ORIGINAL PAPER

Evaluating the Arsenic, Cadmium, Lead, and Copper levels in certain imported tea samples consumed in iran

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ABSTRACT

Seven majorly consumed brands of several teas (A1, A2, M1, M2, S, D, and C teas) were selected for the present study. In this study, the heavy metal contents including copper (Cu), cadmium (Cd), arsenic (As), and lead (Pb) were assessed in the black tea samples consumed in Iran. The content of the heavy metals in the samples was analyzed using atomic absorption spectroscopy (AAS). Notably, the minimal amount of As (0.043 ± 0.006 ppm), Pb (0.040 ± 0.005 ppm), Cd (0.016 ± 0.001 ppm), and Cu (5.36 ± 0.49 ppm) concentrations were found in the M1, S, M2, and M2 teas, respectively; whereas, the maximal amount of As (0.287 ± 0.007 ppm), Pb (0.228 ± 0.002 ppm), Cd (0.101 ± 0.040 ppm), and Cu (37.4 ± 0.53 ppm) concentrations were found in the D, A1, M1, and D teas, respectively. Considering the present safety standards, the tea versions selected in this study were determined to be fit and safe for human consumption.

Keywords: Black tea, Heavy metals, Atomic absorption spectroscopy

Introduction

Tea is a widely consumed beverage, which is mostly served worldwide, and the daily consumption of about 18–20 billion tea cups worldwide emphasize its economic and social interest.[1-2] Tea is extremely popular, with more than 40 countries worldwide growing it at present, which contributes to 90% of the world's total output by the Asian countries. Tea contains essential elements beneficial for human health, which specifically include antioxidants, flavonoids, minerals, and trace elements.[3] The chemical composition of tea and its leaves is widely studied in scientific literature, from medical, toxicological, or environmental point of view. The tea plant usually absorbs heavy metals from the soil, which accumulate in its leaves. Therefore, tea can be considered as a rich source of certain essential dietary metals required for humans. Heavy metal contents of certain foods are gaining interest due to their beneficial or toxic nature. Some heavy metals including iron, zinc, copper, chromium, cobalt, and manganese are essential; whereas arsenic, lead, cadmium, nickel, and mercury are toxic at certain levels. Several scientific studies have reported the potential health implications of trace metals in tea.[4]

Food naturally contains copper (Cu); thus, we consume about 1 mg of Cu daily, and in general, the amount of Cu in our body remains constant. Although Cu is beneficial for good health, exposure to the higher doses of Cu can have adverse effects on the liver and kidney and may even cause mortality. Cadmium (Cd) present in water and food (about 5–10%) enters the human body through the digestive tract and can be retained there for several years. If the Cd levels go beyond the safety or permissible limit, they may cause kidney damage. Lead (Pb) is a

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highly toxic metal, which mainly targets the nervous system. Pb exposure may also lead to weakness in the ankles and fingers; moreover, it may also cause a slight increase in the blood pressure and may adversely affect the sperm production.[5] Arsenic (As) is majorly associated with skin and lung cancer, peripheral neuropathy, and anemia in humans.[6] Several factors, including the variety of tea plant, soil/atmospheric conditions, the shelf life of raw materials used, and the processing of leaves, might influence the heavy metal concentration in both tea plants and the final tea products.[7-12] This study aimed to determine the As, Cd, Pb, and Cu concentrations of various imported tea brands, mainly consumed in Iran.

Materials and Methods

The black tea varieties collected from several countries were imported to the packaging tea factory, in April 2016. The brands are kept confidential for ethical reasons. All chemicals were of analytical grade from Merck Chemical Company, Darmstadt, Germany, and were used without further purification. Based on a previous study,[11] the analytical measurements for As were performed using the hydride generation system. The manufacturer operation procedure involved continuous addition of the reductant, comprising 0.3% $NaBH_4$, 1 mM $KMnO_4$, and 1.5% HCL. The Cd, Pb, and Cu levels were assessed by drying 5–10 g of the test portion to nearest 0.001 g on a water bath at 100 ºC and were then ashed at 400 ºC with a gradual increase (≤50 ºC/h) in the temperature. 5 mL $HClO_4$ acid 5 M was added and the solution was evaporated in the water bath until it dried completely. The residue was dissolved in 10.0–20.0 mL HNO_3 0.1 M. Blanks were treated in a similar way as the products and they were analyzed by atomic absorption spectrometry, Varian-Plus 10 instrument.

Results and Discution

The results obtained by analyzing the tea samples using the AAS method are summarized in Table 1. A wide variety of tea samples collected from various brands was rich in the heavy metal content. The Cu, As, Cd, and Pb amounts were assessed in the black tea samples. The mean (± standard deviation) and the metal concentration range are summarized in Table 1. Notably, the minimal amount of As (0.043 ± 0.006 ppm), Pb (0.040 ± 0.005 ppm), Cd (0.016 ± 0.001 ppm), and Cu (5.36 ± 0.49 ppm) concentrations were found in the M1, S, M2, and M2 teas, respectively; whereas, the maximal amount of As (0.287 ± 0.007 ppm), Pb (0.228 ± 0.002 ppm), Cd (0.101 ± 0.040 ppm), and Cu (37.4 ± 0.53 ppm) concentrations were found in the D, A1, M1, and D teas, respectively.

Table 1. The levels of arsenic, lead, cadmium, and copper in various samples

Samples	As (ppm)	Pb (ppm)	Cd (ppm)	Cu (ppm)
M1	0.0431±0.031	0.0625±0.0511	0.123±102	24.6±24.15
M2 tea bag	0.108±0.09	0.0625±0.0565	0.016±0.001	5.36±4.89
C	0.1002±0.9500	0.05361±0.0671	0.046±0.051	3.05±3.09
S	0.057±0.041	0.049±0.051	0.1±0.12	15.46±16.10
A1	0.07781±0.08871	0.278±0.0304	0.0305±0.0315	18.65±18.96
A2 tea bag	0.0520±0.062	0.278±0.030	0.0305±0.0371	18.65±18.54
D	0.287±0.302	10.12±0.099	0.0521±0.0429	37.41±38.42

Copper

The Cu contents in the assessed tea samples ranged about 3.05–37.41 ppm with a mean value of 17.59 ppm (Table 1). The results indicate that the minimum and maximum Cu content values in the tea samples were 3.05 ± 0.89 and 37.41 ± 0.53 ppm for C and D teas, respectively.

The variation of Cu content in the tea could be attributed to the rolling machine and fungicides, different types, grade, and cultivation areas of the teas.[13] The achieved results indicate higher values (13.2 ± 0.96 µg/g) than those reported by Naithani and Kakkar (11.1 µg/g)[14] and lower values than those reported by Matsuura et al.[15] (27.7 ± 0.7 µg/g), Narin et al.[16] (24.8 ± 1.4 µg/g), and Ashraf and Mian[17] (18.1 ± 6.9 µg/g), respectively. In this study, all studied samples comprised Cu below the standard maximum values set by the Iranian National Standardization Organization (50 µg/g). Therefore, the Cu concentrations in the tea samples are appropriate from the perspective of the consumer health (Fig. 1).[18]

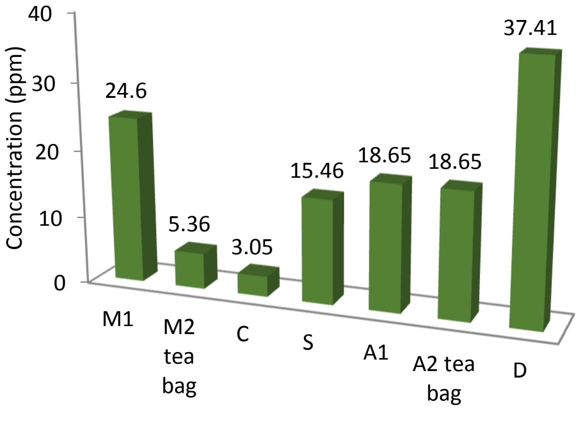

Fig. 1. Distribution of Cu in black tea samples

Lead

The Pb concentration in the samples is summarized in Table 1, with a mean value of 0.13 ppm. The results indicate that the minimum and maximum of Pb content in the tea samples were 0.049 ± 0.005 and 0.278 ± 0.002 ppm for S and A1 teas, respectively. The core sources of Pb in the tea samples could be their growth media, such as soil.[13]

Considering the findings of the present study, the Pb concentration levels were lower than those reported by Narin et al.[16], Ashraf and Mian,[17] Han and Li,[19] and Matsuura et al.[13] In this study, the Pb concentration in samples (Fig. 2) was detectable at low levels (<1 µg/g). This amount is lesser than the permissible limit (1 µg/g) set by the Iranian National Standardization Organization, and compared to the limit prescribed by other countries such as China (5 µg/g) and India (10 µg/g), the samples were acceptable.

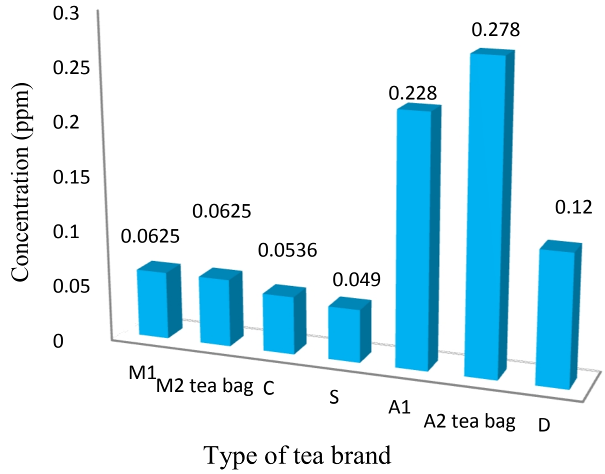

Fig. 2. Distribution of Pb in black tea samples

Arsenic

The results indicate that the minimum and maximum amount of As content in the tea samples were 0.0431 ± 0.006 and 0.287 ± 0.007 µg/g for M1 and D teas, respectively (Table 1). Fertilizers and pesticides may elevate the As levels in the soil.[20-21] As present in the soil could be absorbed by the plants and it gets accumulated in them.[21] Yuan et al. reported the As concentration ranging from below the detection limit to 4.81 mg kg^{-1} in the Chinese tea leaves, and Madeja et al. obtained the mean values of As concentrations ranging from the detection limit to 0.32 mg kg^{-1} in the tea samples available in various countries.[22] All samples contained As levels below the standard maximum limit set by the Iranian National Standardization Organization (0.15 µg/g; Fig. 3).

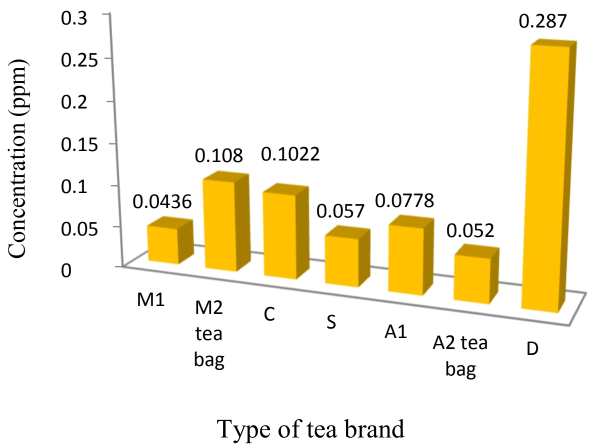

Fig. 3. Distribution of As in black tea samples

Cadmium

The results indicate that the minimum and maximum Cd content in the tea samples were 0.016 ± 0.001 and 0.101 ± 0.04 ppm for M2 and M1 teas, respectively (Fig. 4). This amount is lesser than the permissible limit (1 µg/g) set by the Iranian National Standardization Organization. Our results are in accordance to other studies from various countries. For example, Ferrara et al. reported that the Cd levels of the analyzed samples were below the detection limit by using flame atomic absorption spectroscopy; however, Narin et al. have reported 2.0 ± 0.2 µg/g Cd in the Turkish tea sample. In a study by Sreenivasan et al., they found that the Cd level was 0.81 ± 0.32 µg/g in the tea samples collected from South India. Existing Cd in soils can enter the tea plant through fertilizers and pesticides. Moreover, the different methods used for processing and storage could be the major contributory factors for the Cd concentration.[23]

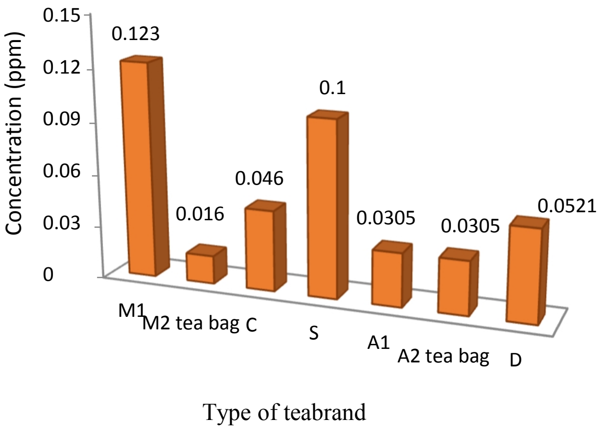

Fig. 4. Distribution of Cd in black tea samples

Conclusion

This study was conducted in order to provide information on the concentrations of metals including Cu, As, Pb, and Cd in the black tea samples, consumed in Iran. The difference in the metal concentrations, may therefore, be attributed to the tea products being produced in several tea estates with varying metal concentrations in the soils, resulting in the varied elemental uptake by the tea leaves. Due to the lack of information emphasizing the acceptable contents of the heavy metals in teas, the maximum permissible and safe concentration of each metal needs to be immediately specified.

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