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A study on heavy metal content in black tea available in domestic market in India

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ABSTRACT

Tea is one of the most popular beverages in the world. Thus, the chemical components in tea have received great interest because they are related to health. Tea is used in folk medicine for headache, digestion, diuresis, enhancement of immune defense, as an energizer and to prolong life. The intake of food and beverages contaminated by heavy metals is harmful to human health and several countries have imposed laws to restrict the presence of heavy metals concentration in food and beverages. In this study, the concentration of two heavy metals including Lead (Pb) and Copper (Cu) were determined by atomic absorption spectrometry on samples collected from different parts of India. The results showed that the only 12 samples out of 82 samples analysed were found to contain Lead in very low level ranges from Not detected to 0.144 ppm. The permissible level for Lead (Pb) as per FSSAI in tea is 10 ppm (max). Cu content was present in 19 samples out of 82 samples analysed with value range from not detected to 0.114 ppm. The permissible level of Copper (Cu) in tea as per FSSAI is 150 ppm (max). All the samples were within the permissible limits. Therefore, it may not produce any health risk for human consumption, if other sources of toxic metals contaminated food are not taken.

Keywords: Black tea; Heavy metal; Atomic absorption spectrometry.

INTRODUCTION

Tea (*Camellia sinesis)* is the most widely consumed beverages because of its taste aroma and health benefits. Tea is used in folk medicine for headache, digestion, dieresis, enhancement of immune defense, as an energizer and to prolong life [1, 2]. Tea is also considered to have beneficial effects on the prevention of many diseases including cancer [3], Parkinson disease [4], myocardinal infarction [5] and coronary artery disease [6]. Tea can be contaminated by heavy metals during growth period and manufacturing processes. The main sources of heavy metals in plants are their growth media, nutrients, agro inputs, soil and others factor such as pesticides and fertilizers [7]. Heavy metals along with other pollutants are discharged to the environment through industrial activity, automobile exhaust, heavy duty electric power generators and pesticides used in agriculture etc and enter into the food and beverages and then into the food chain. Heavy metals have great significance due to their tendency to accumulate in the vital human organs over prolonged period of time. Heavy metals especially Lead (Pb) is a physiological and neurological toxin that can affect several organs in the human body. Lead can also damage kidneys and reproductive systems [8]. Heavy metal such as Copper is essential for human body as it is an integral part of numerous enzymes including ferro-oxidase (ceruloplasmin), cytochrome-c-oxidase, superoxide dismutase etc. It also plays a role in iron metabolism melanin synthesis and central nervous system function. However, chronic (long term) effects of copper exposure can damage the liver and kidneys. Acute symptoms of copper poisoning by ingestion include vomiting, hematemesis (vomiting of blood), hypotension (low blood pressure), melena (black "tarry" feces), coma, jaundice (yellowish pigmentation of skin) and gastrointestinal distress. Therefore, it is important to monitor the concentration of these metals in beverages especially tea which is directly consumed by wide population. In the present study, the concentration of these two heavy metals including Lead (Pb) and Copper (Cu) was determined in Black tea samples collected from different geographical regions of India.

MATERIALS AND METHODS

Sample Collection

A total of 82 Black tea samples in loose form and packed were purchased from market from different Geographical area such as Mumbai, Kanpur, Jaipur, Kochi, Kolkata, Chennai, New Delhi, Amritsar, Bhopal, Guntur and Nagpur.

Apparatus and reagents

Atomic Absorption Spectrophotometer AAS 7000SP with air-acetylene base for flame; Microwave Digestion System (Model 3000, Anton Paar), Contaminated free digestion vessels are used for digestion, Mixer – For grinding the sample, Volumetric Flask (100 ml), Pipettes, Funnels (Glass or plastic), Filter paper Watman No.4 or equivalent and Glass rods Concentrated HCl (AR Grade), Concentrated HNO_3 (AR Grade), Distilled water, Lead standard (99.99%) and Copper Standard (99.99%).

Sample preparation and digestion

One portion of a well homogenized sample was grinded in a mixer. From this, 0.1g of ground sample (dried) was weighed into digestion Teflon vessel. 6 ml concentrated HNO_3 and 1 ml concentrated HCl was added in the sample in fume hood. Vessels were left aside for 5 minutes to initial vigorous reaction. Teflon vessels were closed in position in Microwave Digestion System (Model 3000, Anton Paar). Door was closed properly. After 50 minutes, digestion was over. System was cooled to room temperature. The digestion vessels were unscrewed. Cap and sides of Teflon vessel were rinsed with distilled water. Solution was filtered into 100 ml volumetric flask. Filter paper and funnel was washed properly then solution was made up to mark with distilled water. A reagent blank, sample blank, spike samples were prepared in the same manner with the same quantity of acid as for samples.

Preparation of standards

Stock standard solution (1000 ppm)

0.10 g Pb (99.99%) / Cu (99.99%) powder was dissolved into 2 ml HNO_3: H_2O(1:1) solution. Then it was made up to 100 ml volumetric flask with distilled water.

Intermediate Standard (100 PPM)

10 ml of 1000 ppm solution was Pipetted out into 100 ml volumetric flask and made up to mark with distilled water.

Working Standards

The range of working/calibration standards were prepared such as blank (0), 0.5ppm, 1 ppm, 2 ppm, 4 ppm and 6 ppm in 100 ml volumetric flask.

Analysis of Lead (Pb) and Copper (Cu) by AAS

Analysis of Lead and Copper in tea samples was carried out using Flame and air-acetylene AA 7000 SP workstation as Per AOAC Official method 999.10.

RESULTS

A total of 82 samples were analysed for the presence of Lead (Pb) and Copper (Cu) on AAS 7000 at Central Agmark Laboratory, Nagpur. The samples were received from various Regional Agmark Laboratories all over India. Table 1 showed the Analytical conditions for analyzing heavy metal in tea samples for AAS.

Table 1. Analytical Conditions of AAS for analyzing heavy metals in tea Samples

Parameter	Lead	Copper
Wavelength (nm)	217	324.7
Slit width (nm)	0.4	0.2
Lamp current (mA)	4.0	2.0
Types of Flame	Air-Acetylene	Air-Acetylene
Fuel Gas pressure (M Pa)	0.0	0.10
Burner Height (mm)	8.0	8.0
Fuel Gas Flow rate (L/mm)	1.70	1.70
Combustion-supporting gas	Air	Air
Sampling speed	10	50
Integral time (s)	1.0	2.0
Smooth curve factor	1	10
Units	ppm	ppm

It has been found that out of 82 samples, 12 samples were found to be positive for Lead (Pb). Table 2 indicates the range of Lead Content in ppm in tea samples received from different geographical area such as New Delhi, Amritsar, Kochi, Bhopal, Nagpur, Guntur, Mumbai, Kanpur and Rajkot. The range of Lead (Pb) is from not detected i.e 0.000 ppm to maximum of 0.144 ppm. Results are expressed by mean ± SD.

It has been found that out of 82 tea samples analyzed, 19 samples were found to be positive for copper (Cu). Table 3 indicates the copper concentration in ppm in tea samples received from different regions of India. The Copper (Cu) content ranging from Not detected i.e 0.000 ppm to 0.114 ppm. Results are expressed by mean ± SD.

Table 2. Level of Lead (Pb) in mg/kg in tea samples obtained from different regions (n= 82)

Region	Sample Size	Min.	Max	Mean	SD
New Delhi	8	0.000	0.000	0.000	0.000
Amritsar	6	0.000	0.108	0.0291	0.047
Kochi	3	0.000	0.104	0.035	0.049
Bhopal	3	0.000	0.108	0.036	0.062
Nagpur	27	0.000	0.144	0.006	0.027
Guntur	5	0.000	0.044	0.012	0.019
Mumbai	8	0.000	0.061	0.015	0.027
Kanpur	6	0.000	0.057	0.009	0.023
Rajkot	16	0.000	0.000	0.000	0.000

Table 3. Level of Copper (Cu) in mg/kg in tea samples obtained from different regions (n= 82)

Region	**Sample Size**	**Min.**	**Max**	**Mean**	**SD**
New Delhi	8	0.000	0.016	0.007	0.011
Amritsar	6	0.000	0.012	0.0019	0.005
Kochi	3	0.000	0.000	0.000	0.000
Bhopal	3	0.000	0.000	0.000	0.000
Nagpur	27	0.000	0.059	0.007	0.014
Guntur	5	0.025	0.094	0.047	0.029
Mumbai	8	0.000	0.114	0.002	0.004
Kanpur	6	0.000	0.039	0.007	0.016
Rajkot	16	0.000	0.000	0.000	0.000

DISCUSSION

Lead

The permissible level for Lead (Pb) as per FSSAI in tea in India and WHO is 10 ppm (max.) The permissible limit for other countries such as Thailand is also 10 ppm while for other countries, such as China and Iran, the permissible limit is 5 ppb and 1 ppb respectively. It has been found that maximum concentration of Lead (Pb) in tea samples i.e. 0.144 ppm, is within the permissible limits as per Indian and Thailand regulation and as per WHO, however the same is much higher as per China and Iranian regulation.

Hussain et., al 2006 [9] also reported the concentration of Lead (Pb) in commercial tea brands ranges from 0.25 ppm to maximum of 4.75 ppm and was within the prescribed limits in herbs by WHO . Shekoohiyan et al., 2012 [10] also reported the Lead (Pb) content in tea infusion at different time intervals such as 5, 15, 60 min was 0.802, 0.993 and 1.367 mg/kg of tea dry weight. Justyna et., al 2016 (11) reported the Lead (Pb) concentration 0.10 mg/100g among the Green tea samples from India while Moreda Pinerro et., al 2003 [12] reported a concentration of 0.21 mg/100g in Chinese tea. Japanese tea has highest Pb concentration of 0.84 mg/100g, however they are within the permissible limit as per WHO and India.

Souza (2005) [13] implied that 96% of Lead (Pb) in the atmosphere is of anthropogenic origin. It was reported that Pb is more bioavailable to tea plants growing in highly acidic soils [14, 15]. The concentration of Lead (Pb) in tea samples marketed in Mashad (Iran) was detectable at high levels (> 2 µg/g) which is higher than permissible level (1 µg/kg) given by Iranian Ministry of Health, but compared to limit prescribed by other countries such as China, India and Thailand, the samples were acceptable [7]. Previous studies demonstrated that range for Pb was from 0.03 to 14.84 µg/g in Saudi Arabia, 0.198 to 6.345 µg/g in China and 0.26 to 0.83 µg/g in India [16, 17, 18]**.**

The main sources of Lead (Pb) in tea samples are their growth media such as soil. Lead contamination in soil usually can be attributed to industrial activities (smelting process), agricultural activities (application of insecticides) and urban activities (combustion gasoline). Tea plants normally are grown in highly acidic soils where Lead (Pb) is more bioavailable for root uptake. Deposits from polluted air into the leaves of the plant can be another source of lead contamination of tea [14]**.**

Copper

The permissible level of Copper (Cu) in tea as per FSSAI is 150 ppm (maximum) in India. In other countries, upper limit imposed on tea is China (60 µg/g), Japan (100 µg/g) and Australia, United Kindgom and the United States (150 µg/g), Iran (150 µg/g) respectively. All the tea samples analysed were found to contain Cu(Maximum value is 0.114 ppm) at level below those set as the Standard maximum values by all the countries. Karimi et al., 2008 [7] reported the Cu content in tea samples ranges from 17.59 to 32.80 µg/g, however Hussain et al., 2006 [9] reported much Intermediate Standard (100 PPM) tea samples. Similarly, Justyna at al., 2006 [11] reported Cu content ranges from 1.34 to 2.59 µg/100g from Green tea samples of China, India, Japan and Poland. Pekal et al., 2013 [19] also reported similar level of Copper (1.8 mg/100g) for Indian green tea. The copper (Cu) content in the present study was found to be lowest than previous studies. The copper (Cu) content in all the studies was within the permissible limits as defined by the Indian and other countries legislation. Hence, it does not pose a serious health risk. Tea samples analysed from different regions of India may not produce health risk for human consumption, if other sources of toxic metals contaminated food are not taken.

CONCLUSION

Screening of 82 commercial tea samples received from different regions of India revealed that all the tea samples were found to contain Lead (Pb) within the permissible limit as specified by India, WHO and Thailand legislation. All the 82 samples analysed were found to contain Copper (Cu) within the permissible limit as specified by different countries. In view of this, it has been concluded that intake of beverage prepared from tea samples may not produce any health risk for human consumption, if other sources of toxic metals contaminated food are not taken.

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