2007), [5]. Approximately 34 thousand hectares of lands in Guilan and Mazandaran provinces have been cultured for tea, almost half of the dry tea interior production and the remainder comes from imports. Most important source of nutrient uptake by leaf tea is from the medium [4].

Many studies have proved that tea has some beneficial effects on human health such as prevention from Parkinson’s disease, cardiovascular disease [6], cancer [7], immune disorders [8] and decrease of blood cholesterol levels [9]. Rapid urbanization and industrialization in recent decades has increased these metals in tea and other foods [10]. Plants receive these trace elements from growth media [11]; other sources include application of pesticides and fertilizers [12]. Heavy metals such as Pb, Cd and As create concerns for tea consumers. In addition, fluoride concentration is usually very high in black tea [13]. Pb is a physiologic and neurological toxin that can affect several organs in the human body. Each country sets tolerable limit for Pb concentration in tea leaves. And 20 mg/kg in Japan, while in China the limit is 2 mg/kg.

Cd and Pb can reduce cognitive development and intellectual performance in children and damage kidneys and the reproductive system [14]. Cd is also identified to be carcinogenic, and has been related to lung and prostate cancer [15]. Arsenic is strongly
related with lung and skin cancer in humans, and may cause other interior cancers as well. Skin lesions, peripheral neuropathy, and anemia are characteristics of chronic arsenic intake. Also, As is a major risk factor for black foot disease, which is caused by intake polluted ground water [16]. In a study the concentration of Aluminum was determined in black tea infusion samples [17]. Therefore, determination of these elemental compositions in tea and related products is very essential [18]. The main aim of this study was to investigate the quantity of Pb, As and Cd levels in tea samples that are cultivated in Guilan and Mazandaran provinces in north of Iran.

**Materials and methods**

This study was carried out between September and November 2010 on tea samples that are cultivated in Guilan and Mazandaran Provinces in north of Iran (Figure 1). Guilan and Mazandaran have a humid temperate climate with enough annual precipitation. 105 black tea samples were obtained randomly from 105 farms in the two different regions of Lahijan and Guilan provinces. The amount of each sample was about 100 g.

The glassware containers used for analysis were washed with detergent and rinsed several times with tap water to remove absorbance due to detergent; then they were soaked overnight in 6 N HNO₃ (Merck) solutions and

| Region Name  | No |
|--------------|----|
| Amlash       | 1  |
| Bazkiagorab  | 2  |
| Fuman        |    |
| Ketalom      | 4  |
| Kelar Abad   | 5  |
| Lahijan      | 6  |
| Ramsar       | 7  |
| Rasht        |    |
| Shaft        |    |
| Siahkal      | 10 |
| Soumahesara  | 11 |
| Tonekabon    | 12 |

![Figure 1 Location of Guilan and Mazandaran provinces and sampling regions.](image)

Table 1 The levels of lead, cadmium and arsenic in different infusions (n = 945)

| Heavy Metals (mg/kg) | Infusion times (min) |
|----------------------|----------------------|
|                      | 5        | 15       | 60       |
| Pb       | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  |
| 0.00 | 3.28 | 0.802 | 0.63 | 0.00 | 2.95 | 0.993 | 0.66 | 0.01 | 8.16 | 1.367 | 1.06 |
| Cd      | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  |
| 0.00 | 2.02 | 0.135 | 0.27 | 0.00 | 3.88 | 0.244 | 0.46 | 0.01 | 3.04 | 0.343 | 0.47 |
| As      | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  |
| 0.00 | 1.15 | 0.277 | 0.27 | 0.00 | 3.09 | 0.426 | 0.40 | 0.01 | 3.72 | 0.563 | 0.45 |
finally rinsed with deionized water. All aqueous solutions and dilutions were prepared with ultrapure water (c). 5 g of each tea sample was weighted by a digital analytical balance (Mettler Toledo, Switzerland) with ± 0.0001 g precision and then was added to 500 mL of boiling tap water and allowed to infuse for 5, 15 and 60 min. Then samples were filtered under vacuum (using a Whatman No.42 filter paper) to eliminate any turbidity or suspended substance. Liquors from the first, second and third infusions were analyzed for lead, cadmium and arsenic contents by Inductively Coupled Plasma Optic Emission Spectrometry (ICP-OES EOP, Spectroacros, Germany). The blank solution was prepared in similar way without black tea.

The purity of argon as carrier gas was 99.999% (grade 5), with a flow rate of 0.7 L/min for supplementary and Modified Lichte nebulizer and 13 L/min for coolant flow. The speed of 4 channel peristaltic pump was 60 rpm for 45 S in pre-flush condition and 30 rpm for analysis. The power level was adjusted on 1400 KW. Before quantitative analysis of samples, calibration curves of the desired metals were prepared using a series of diluted standard solutions. The recovery percentage, detection limits, and % R.S.D for triplicate measurements of the measured elements were 90%–95%, 0.3 ppb, and less than 5%, respectively. Statistical analysis of the obtained results was preformed by SPSS 18 and One Way ANOVA test was used; results are expressed by mean ± SD.

### Table 2: The levels of Pb (mg/kg) in different infusions of tea samples (n=315)

| Region     | Sample size | Infusion time (min) | Min | Max | Mean | SD  | Min | Max | Mean | SD  | Min | Max | Mean | SD  |
|------------|-------------|---------------------|-----|-----|------|-----|-----|-----|------|-----|-----|-----|------|-----|
| Amlash     | 30          | 5                   | 0.32| 2.03| 1.08 | 0.62| 0.41| 1.57| 1.10 | 0.38| 0.48| 8.16| 2.192| 2.17|
| Bazkiagorab| 3           | 15                  | 0.51| 0.51| 0.508| 0.00| 0.6 | 0.6 | 0.597| 0.00| 0.62| 0.62| 0.624| 0.00|
| Fuman      | 24          | 60                  | 0.00| 0.76| 0.424| 0.29| 0.01| 0.85| 0.534| 0.34| 0.05| 1.25| 0.725| 0.45|
| Ketalom    | 60          | 5                   | 0.00| 2.38| 0.535| 0.63| 0.00| 2.91| 0.732| 0.76| 0.01| 3.73| 0.999| 0.90|
| Kelar Abad | 18          | 15                  | 0.15| 1.52| 0.917| 0.51| 0.26| 1.71| 1.166| 0.49| 0.87| 2.35| 1.457| 0.48|
| Lahijan    | 45          |                     | 0.06| 3.28| 0.937| 0.79| 0.34| 2.92| 1.102| 0.66| 0.44| 2.85| 1.317| 0.64|
| Ramsar     | 3           | 5                   | 0.41| 0.41| 0.415| 0.00| 0.59| 0.59| 0.594| 0.00| 0.63| 0.63| 0.632| 0.00|
| Rasht      | 21          | 60                  | 0.39| 0.86| 0.627| 0.17| 0.59| 1.67| 0.949| 0.36| 0.6 | 2.35| 1.270| 0.64|
| Shaft      | 12          | 5                   | 0.36| 0.62| 0.496| 0.13| 0.58| 0.81| 0.688| 0.10| 0.6 | 1.31| 0.919| 0.30|
| Siahkal    | 48          | 15                  | 0.23| 2.82| 1.211| 0.76| 0.25| 2.95| 1.455| 0.91| 0.44| 4.32| 1.938| 1.15|
| Sournahesara| 6          | 60                  | 0.98| 1.51| 1.246| 0.37| 1.58| 2.32| 1.948| 0.52| 1.82| 2.72| 2.271| 0.63|
| Tonekabon  | 45          |                     | 0.06| 1.33| 0.708| 0.44| 0.22| 1.43| 0.865| 0.43| 0.35| 2.35| 1.208| 0.60|

### Table 3: The levels of Cd (mg/kg) in different infusions of tea samples (n=315)

| Region     | Sample size | Infusion time (min) | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  | Min  | Max  | Mean | SD  |
|------------|-------------|---------------------|------|------|------|-----|------|------|------|-----|------|------|------|-----|
| Amlash     | 30          | 5                   | 0.03 | 1.06 | 0.387| 0.41| 0.06 | 1.15 | 0.545| 0.42| 0.07 | 1.25| 0.597| 0.43|
| Bazkiagorab| 3           | 15                  | 0.02 | 0.02 | 0.016| 0.00| 0.02 | 0.02 | 0.019| 0.00| 0.03 | 0.03| 0.028| 0.00|
| Fuman      | 24          | 60                  | 0.02 | 0.26 | 0.077| 0.08| 0.03 | 0.4  | 0.121| 0.12| 0.05 | 0.78| 0.225| 0.24|
| Ketalom    | 60          | 5                   | 0.01 | 0.82 | 0.188| 0.22| 0.01 | 0.99 | 0.283| 0.30| 0.02 | 0.99| 0.315| 0.32|
| Kelar Abad | 18          | 15                  | 0.00 | 2.02 | 0.351| 0.82| 0.02 | 3.88 | 0.889| 1.51| 0.02 | 3.04| 1.072| 1.10|
| Lahijan    | 45          | 60                  | 0.00 | 0.26 | 0.052| 0.06| 0.01 | 0.31 | 0.068| 0.07| 0.01 | 0.43| 0.091| 0.102|
| Ramsar     | 3           | 5                   | 0.04 | 0.04 | 0.039| 0.00| 0.06 | 0.06 | 0.055| 0.00| 0.07 | 0.07| 0.068| 0.00|
| Rasht      | 21          | 60                  | 0.00 | 0.57 | 0.203| 0.21| 0.01 | 0.69 | 0.288| 0.27| 0.01 | 0.8 | 0.383| 0.34|
| Shaft      | 12          | 5                   | 0.00 | 0.22 | 0.106| 0.11| 0.02 | 0.36 | 0.157| 0.16| 0.03 | 0.63| 0.258| 0.26|
| Siahkal    | 48          | 15                  | 0.00 | 0.1  | 0.028| 0.03| 0.00 | 0.22 | 0.064| 0.05| 0.01 | 1.17| 0.165| 0.26|
| Sournahesara| 6          | 60                  | 0.00 | 0.00 | 0.002| 0.00| 0.01 | 0.01 | 0.012| 0.00| 0.02 | 1.17| 0.591| 0.81|
| Tonekabon  | 45          |                     | 0.00 | 0.23 | 0.045| 0.06| 0.01 | 1.06 | 0.226| 0.35| 0.06 | 1.76| 0.511| 0.56|
Results
The results of Pb, Cd and As obtained from tea infusion samples in 5, 15 and 60 min are presented in Table 1. The mean ± SD level of Pb in 5, 15 and 60 min in infusion tea samples were 0.802 ± 0.63, 0.993 ± 0.66 and 1.367 ± 1.06 mg/kg of tea dry weight, respectively. The mean level of Cd in 5, 15 and 60 min in infusion tea samples were 0.135 ± 0.27, 0.244 ± 0.46 and 0.343 ± 0.47 mg/kg of tea dry weight, respectively. The mean level of As in 5, 15 and 60 min in infusion tea samples were 0.277 ± 0.27, 0.426 ± 0.40 and 0.343 ± 0.47 mg/kg of tea dry weight, respectively. The results also showed that infusion time influenced upon the amount of Pb, Cd and As in infusion tea (P < 0.001), (P = 0.001) and (P < 0.001), respectively.

Table 2 presents the amount of Pb content according to locations and infusion time. The maximum level of Pb was determined in Soumehe-sara, for which the amount of this metal in infusion times of 5, 15 and 60 min were 1.24 ± 0.37, 1.94 ± 0.52 and 2.27 ± 0.63 mg/kg, respectively. The minimum level of Pb was determined in Fuman, and the amount in infusion times of 5, 15 and 60 min were 0.424 ± 0.29, 0.534 ± 0.34 and 0.725 ± 0.45 mg/kg, respectively. Also results showed location influenced upon the amount of Pb in infusion tea samples (P < 0.001).

Table 3 showed the amount of Cd content according to locations and infusion time. The maximum level of Cd was determined in Amlash, for which the amount of this metal in infusion times of 5, 15 and 60 min were 0.387 ± 0.41, 0.545 ± 0.41 and 0.597 ± 0.43 mg/kg, respectively. The minimum level of Cd was determined in Soumehe-sara, for which the amount of this metal in infusion times of 5, 15 and 60 min were 0.002 ± 0.00, 0.012 ± 0.00 and 0.591 ± 0.81 mg/kg, respectively. Also results showed location influenced upon the amount of Cd in infusion tea samples (P < 0.001).

Table 4 The levels of As (mg/kg) in different infusions of tea samples (n = 315)

| Region     | Sample size | Infusion time (min) | Pb         | Cd         | As         |
|------------|-------------|---------------------|------------|------------|------------|
|            |             | 5                   | 15         | 60         |            |
| Amlash     | 30          | Min: 0.22, Max: 1.10, Mean: 0.552, SD: 0.30 | Min: 0.28, Max: 1.3, Mean: 0.709, SD: 0.35 | Min: 0.57, Max: 1.16, Mean: 0.771, SD: 0.21 |
| Bazkiagorab| 3           | Min: 0.01, Max: 0.01, Mean: 0.011, SD: 0.00 | Min: 0.01, Max: 0.01, Mean: 0.014, SD: 0.00 | Min: 0.02, Max: 0.02, Mean: 0.022, SD: 0.00 |
| Fuman      | 24          | Min: 0.01, Max: 0.39, Mean: 0.159, SD: 0.18 | Min: 0.02, Max: 0.59, Mean: 0.243, SD: 0.21 | Min: 0.02, Max: 0.79, Mean: 0.343, SD: 0.28 |
| Ketalom    | 60          | Min: 0.00, Max: 0.62, Mean: 0.198, SD: 0.21 | Min: 0.01, Max: 0.78, Mean: 0.299, SD: 0.23 | Min: 0.01, Max: 0.86, Mean: 0.389, SD: 0.26 |
| Kelar Abad | 18          | Min: 0.00, Max: 1.15, Mean: 0.410, SD: 0.43 | Min: 0.04, Max: 3.09, Mean: 0.974, SD: 1.09 | Min: 0.56, Max: 3.72, Mean: 1.411, SD: 1.19 |
| Lahijan    | 45          | Min: 0.00, Max: 0.59, Mean: 0.213, SD: 0.15 | Min: 0.02, Max: 0.7, Mean: 0.353, SD: 0.18 | Min: 0.04, Max: 0.79, Mean: 0.459, SD: 0.20 |
| Ramsar     | 3           | Min: 0.22, Max: 0.22, Mean: 0.224, SD: 0.00 | Min: 0.29, Max: 0.29, Mean: 0.292, SD: 0.00 | Min: 0.04, Max: 0.43, Mean: 0.43, SD: 0.00 |
| Rasht      | 21          | Min: 0.00, Max: 0.57, Mean: 0.155, SD: 0.20 | Min: 0.00, Max: 0.59, Mean: 0.200, SD: 0.22 | Min: 0.05, Max: 0.6, Mean: 0.247, SD: 0.19 |
| Shaft      | 12          | Min: 0.00, Max: 0.42, Mean: 0.207, SD: 0.17 | Min: 0.00, Max: 0.57, Mean: 0.321, SD: 0.24 | Min: 0.01, Max: 0.6, Mean: 0.377, SD: 0.27 |
| Siahkal    | 48          | Min: 0.02, Max: 0.65, Mean: 0.218, SD: 0.19 | Min: 0.08, Max: 0.77, Mean: 0.396, SD: 0.23 | Min: 0.24, Max: 1.04, Mean: 0.644, SD: 0.24 |
| Sournahesara| 6          | Min: 0.36, Max: 0.57, Mean: 0.465, SD: 0.14 | Min: 0.52, Max: 0.97, Mean: 0.745, SD: 0.31 | Min: 0.59, Max: 1.02, Mean: 0.806, SD: 0.31 |
| Tonekabon  | 45          | Min: 0.02, Max: 0.97, Mean: 0.404, SD: 0.37 | Min: 0.02, Max: 1.18, Mean: 0.513, SD: 0.41 | Min: 0.1, Max: 1.36, Mean: 0.661, SD: 0.44 |

Table 5 The amount of Pb, Cd and As (mg/kg) in different tea samples from other countries

| Ref. | Country     | Year | Pb         | Cd         | As         |
|------|-------------|------|------------|------------|------------|
| 23   | Iran        | 2005 | 0.531 – 5.3| 0.038 – 0.272| Non-detectable |
| 5    | Iran        | 2010 | Non-detectable | Non-detectable | Non-detectable |
| 4    | Saudi Arabia| 2008 | 0.3 – 2.2 | 0.3 – 2.2 | Non-detectable |
| 10   | China       | 2005 | ———— | 0.056 | 0.28 |
| 6    | China       | 2007 | 0.198 – 6.345 | ———— | ———— |
| 24   | Pakistan    | 2006 | 0.25 – 4.75 | Non-detectable | ———— |
| 3    | Egypt       | 2008 | 0.03 – 0.76 | ———— | ———— |
| 21   | Turkey      | 2004 | < 8 – 27.3 | < 1 – 3 | ———— |
| 18   | Thailand    | 2006 | 0.0237 | 0.0071 | 0.00084 |
| 26   | India       | 2008 | 0.81 ± 0.32 | 0.14 ± 0.06 | ———— |
Table 4 shows the amount of As content according to locations and infusion time. The maximum level of As was determined in Amlash, which the amount of this metal in infusion times of 5, 15 and 60 min were 0.052 ± 0.3, 0.709 ± 0.35 and 0.771 ± 0.21 mg/kg respectively. The minimum level of As was determined in Bazkiator, which the amount of this metal in infusion times of 5, 15 and 60 min were 0.011 ± 0.00, 0.014 ± 0.00 and 0.022 ± 0.00 mg/kg, respectively. Also results showed location influenced upon the amount of As in infusion tea samples (P < 0.001).

Discussion
The results showed that the maximum and minimum Pb of lead was determined in Soumahesara and Fuman, respectively. Also the maximum and minimum level for Cd was observed in Amlash and Soumahesara and the maximum and minimum level of As was determined in Amlash and Bazkiator. This study showed locations and infusion time influenced upon the amount of these metals (P < 0.05). The concentration of Pb in tea samples was lower than the permissible level (1 µg/kg) given by Iranian Ministry of Health. The amount of Pb level for Iran's tea samples were acceptable compared with limit prescribed by other countries such as China (5 µg/kg), India (10 µg/g) and Thailand (10 µg/g). The concentration of Cd in tea samples was lower than the standard limited value in Iran (10 mg/kg). The concentration of As in tea samples varied by locations and infusion time, that is below than that set as the standard maximum values by Iranian Ministry of Health (As 150 µg/g). All samples contained As at levels below by set the standard maximum values (4 mg/kg) [18].

The arsenic main sources of these heavy metals in tea samples are their growth media, such as soil. When fertilizers are applied to soils in tea cultivated area, heavy metals can be up taken by the plants. Soil contamination usually can be attributed to industrial, agricultural and urban activities. Table 5 shows the amount of Pb, Cd and As in tea samples from India, Turkey, Thailand, Taiwan, Pakistan, China, Ethiopia, Saudi Arabia, Iran and Nigeria [4,19-28].

Tea samples from north of Iran do not seem to be heavily contaminated with Pb, Cd and As. Tea samples from north of Iran do not seem to be heavily contaminated with Pb, Cd and As. Since the tea cultivation lands in north of Iran provide much of black tea being consumed in Iran and the exported amount to other countries, it is recommended all elements and compounds in tea infusions to be analyzed for safe consumption of black tea. In order to be in safe side, it is recommended that tea to be prepared with heavy metal free and very low fluoride waters and preferably bottled water [29].

Conclusion
After drinking water, tea is the most consumed beverage in Iran. In this regard health aspects related to tea is very important and therefore consumers should be very confident on the absence of any pollutants in black tea. The presence of any variations in metal contents in this study could be as a matter of the differences in methods of storage, tea leaf processing and the difference in soil metal concentrations. In addition, application of fertilizers causes increase of heavy metals in the cultivated soil.

In this study concentrations of lead, cadmium and arsenic were measured in black tea samples from different locations in different infusion times. It was deduced from the study that transfer of metals from black tea to brew depends on both locations and infusion times. The levels of lead, cadmium and arsenic were lower than the standards limits. Due to the lack of standards for all heavy metals in tea, it is recommended that the maximum allowable and safe concentrations to be established.

Competing interests
The author(s) declare that they have no competing interests.

Authors’ contributions
This study is a part of a research project. The study was directed by Dr. AHM who is the corresponding author and made the final preparation of article. Engineers SS, MG, and AM were engaged in sample preparations and laboratory work. Dr. MY helped on statistical data analysis and engineer SN as ICP expert performed the experiments by this device. The overall implementation of this study including the design, sample collection and preparations, laboratory experiments, data analysis, and manuscript preparation was performed by the corresponding author and the above team. All the authors have made extensive contribution into the review and finalization of this manuscript. All authors have read and approved the final manuscript.

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References
1. Dufresne CJ, Farnsworth NR. A review of latest research findings on the health promotion properties of tea. J Nutr Biochem 2001;12:404–421.
2. AL-Saleha I, Coskuro S, Masihoura A, Shimwara N, EL-Dousha I, Billedoa G, Jaroudic K, Abdulaziz AL-S, AL-Kabrab M, Mohamedd GED. Exposure to heavy metals (lead, cadmium and mercury) and its effect on the outcome of in-vitro fertilization treatment. Int J Hgy Environ Health 2007, article in press.
3. Lasheen YF, Awad NS, El-Khalafawy A, Abdel-Rassoul AA: Annual effective dose and concentration levels of heavy metals in different types of tea in Egypt. International Journal of Physical Sciences 2008, 3:112–119.

4. Ashraf W, Mian A: Levels of selected heavy metals in black tea varieties consumed in saudi arabia. Bull Environ Contam Toxicol 2008, 81:101–104.

5. Salahinejad M, Aflaki F: Toxic and Essential Mineral Elements Content of Black Tea Leaves and Their Tea Infusions Consumed in Iran. Biol Trace Elem Res 2010, 134:109–117.

6. Qin F, Chen W: Lead and copper levels in tea samples marketed in Beijing, China. Bull Environ Contam Toxicol 2007, 78:118–121.

7. Siddiqui IA, Raisuddin S, Shukla Y: Protective effects of black tea extract on testosterone induced oxidative damage in prostate. Cancer Lett 2005, 227:25–132.

8. Mark H: The beneficial effects of tea on immune function and inflammation: a review of evidence from in vitro, animal, and human research. Nutr Res 2007, 27:373–379.

9. Fujita H, Yamagami T: Antihypercholesterolemic effect of Chinese black tea extract in human subjects with borderline hypercholesterolemia. Nutr Res 2008, 28:450–456.

10. Han W, Shi Y, MA L, Ruan J: Arsenic, cadmium, chromium, cobalt, and copper in different types of Chinese tea. Bulletin of environmental contamination and toxicology 2005, 75:272–277.

11. Herrador MA, Gonzalez AG: Pattern recognition procedures for differentiation of green, black, and oolong teas according to their metal content from inductively coupled plasma atomic emission spectrometry. Talanta 2001, 53:1249–1257.

12. Atafar Z, Mesdaghinia A, Nouri J, Homae M, Yunesian M, Ahmadimoghaddam M, Mahvi AH: Effect of fertilizer application on soil heavy metal concentration. Environ Monit Assess 2010, 160:83–89.

13. Mahvi AH, Zazali MA, You necian M, Esfandiyari Y: Fluoride content of Iranian black tea and tea liquor. Fluoride 2006, 39:266–268.

14. ATSDR: A Toxicological profile for Cadmium. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. Division of Toxicology and Human Health Sciences; 2012.

15. Yang F, Li YP: The effects of different marinating method on solubility of the lead in tea leaves. Chin J Health Lab Technol 2001, 39:349.

16. Chen H W: Gallium indium, and arsenic pollution of groundwater from a semiconductor manufacturing area of Taiwan. Environ Contam Toxicol 2006, 77:289–296.

17. Moghaddam MA, Mahvi AH, Asgari AR, Yonesian M, Ja hed GH, Nazmara SH: Determination of aluminium and zinc in Iranian consumed tea. Environ Monit Assess 2008, 144:25–30.

18. Nookabkaew S, Rangkadilok N, Satayavivad J: Determination of trace elements in herbal tea products and their infusions consumed in Thailand. J Agric Food Chem 2006, 54:9999–9944.

19. Natesan S, Ranganathan V: Contents of various elements in parts of the tea plant and in infusions of black tea from southern India. J Sci Food Agric 1990, 51:125–139.

20. Onianwa PC, Adetola KG, Iwegbue CMA, Ojo MF, Tella OO: Trace heavy metals composition of some Nigerian beverages and food drinks. Food Chem 1999, 66:275–279.

21. Narin I, Colak H, Turkoglu O, Soyak M, Dogan M: Heavy metals in black tea samples produced in Turkey. Bull Environ Contam Toxicol 2004, 72:844–849.

22. Ebadi AG, Zare S, Mahdavi M, Babae M: Study and Measurement of Pb, Cd, Cr and Zn in Green Leaf of Tea Cultivated in Gillan Province of Iran. Pak J Nutr 2005, 4:270–272.

23. Hussain I, Khan F, Iqbal Y, Khalil SJ: Investigation of heavy metals in commercial tea brands. Jour.Chem.Soc.Pak 2006, 28:246–251.

24. Qin F, Chen W: Lead and copper levels in tea samples marketed in Beijing, China. Bull Environ Contam Toxicol 2007, 79:247–250.

25. Seenivasan S, Mankandam N, Muralidhara N, Sekasundaram R: Heavy metal content of black teas from south India. Food Control 2008, 19:746–749.

26. Shen F-M, Chen H-W: Element Composition of Tea Leaves and Tea Infusions and Its Impact on Health. Bull Environ Contam Toxicol 2008, 80:300–304.