

Heavy Metal Concentration in Black Tea in Iran

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Background & Aims of the Study: Tea is one of the most important beverages that consumes in several parts of the world including Iran. Tea plant can be contaminated during manufacturing processes and growth period by pollutants such as heavy metals. In this study, the concentration of some heavy metals in different brands of both Iranian and imported black tea to Iran was investigated to survey the human exposure to such pollutants.

Materials & Methods: The study was carried out on different brands of black tea that most widely consume in Iran. The samples were collected from available supermarkets in Tehran city and concentrations of Mn, Cd and Cu were determined in black tea, using ICP-OES. Finally obtained results, by one way ANOVA analysis, compared to maximum contaminant concentration which is determined by WHO.

Results: Results showed that concentrations of measured heavy metals in sampled black tea were different according to the brand of tea. The mean of Mn, Cu and Cd elements in all tea samples were 664.78, 26.15 and 0.194 µg/g, respectively. Generally, Cu content in studied samples was not significantly above WHO but Cd content, in some cases, was significantly higher than WHO. The guideline value is not given by WHO for Mn content of tea.

Conclusions: According to the obtained results, Cd content is exceeding than WHO standards, therefore, control of Cd, as a toxic element that can accumulate in living systems, is necessary.

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Background

The tea plant which used as one of the popular, oldest and non-alcoholic beverages in the world is provided from the leaves of *Camellia Sinensis*. This evergreen shrub that belongs to *Camellia* spp. is native to China, some parts of India and also can be grown in other tropical, subtropical and temperate areas (1).

It is estimated that about 18–20 billion tea cups are consumed in the entire world everyday (2). Iran is one the most important producers of this plant in the world and people of Iran are among

the largest consumers of tea in the world (3). Approximately, in Iran (Guilan and Mazandaran provinces), 34 thousand hectares of lands have been cultured for tea (4). Generally, Iran consumes about 5% of the total tea of the world, by having only 1% of world population (5) and Iranians with consumption of 1.6 kg, from 2005 to 2007, have one of the highest per capita rates of tea consumption in the world (3). From the total presented tea of Iran, approximately, 50% is provided from Iran and 50% from formal and informal imported tea (6,7).

Tea contains several essential compounds for human health such as different kinds of vitamins, proteins, alkaloids, some types of enzymes, aromatic substances, essential minerals and trace elements (8). Also, it is rich of flavonoid and phenolic acid compounds that have anti-oxidative effects which protect human body against different disease (9). In recent years many studies have been conducted on the properties of drinking tea and its medicinal effects on human health (10,11). These effects including anti-oxidative effects (12), effects on immune system raising (13), supporting some organs such as lung, prostate, breast against cancers (14,15,16) and reduction of the level of cholesterol in the blood (17).

Some trace elements can be absorbed by tea consumption in human body. Accumulated essential and nonessential trace elements in tea leaves may increase metal levels in human body (18). Contamination of the tea plant by heavy metals can be done both in growth period of tea in the field and processing steps in factory (19). Some sources of these contaminants in tea leaves are soil, nutrients, fertilizers and pesticides that consumed by tea in growth period (20). Heavy metals which enter into the food chain can cause different problems for human health (19).

When made teas are brewed, elements included can be extracted into infusions and thus making this beverage a rich source of some elements. Due to daily consumption of tea, the presence of heavy metals is considered to have various health problems.

Some heavy metals such as zinc (Zn), iron (Fe), chromium (Cr), copper (Cu), cobalt (Co) and manganese (Mn) are essential elements, while some of them including cadmium (Cd), lead (Pb), mercury (Hg) and nickel (Ni) are toxic elements at certain levels (21).

In this study we survey the content of Mn, Cd and Cu in some Iranian and imported black tea brands in Iran.

Cd is a toxic element with sterilizing, teratogenic and carcinogenic effects (22). This

element can accumulate in living systems and can cause renal distraction, lung inadequacy, bone injury, cancer and high blood pressure in humans (23).

Cu as an essential component for human health is a completely necessary element for some enzyme structures, despite these; it is a toxic metal and causes some pathogenic traits, such as non-Indian childhood cirrhosis (24) and Wilson's disease (25).

Mn is an essential element for some enzymes such as pyruvate carboxylase of liver, Mn-dependent or superoxide dismutase of mitochondry and also arginase (26).

Some studies were performed to survey different heavy metal concentrations in leaves of tea plant. According to these studies, the highest metal levels is accrued in black tea (27-30) and lower metal levels in green tea (31) and herbal tea (32,33).

Aims of the study: In Iran, tea beverage is one of the essential parts of daily life for many people; so, in this study we wanted to survey that public human health is maintained by consumption of this beverage. This study aimed to survey the concentration of Cu and Mn (as essential trace elements) and Cd (as potentially toxic element) in black tea, from different available Iranian and imported tea brands in Iran markets and comparison of these amounts with maximum contaminant concentration of heavy metals defined by the World Health Organization (WHO) (34).

Materials & Methods

Collection and preparation of samples

A total of 10 Iranian (numbers 8, 10, 12, 13, 14, 16, 20, 22, 26 and 30 in table 1) and 22 imported (other numbers in table 1) tea, which were commonly used in Iran were bought from local supermarkets in Tehran city in September 2013. For determining Cd, Cu and Mn levels, sampled tea leaves dried, cooled and powdered with blender. 5.0 g of milled sample was digested by perchloric and nitric acids, analyzed by ICP (Inductively Coupled Plasma

Optic Emission Spectrometry End of Plasma, - OES EOP, Spectroacros, Germany), according to the method of Sposito (35). Standard materials were $\text{Cd}(\text{NO}_3)_2$, MnCl_2 and $\text{Cu}(\text{NO}_3)_2$. Means of Cd, Cu and Mn were determined, using triplicate samples.

Statistical analysis

In order to survey differences among the heavy metal concentration of the types of studied samples with WHO standards, one way ANOVA analysis was applied, using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA) with the significance levels of $P < 0.001$ and $P < 0.01$.

Results

Cd, Mn and Cu levels of Iranian and imported dried black tea are presented in table 1. The obtained results show that the mean of Mn, Cu and Cd elements in all tea samples were 664.78, 26.15 and 0.194 $\mu\text{g/g}$, respectively. The total contents of Mn, Cu and Cd in the collected samples have been ranged from 238.00 to 993.00, 12.24 to 39.90 and 0.01 to 0.45 $\mu\text{g/g}$, respectively. Comparison of the obtained results with maximum contaminant levels provided with WHO are presented in figures 2 and 3. The guideline value is not given by WHO for Mn content in tea (figure 1).

Table 1) Total contents of Mn, Cu and Cd in studied Iranian and imported dried black tea ($\mu\text{g/g}$ of dry weight basis)

| Brand tea | Mn | Cu | Cd |
|-----------|--------|-------|------|
| 1 | 502.00 | 27.09 | 0.06 |
| 2 | 640.00 | 16.34 | 0.07 |
| 3 | 754.00 | 35.05 | 0.19 |
| 4 | 423.00 | 39.9 | 0.43 |
| 5 | 323.00 | 23.85 | 0.07 |
| 6 | 993.00 | 14.45 | 0.08 |
| 7 | 591.00 | 34.12 | 0.05 |
| 8 | 649.00 | 34.21 | 0.27 |
| 9 | 442.00 | 35.49 | 0.04 |
| 10 | 529.00 | 12.24 | 0.01 |
| 11 | 238.00 | 23.19 | 0.02 |
| 12 | 623.00 | 25.19 | 0.45 |
| 13 | 701.00 | 35.94 | 0.17 |

| | | | |
|-------------|---------------|--------------|-------------|
| 14 | 840.00 | 16.84 | 0.32 |
| 15 | 748.00 | 28.23 | 0.09 |
| 16 | 882.00 | 27.75 | 0.33 |
| 17 | 940.00 | 32.39 | 0.15 |
| 18 | 558.00 | 31.29 | 0.27 |
| 19 | 434.00 | 21.2 | 0.16 |
| 20 | 322.00 | 28.3 | 0.08 |
| 21 | 445.00 | 27.12 | 0.45 |
| 22 | 679.00 | 37.45 | 0.23 |
| 23 | 649.00 | 23.12 | 0.05 |
| 24 | 739.00 | 12.49 | 0.36 |
| 25 | 893.00 | 36.35 | 0.33 |
| 26 | 534.00 | 28.34 | 0.34 |
| 27 | 940.00 | 18.16 | 0.15 |
| 28 | 858.00 | 19.32 | 0.04 |
| 29 | 782.00 | 19.65 | 0.15 |
| 30 | 943.00 | 33.13 | 0.04 |
| 31 | 467.00 | 23.52 | 0.32 |
| 32 | 572.00 | 15.32 | 0.45 |
| Mean | 664.78 | 26.15 | 0.19 |

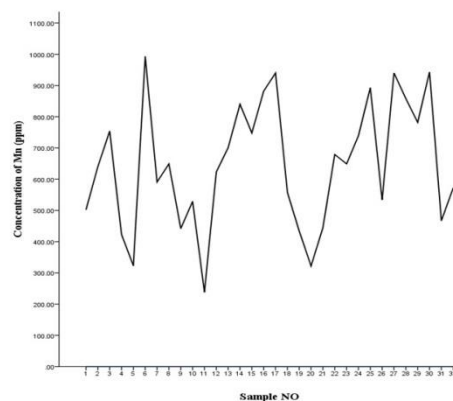


Figure 1) Concentrations of Mn in sampled tea

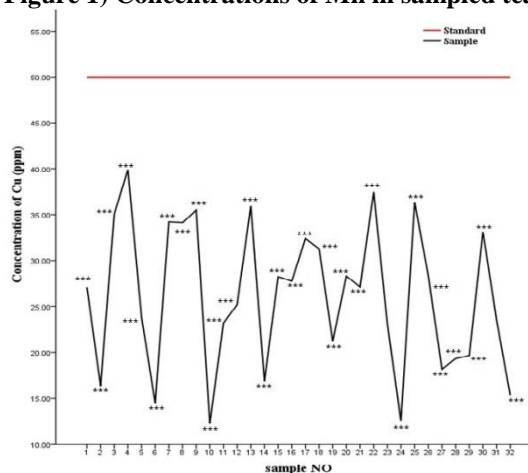
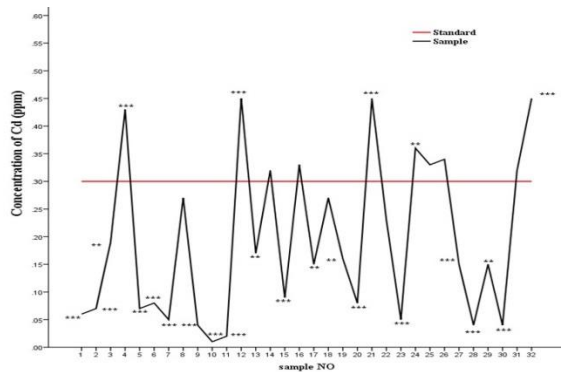


Figure 2) Concentrations of Cu in sampled tea and WHO



(***: P<0.001), (**: P<0.01)

Figure 3) Concentrations of Cd in sampled tea and

WHO

Discussion

Tea is a popular and common beverage in Iran after water. Therefore, health of tea is a very important factor and consumers of this beverage should be assured on the absence of pollutants such as heavy metals in consumed tea. Heavy metals are very toxic elements to living organisms even in low concentrations because of their cumulative effects, may cause some problems such as cancer and other dangerous diseases (36,37). In this study, the level of two essential elements (Mn and Cu) and one non-essential element (Cd) in commercially available black tea from different brands was determined by ICP. In table 1, the concentrations of measured metals are presented.

According to this study, there are trace metals in the tea and, therefore, in its beverage. As shown in table 1, total concentration of heavy metals in studied brands of tea is different. These differences are affected by some factors such as type of the soil, rainfall amounts, altitude of growth location, genetic, age of the plant and pollution by different pollutants (38,39).

The measured concentrations of heavy metals in the sampled tea are arranged as follows: Mn>Cu>Cd. Saud and Oud (40) and Street (38) showed similar results in their studies, and

reported the ability of tea leaves to intake and accumulate of heavy metals.

Ansari et al (41) reported that Mn have the highest concentration among measured metals in imported and Iranian dried tea. Street et al (38) reported that the level of Mn is higher than the levels of other studied metals in Czeck Republic imported tea samples. Also, Kumar et al. (42) have showed higher Mn concentrations (1100–2678 mg/kg) in dried leaves of tea compared to the total levels of other measured heavy metals from Turkey and Japan countries. These results are in accordance with our obtained results.

Mn has good effects on human health; it is an essential element for structure of some enzymes and has antioxidative effects in the human body. Thus, few consumption of tea can provided daily Mn for human health (26,43). Despite these cases, overconsumption of Mn is detrimental to human health. Determination of the Mn content in tea was reported by many authors (38, also see table 2).

Cu is necessary trace metal for humans health, also. For example, it is essential component for some enzyme systems. The available data show that deficiency of Cu is greater risk compared to the excess intake of this metal for human health (44). Cu contamination could usually result from the rolling machine and fungicides (45). High concentrations of Cu are dangerous for human. Thus, the daily amount of Cu in consumed food, water and other beverages such as tea must be controlled (46). The difference of Cu concentration in the teas is affected by some factors such as different conditions of the growth areas. Xie et al (47) and Ferrara et al (48) studied the Cu levels in tea. Also, in a study by Han et al (49), high concentrations of Cu in some tea leaves were reported (also see table 2).

Cd is a very toxic element that human can be exposed with it in the environment or at work conditions. This element can accumulate efficiently in the human body throughout life. Cd is toxic to the kidney and bone; it can

increase demineralization of bone. In the industry excessive exposures to Cd can cause the cancer of lung (50). Determination of the

Cd content in tea was reported in different researches (48, also see table 2).

Table 2) Levels of Mn, Cu and Cd in black tea in some other parts of the world ($\mu\text{g/g}$)

| Element | Total mean ($\mu\text{g g}^{-1}$) | Country | Reference number |
|---------|-------------------------------------|--------------------|------------------|
| Mn | 648.67 | Saudi Arabia | 20 |
| | 641 | - | 40 |
| | ND- 1.50×10^4 | - | 51 |
| | 1570 | Nigeria | 52 |
| Cu | 28.66 | Saudi Arabia | 20 |
| | 27 | - | 40 |
| | 24.1 | Nigeria | 52 |
| | 24.07 | South India | 53 |
| | 25.43 | China | 54 |
| | 0.3 | Taiwan | 55 |
| | Cd | 1.1 | Saudi Arabia |
| 2.0 | | Turkey | 2 |
| 0.3-2.2 | | Saudi Arabia | 2 |
| 0.13 | | Nigeria | 21 |
| 0.056 | | China | 49 |
| 0.13 | | Nigeria- beverages | 40 |
| 0.05 | | Saudi Arabia | 40 |
| ND-8.60 | | - | 51 |
| 0.14 | | South India | 53 |
| 0.07 | | Taiwan | 55 |
| < 1-3 | | Turkey | 56 |
| 0.0071 | Thailand | 57 | |
| 0.66 | India | 58 | |

As shown in table 1, the minimum and maximum Mn content was 238 and 993 $\mu\text{g/g}$ in samples 11 and 6, respectively. The guideline value is not given by WHO for Mn content in tea (figure 1).

Sample 10 possesses the lowest contents of Cu and Sample 4 possesses the highest contents of Cu, according to table 1. Contents of Cu which is reported here was 12.24 to 39.9 $\mu\text{g/g}$ in studied tea samples. Cu content in studied samples was not significantly higher than in WHO and generally Cu level in all studied samples were within the limits suggested by WHO (figure 2).

The results revealed that the Cd concentrations in studied tea were between 0.01 and 0.45 $\mu\text{g/g}$ for samples 10, 21 and 32, respectively. Results showed that Cd content in samples 4, 12, 21, 24 ($p < 0.001$) and sample 24 ($p < 0.01$) was significantly higher than WHO (figure 3).

Conclusion

Contents of measured heavy metals in analyzed black tea samples were much diversified in different brands, which could have been due to species diversity and soil properties. Mn, Cu and Cd have the highest concentrations in the studied black teas, respectively. Obtained results in this study confirmed that Cu concentrations in studied samples were within the permissible WHO limits and Cd content is exceeding than WHO standards. Tea leave can be an important dietary source of Cd, therefore, control of Cd as a toxic element that can accumulate in living systems, is necessary. The guideline value is not given by WHO for Mn content in tea.

In Iran, drinking of tea beverages is an essential part of daily life for some people, therefore, different studies about the content of different

pollutants must continue to ensure that health of this beverage is preserved. It is absolutely necessary to control the quality of raw materials of edible and medicinal plants and to determine the amounts of different contaminants, such as toxic metals, to avoid high consumption of them in long-term use.

Footnotes

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Conflict of Interest:

The authors declared no conflict of interest.

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