Levels of metals in commercially available tea from some selected markets in Ghana

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ABSTRACT

Metal monitoring in food, like teas, provides basic information on safety aspects of food in regulatory processes in terms of suitability of food for consumption, as well as its nutritional value. The aim of this work was to measure the total content of Cd, Cr, Co, Cu, Fe, Mn, Pb and Zn in ten brands of commercially available black tea, on the Ghanaian market. All of the samples were microwave-assisted acid digested followed by measurement of the elemental contents by flame atomic absorption spectrometry (FAAS). The concentrations of all the elements varied among the different brands of tea analysed. The total contents of Fe were comparatively higher than the other analyzed elements and varied between 302.95–27.30 µg/g. the ranges of the other elements observed, in µg/g, were as follows: Cr (<0.006-0.90), (3.85- 9.95), Mn (5.34-219.25), Pb (<0.001-2.05) and Zn(2.80-5.50). Cadmium and Cobolt were below detection limits. All values recorded were below the maximum permissible limit set by the WHO.

Introduction

Tea is one of the most popular beverages in the world. It is a good dietary source of essential trace metals for humans. It is also known to contain flavonoids, minerals and trace elements that are essential to human health (Yingxu Chen et al; 2009). Tea is usually consumed as an infusion prepared by brewing the tea in hot water. Varieties of tea are found on the Ghanaian market and are widely consumed. Its elemental composition has, therefore, been the object of broad scientific studies from medical, toxicological and environmental points of view.

Various surveys on the medicinal value and benefits of tea consumption have taken place in recent years (Dufresne and Farnworth, 2001; Weisburger, 1997). Some of the possible benefits of drinking tea are immune system boosting and antioxidative activity (Mark, 2007). Others include protective effect against a wide range of cancers (including lung, prostate, and breast cancer) and reduction of blood cholesterol levels (Fujita and Yamagami, 2008; Siddiqui et al., 2005; Way et al., 2004).

The presence of some trace elements, such as arsenic, chromium, cadmium, lead, etc. in tea is, however, a major concern due to the accompanied adverse health effects. Some of the major sources of these trace elements to the tea plants are pesticides and fertilizers. Other sources include growth media such as nutrient solutions and soils (Subbiah et al., 2008). Though the availability of these metals to plants are known to depend on, among other factors, the extent to which trace elements are bound to soil constituents, the assessment of these toxic trace metals is not unimportant.

In this work, the content of essential and toxic trace elements, Cd, Cr, Co, Cu, Fe, Mn, Pb and Zn in black tea samples available on some selected markets in Accra, Ghana were determined by Flame Atomic Absorption Spectrometry. This was with the aim of accessing the profile of these elements in black tea marketed in Accra, Ghana in order to make available, information on the health risks and or the nutritional benefits associated with daily consumption of black tea.

Methodology

Sample collection and preparation

Ten brands of commercially available tea leaf samples (packed in tea bags) were purchased from some markets in Accra, Ghana, for the analysis.

Sample preparation and analysis were done at laboratories of Ghana Atomic Energy Commission. The samples were dried and pulverized for homogenization before use. A mass of 0.5g of the pulverized sample was weighed into TFM Teflon vessels of a microwave digester (Milestone ETHOS 900). To the weighed mass, 6ml of concentrated HNO_3 and 1ml H_2O_2 were added. The vessels were swirled gently and then vertically fitted into the microwave digester. The digestion was done for 20 minutes. The digestate was cooled down in a water bath to reduce high temperature and pressure build-up within the vessels. The contents of the vessels were then transferred quantitatively into volumetric flasks. The cooled digestates were diluted to 10ml using deionized water. Reagent blanks and standards were prepared and subjected to the same digestion procedure as the samples.

Analytical procedure

The samples and the blank were analyzed for some major and trace elements using flame atomic absorption spectrometer (Varian AAS 240FS). The analytical conditions for the operation of the AAS equipment are shown in Table 1.

Results and Discussion

The total concentrations of 9 elements in 10 brands of the black tea samples are shown in Table 2. The concentration of each element was estimated on the dry weight basis. Cadmium and cobalt were below the detection limits of the analytical method. The different tea samples however contained the

elements Cr, Cu, Fe, Mn, Pb and Zn in detectable levels. Chromium ranged from <0.006-0.90 in µg/g, with Cu ranging from 3.85-9.95 µg/g. The ranges of the remaining elements, µg/g, were; Fe(33.70-302.95), Mn(5.34-219.25), Pb(<0.001-2.05) and Zn(2.80-5.50)

Chromium (Cr)

The levels of Cr in six brands of the tea samples (i.e IPA, RIS, SPR, THP, TTY and ZES) were below detection limit, as shown in Table 1.

However, Cr recorded the highest concentration of 0.90 µg/g in PGT whilst CLA and LPN recorded the same concentration (i.e 0.65 µg/g). The concentration of Cr in GDY was 0.50 µg/g. The concentration range (i.e <0.006-0.90) observed in this work was less than that recorded by Subbiah et al., 2008 reported higher concentration of Cr in black tea samples from South India.

These tea samples were produced from different countries which could contribute to the observed variation in Cr concentration in the different brands of tea samples analyzed. The observed difference could also be due to the different processing methods as well as the conditions under which the processing were done.

Chromium is believed to play an important role in carbohydrate and lipid metabolism. This role it plays via a biologically active form, chromodulin. Chromodulin is a low molecular weight oligopeptide which binds four ions of chromium(III) to potentiate the action of insulin in converting glucose to lipids and carbon dioxide (Sareen et al, 2012).

Iron (Fe)

The results show that these ten brands of black tea contained Fe concentration ranging from 27.30 to 302.95 ug/g with a mean value of 109.32 ug/g. From Fig 1, the lowest concentration (i.e. 27.30 ug/g) was observed in RIS tea brand whilst the highest concentration of 302.95 ug/g was observed in CLA tea brand. Waqar and Mian (2008), reported a concentration range of 108.5 to 351.6 ug/g with a mean value of 189 ug/g in their study of different tea brands imported from India to Saudi Arabia. This is comparable with the present study findings.
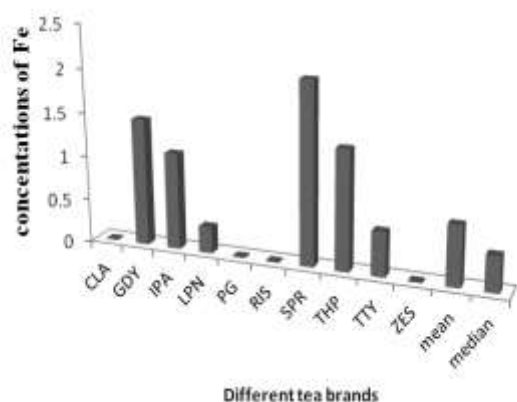

Fig. 1. levels of Fe in the various brands of tea analysed

The reason for the high concentration maybe due to the varying properties of the growth media - nutrients, agro inputs, soil etc.

Pedro et al., (2001) have shown Fe concentration to be in the range of 74 to 1000 ug/g for black tea samples having different geographical origins. Iron together with haemoglobin and ferridoxin plays a central role in metabolism. However, its deficiency results in anaemia. Anaemia leads to reduced immune function and resistance to infections, development delays and irreversible work performances (Cooper et al. 2006; Naghii and Fouladi, 2006).

Copper (Cu)

The mean Cu concentration of the analyzed black tea samples was 7.22 ug/g. The lowest level of Cu was found in PG tea brand as 3.85 ug/g, whereas the highest of 9.95 ug/g was in GDY (Fig 2).

Though excessive amounts of copper can induce chlorosis and Fe deficiency, the concentration recorded for Cu in all the tea samples were below the permissible limit of 20.0 ug/g set by the WHO,1998. Comparable results for Cu have been reported (Waqar and Mian, 2008; Naithani and Kakkar, 2005). Narin et al., 2004, reported a mean Cu concentration of 24.8 ±1.4 ug/g in black tea samples of Turkey. Seenivasan et al., (2008) also reported a mean Cu concentration of 24.07 ± 2.25 ug/g in black teas from South India.
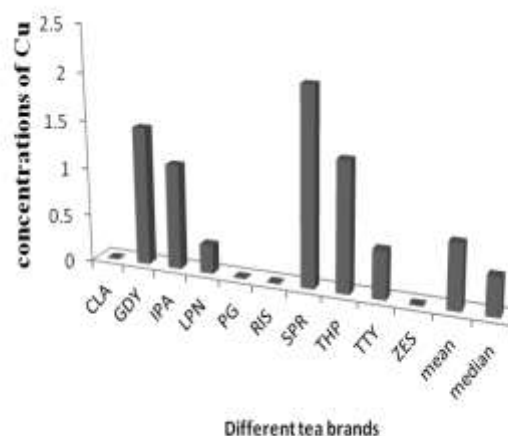

Fig. 2. levels of Cu in the various brands of tea analysed

Manganese (Mn)

Manganese was present in all the tea samples analyzed. Among the investigated metals, Mn showed the second highest concentration. The levels of Mn were in the range 5.34 ug/g (in TTY) to 219.25 ug/g (in LPN) with a mean value 108.374 ug/g. The higher levels measured indicate the ability of these leaves to accumulate Mn and can also be a good source of dietry Mn. Manganese is essential for normal functioning of nerve, heartbeat, central nervous system. It is also a good anti-oxidant. It is a micronutrient for bone formation and aids enzymatic actions (Bakhru, 2002).

The observed higher levels of Mn could also result from the processing of the leaves into the various tea brands. The variations (Fig 3) in the levels of Mn also suggest that the tea available on the market were made from leaves collected from different regions with different soils. Marbaniang et al also reported comparatively high levels of Mn (from 111.4 to 143.8 ug/g with a mean value of 129.5 ug/g) in tea available at Shillong in India. Lower levels have, however, been reported in other studies. Tahir et al. (2008) reported a range from 0.52 to 1.9 mg/dm^3 and Saud and Al - Qud (2003) recorded values within the range 1.95-4.5 ug/g.

Zinc (Zn)

From Fig 4, the concentration of Zn in the samples were found to range from 2.80 ug/g to 5.50 ug/g with a mean of 4.48 ug/g. PG recorded the lowest concentration whilst ZES recorded the highest (Fig 4).

Table 1: Analytical characteristics of AAS 240FS

Metal	lamp current (nA)	wavelength (nm)	slit width(nm)	fuel /gas	oxidant	working range (ug/ml)
Cd	4	228.8	0.5	acetylene	air	0.02-3
Co	7	240.7	0.2	acetylene	air	0.05-15
Cr	7	357.9	0.2	acetylene	air	0.06-15
Fe	5	248.3	0.2	acetylene	air	0.06-15
Mn	5	279.5	0.2	acetylene	air	0.02-5
Cu	4	324.7	0.5	acetylene	air	0.03-10
Zn	5	213.9	1.0	acetylene	air	0.01-2
Pb	5	217.0	1.0	acetylene	air	0.1-30

Table 2.0: Concentration of elements, in µg/g, in some commercially available tea from Ghana

| Sample codes	Cd	Co	Cr	Cu	Fe	Mn	Pb	Zn
CLA	<0.002	<0.005	0.65	6.95	302.95	183.65	<0.001	5.20
GDY	<0.002	<0.005	0.50	9.95	289.50	99.25	1.45	5.30
IPA	<0.002	<0.005	<0.006	9.85	33.70	82.95	1.10	5.35
LPN	<0.002	<0.005	0.65	4.55	66.10	219.25	0.30	3.00
PG	<0.002	<0.005	0.90	3.85	43.10	193.45	<0.001	2.80
RIS	<0.002	<0.005	<0.006	9.10	27.30	51.20	<0.001	4.75
SPR	<0.002	<0.005	<0.006	6.90	160.15	112.95	2.05	4.50
THP	<0.002	<0.005	<0.006	7.20	48.80	59.85	1.35	4.90
TTY	<0.002	<0.005	<0.006	4.05	81.45	5.34	0.50	3.45
ZES	<0.002	<0.005	<0.006	9.80	40.10	75.85	<0.001	5.50
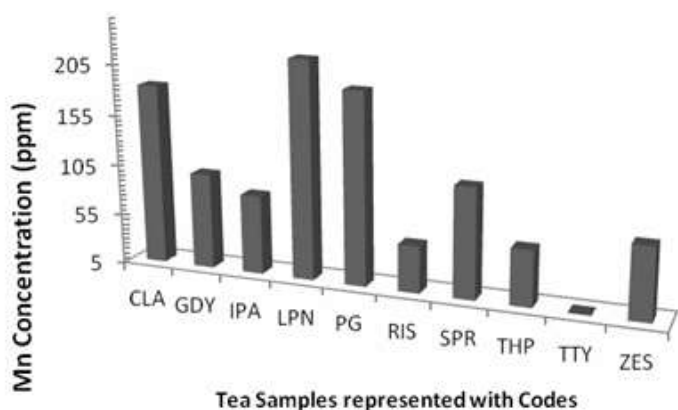
Fig. 3. levels of Mn in the various brands of tea analysed
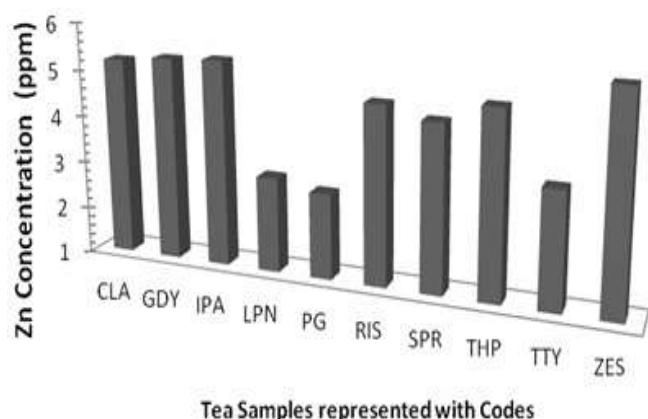

Fig. 4. levels of Zn in the various brands of tea analysed

The concentrations of Zn in all the ten samples were below the permissible limit of 10 ug/g (Ebadi et al, 2005). Zinc is important in metabolic function and growth in man. However, harmful effects of Zn generally begin at levels 10-15 times higher than the amount needed for good health. Ingestion of large doses, even for a short time, can cause stomach cramps, nausea and vomiting. Taken longer, it can cause anaemia and reduce the levels of good cholesterol (ATSDR, 2005).

Lead (Pb)

Lead was found in variable amounts in all the tea samples analysed (Fig 5). For example, the highest concentration (2.05ug/g) was found in SPR. This was followed by 1.45ug/g (GDY), 1.35ug/g (THP), 1.10ug/g (IPA), 0.50ug/g (TTY) and 0.30ug/g (LPN). Pb contents of samples CLA, PG, RIS and ZES were below detection limit.

This variability could be attributed to different environmental conditions such air, water and soil. However, the concentrations of Pb in all the samples were below the WHO (1998) limit of 10ug/g in herbs. It is believed that 95% of Pb in plants is due to foliar uptake (Tjell et al, 1979). Hussain et al (2006) reported 4.75ug/g of Pb in tea purchased from some selected markets in Peshawer of Pakistan. This concentration is higher than the 2.05 ug/g recorded in this work.
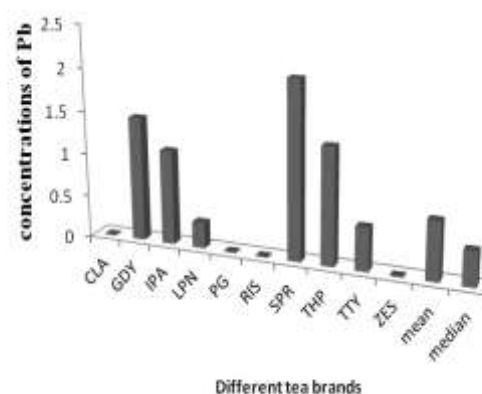

Fig. 5. levels of Pb in the various brands of tea analysed

Conclusion

The concentrations of Cd and Co in the tea samples analysed were below the detection limit of FAAS. The levels of the other metals in the ten tea brands were found in the following Order; Fe (302.95–27.30 ug/g) > Mn (183.65 − 5.34 ug/g) > Zn (5.50 − 2.80 ug/g) > Cu (3.85–9.95 ug/g) > Pb (2.05 - <0.001 ug/g) > Mg (1.37–1.09 ug/g) > Cr (0.09 – <0.006 ug/g).

The observed variation in the concentration of these metals could be due to different environment of origin. The variations also reflect the differences in uptake capabilities of the different plant types from which the tea brands were prepared. Copper, Pb and Zn concentrations were below the WHO permissible limits in all the black tea samples suggesting that consumption of black tea does not pose any health risks with respect to Cu, Pb and Zn. The presence of Cr, Cu, Mg, Mn and Zn indicates that, the black tea samples analysed could be a source of dietary minerals and trace metals.

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