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A Systematic Review on Exposure to Toxic and Essential Elements through Black Tea Consumption in Iran: Could It be a Major Risk for Human Health?

Elahe Rezaee, Maryam Mirlohi[1], Azizolah Fallah[2], Mina Babashahi[3]

Department of Food Technology, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran, [1]Department of Food Technology, School of Nutrition and Food Science, Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran, [2]Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, Shahrekord University, Shahrekord, Iran, [3]Department of Food Technology, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran

Correspondence to:
Dr. Maryam Mirlohi,
Department of Food Technology, Food Security Research Centre, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: m_mirlohi @hlth.mui.ac.ir

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ABSTRACT

Background: Tea is the most popular nonalcoholic beverage worldwide. In recent years, some Iranian studies have shown the occurrence of toxic elements in fresh or dried tea leaves as well as in brewed tea. The present study aimed to ascertain the health risks associated with exposure to toxic and essential element through black tea consumption in Iran by systematically reviewing the accredited articles in the field.

Methods: In order to obtain the relevant articles and academic databases, the search engines covering the specific disciplines were searched for the keywords, including tea, elements, heavy metals and determination. Having provided the complete list of sound articles, being conducted in Iran was considered as the inclusion criteria. Exclusion criteria were established as failure to provide information on the validity parameters and accuracy in the analytical methods. Choosing well conducted, reliable studies, analytical results for the concentration of each element in black tea were utilized in the determination of the hazard quotient (HQ) for the given element and the hazard index (HI) was then determined for all of the elements in each study.

Results: Among the total studies, two were considered to be reliable. Aluminum was found to be the most abundant element in black tea marketed in Iran. Although the HQ for manganese was the highest among the studied elements, HQ and HI values for both toxic elements and essential elements were calculated as less than 1.

Conclusions: The hazard of excessive element intake through black tea consumption should be considered as negligible in Iran. However, related risk for manganese appeared to be more than toxic metals.

Keywords: Black tea, risk assessment, toxic and essential elements, hazard index, hazard quotient, Iran

Review Article

INTRODUCTION

Tea is one of the most popular aromatic beverages in the world. It is commonly prepared by steeping the green leaves and leaf buds of *Camellia sinensis* in hot or boiled water. *C. sinensis* is an evergreen plant that is native to tropical regions and adapted to acidic soils.[1-4] The fresh tea leaves are processed to different levels of oxidation that leads to different types of tea such as white, oolong, green and black tea.[5,6] Although they have been globally well known among different communities, only black and green teas are consumed in Iran. Today, with annual per capita consumption of 1.6 kg, this country ranks the sixth in tea consumption in terms of worldwide.[7] Geographically, the northern and northeastern parts of Iran are dedicated to tea cultivation.[8] Since domestic production does not meet the huge internal tea market demand, the imported products are mainly relied on and consumers can access a diverse range of imported tea brands.[7,9] Tea consummation has been promoted because of a variety of positive health benefits revealed by recent research studies; cancer prevention[2,10] as well as reducing the risk of cardiovascular diseases,[2,11,12] diabetes,[11,13] hyperglycemia[11] and skin cancer.[11,14]

Despite the advantages mentioned above, it has been demonstrated that the camellia shrub can accumulate some elements, present in the environment including heavy metals.[1,10,15] This could significantly jeopardize the safety status of the final product. Biological and industrial processing of tea leaves does not remove heavy metals. Rather, heavy metals, become more concentrated and in turn easily enter into the food chain.[16,17] This has brought about doubts on the stated health benefits of tea.[18,19] Although heavy metals tend to accumulate in many agricultural products, it is found that the accumulation process varies, depending on the type of the plant. In the tea, certain elements have been shown to accumulate to a greater extent than others. The reason, though, is relatively unknown. For instance, the tea plant has been shown to be more capable of lead accumulation in comparison with the mushroom because of the leafy nature of the tea plant.[16,17] Conversely, an increase in chromium concentration in dried tea leaves has been found to be industrially related, and it mostly depends on the tea processing equipment.[18,20,21] Apart from toxic heavy metals, some essential elements for human health have also been revealed to accumulate in tea. Although iron, manganese, zinc and copper play vital roles in human health, their levels required by the body are clearly defined as the recommended daily intake and excessive intake can adversely affect the human's health[22,23] This could easily make the soundness of tea much more complicated.

Today, the science of risk assessment provides researchers with several tools in order to perform computational risk of hazards associated with foods. In the context of heavy metals as one of those hazards, the given risk is commonly evaluated by the proportion of the exposure unit to the defined reference dose, in that for exposure assessment the whole lifetime is taken into consideration as well as the concentration of elements in each type of food under consideration.[6,10,23-25] Risk evaluation of the excessive essential elements could be conducted likewise.[23,25]

There have been some studies carried out in Iran on the concentration of toxic as well as necessary elements in commercial brands of tea on the market.[7,16,26] None of these studies addressed the risks of health effects associated with high concentrations of elements in tea.

The aim of this study was to systematically review those Iranian publications that focused on the concentration of elements in tea and to use the most valid and reliable presented data in order to assess the cumulative risk of different elements via tea consumption in Iran.

METHODS

In order to retrieve relevant articles, academic databases and search engines covering the specific disciplines in agriculture, food, food technology, chemistry, analytical chemistry, biology, environmental science, and health and nutrition were considered. Accordingly, "Agricola," "Agris," "Analytical Science Digital Library," "Analytical Abstract," "Bio Line," "Biological Abstract," "CAB abstract," "Chemical Abstract Service," "EMBASE," "FSTA," "Global Health" "Google Scholar," "Hub Med," "Go PubMed," "Medline plus," "Scielo," "Science citation index," "Science Direct," "Scirus," "Merck Index," "Springer Link," "Web of Knowledge," "Web of science" with no language or date restriction were searched for the key words such as; tea, heavy metal, elements and determination. Iranian scientific databases such as; "Iran medx" and "Magiran" were further probed for the related subjects in Persian. Being conducted in Iran was considered as the inclusion criteria while exclusion criteria was established owing to lack of information on the validity parameters and accuracy in the analytical methods as a part of material and method. In this regard, test precision, reproducibility, r^2 for the calibration curves as well as recovery data was considered as the validity parameters. We extracted data on publication (the first author's last name and year of publication), the origin of tested tea samples, number of the tested samples and the concentration of examined elements (mean ± standard deviation) and maximum concentration of the examined elements if reported in addition, official regulatory organization websites in Iran such as ISIRI databases, the analytical results on the concentration of each element in the black tea was extracted to calculate a hazard quotient (HQ) for the given element. Toxic heavy metals and essential elements were both taken into account. The equations (1, the consumption data was based on the amount of dried tea used. After selecting the well conducted, the safe state of tea consumption regarding the contained elements reported in each study was defined when both calculated HQ and hazard index (HI) indices were less than the value of 1, then, valid articles,

$$\mathrm{HQ} = \frac{\text{Exposure dose}}{RfD} \tag{1}$$

$$\text{Exposure dose} = \frac{Ci * Dv * Ed}{Bw * At}\ \mathrm{mg/kg/day} \tag{2}$$

$$\mathrm{HI} = \sum_{n=1}^{n=k} \text{hazard quotient} = \mathrm{HQ}_{1+}\mathrm{HQ}_{2+\ldots.}\mathrm{HQ}_{\mathrm{k}} \tag{3}$$

Where *Ci* shows the concentration of each element measured for different types of tea in each valid article (mg/kg/, dry tea or mg/l), *Dv* shows the amount of daily tea intake per person in Iran (4.3837 g/person/day).[7] *Ed* indicates the human's lifetime exposure (50 years), *Bw* shows the mean body weight, which was considered as 70 kg for Iranian adults, and *At* is the whole lifetime (70 years). *RfD* for each element was originated from relevant published articles and National Institutes of Health as the Tolerable Upper Intake Level, which defined as the maximum daily intake unlikely to cause adverse health effects.[6,10,27] In the case, *RfD* was not determined for an element, provisional tolerable daily intake, set down by the World Health Organization was used instead.[6,27]

The resulted HQ values for essential elements or toxic ones were, then, summed up separately to obtain the HI indexes for both types of elements.[6]

Having reviewed 51 total relevant articles conducted all over the world, the majority of them have focused on the measurement of a number of elements, mainly heavy metals, in different kinds of tea, however the evaluation of the associated risks has been rarely considered in the published articles. Figure 1, illustrates the frequency distribution of total acquired publications in terms of their main study objectives. The cumulative risk assessment of elements via tea consumption was considered by only 6% of the studies, of which, 50% were exclusively dedicated to black tea (2008). In a study conducted in Turkey, it was stated that high tea consumers in 95th consumption percentile were at risk of arsenic carcinogenicity.[10]

Considering the tea consumption pattern in Taiwan, Shen and Chen[6] reported that for black tea in comparison to oolong and green tea, the calculated HI for arsenic, lead, cadmium and chromium could reach to 0.65, indicating a more risky condition in terms of heavy meals toxicity through the consumption of black tea rather than other types of tea.[6] Of the total 51 acquired articles 9 were performed in Iran.[7-9,16,17,26,28-30] Two studies were eliminated due to their heterogeneous nature of the tested samples; in the first study, which was conducted in 2005, different elements were traced in fresh, green tea leaves that had been supposed to be manufactured into dried black tea[8] and the second study measured the elements in brewed tea.[30]

In spite of the popularity of tea among Iranians and its position as the primary beverage regularly served with/after every daily main meal, only two well-conducted research studies in the field were conducted in Iran.[7,28] In Tables 1 and 2, all of the Iranian studies are summarized. The results presented in both studies are not comparable to other studies. Reviewing the remaining studies, there were considerable variation in the elements assessed, the equipment utilized and the sample

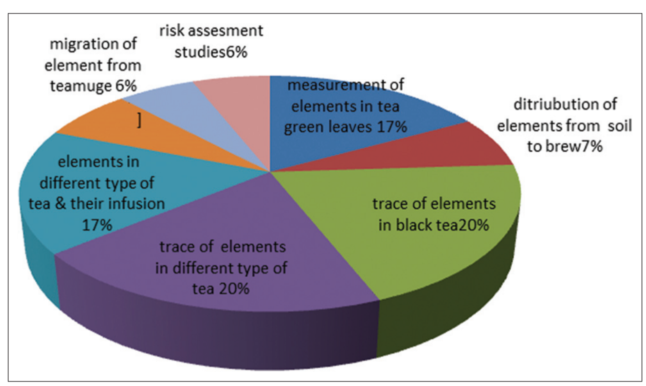

Figure 1: The frequency distribution of the available publications on the toxic or essentials elements in tea, in terms of study objectives

Table 1: Iranian studies carried out on the determination of toxic metals in tea

Concentration of investigated toxic metals mg/kg							**Tea origin**	***n***	**Year**	**Author and reference**
Hg	**As**	**Al**	**Cr**	**Ni**	**Cd**	**Pb**				
-	-	1143	1.54>	10.03	>0.76	1.91*	Iranian	11	2011	Salahinejad
-	-	843	ND	7.54	ND	0.92**				and Aflaki[7]
-	-	1546	1.79	12.40	0.76	2.92***				
-		891.2	>1.76	4.88	>0.68	1.34	Indian			
-	-	616.5	ND	4.5	ND	0.98				
-	-	1297	1.84	5.21	0.59	1.22				
-		968.2	>1.21	5.09	>0.55	1.71	Ceylon			
-	-	584.5	ND	4.13	ND	0.94				
-	-	1338	1.71	7.28	0.65	2.5				
-	-	-	-	-	-	-	NM	45	2009	Hamidi
-	ND	-	-	6.99±1.27	-	0.15±0.07				Ravari and
-	ND	-	-	0.290±0.07	-	0.48±0.25				Daaneshpajooh[29]
0.06±0.01	0.08±0.01	931±36	-	-	-	2.21±0.1	Indian	15	2008	Karimi *et al.*,[28]
-	-	-	-	-	-	-				
-	-	-	-	-	-	-				
0.06±0.01	0.12±0.04	728±59	-	-	-	2.08±0.41	Mixed of imported			
-	-	-	-	-	-	-				
-	-	-	-	-	-	-				
0.07±0.02	0.1±0.01	699±36	-	-	-	2.43±0.39	Sir Lanka			
-	-	-	-	-	-	-				
-	-	-	-	-	-	-				
0.04±0.02	0.08±0.01	932±133	-	-	-	2.28±0.09	Kenya			
-	-	-	-	-	-	-				
-	-	-	-	-	-	-				
0.06±0.01	0.09±0.02	1549±411	-	-		2.59±0.15	Iranian			
-	-	-				-				
-	-	-				-				
-	-	-	-	-	0.67	9.73	Iranian	10	2008	Shokrzade
-	-	-	-	-	0.1305	8.3808				*et al.*,[9]
					1.918	15.4792				
-	-	-	-	-	2.5	2.5	Foreign			
-	-	-	-	-	0.0919	0.6639				
-	-	-	-	-	0.9431	5.4297				
-	-	-	-	-	-	-	NM	31	2007	Moghaddam
-	-	-	53.8	-	-	-				*et al.*,[26]
-	-	-	948	-		-				
-	-	699.2	-	ND	-	ND	Iranian	30	2007	Ansari *et al.*,[16]
-	-	405	-	ND	-	ND				
-	-	1013	-	ND	-	ND				
-	-	388.3	-	ND	-	ND	Imported			
-	-	266.7	-	ND	-	ND				
-	-	622	-	ND	-	ND				
-	-	-	5.75±1.1	2.91±1.9	-	6.97±4.78	NM	44	1390	Malakootian
-	-	-	3.97±1.1	0.63±0.84	-	2.10±0.68				*et al.*,[17]
-	-	-	7.87±1.1	6.25±1.75	-	14.66±1.75				

*The average concentration of the tested element, **The minimum concentration of the tested element, ***The maximum concentration of the tested element. NM=The origin of tea was not mentioned, *n*=the number of the tested samples; ND = Not determined size. Lead and aluminum were most commonly investigated, and the concentration of lead seemed to vary greatly among studies. Arsenic was considered in just two studies[28,29] which came to similar conclusions on its concentration in the tested tea samples. Based on the presented data in Tables 1 and 2, contamination ranges of some of the toxic elements sometimes exceeded the national regulated level. Lead, for example, had the higher concentrations than the permitted level in two studies (1 mg/kg).[17,28] Mercury and cadmium, however, were only tested in one study[28] and the concentrations of both were above the Iranian standard values (0.1 mg/kg and 0.05 mg/kg were set down for cadmium and mercury, respectively).

Considering the essential elements, one study reported violative concentration of copper in the tested tea samples compared with the defined standard (50 mg/kg).[7,28]

Although the difference in sample size is generally regarded as an influential factor in the varied results obtained from similarly conducted studies, it is unlikely to be a principal parameter that has made a distinction among the reviewed Iranian studies; since, in none of them, sample size has exceeded 50 even in the most comprehensive ones. In this review; hence, in order to select the accredit publications, attention to the method's validation criteria was regarded as the most important factor to screen the obtained studies and the priority was set mainly based on the validity parameters of analytical experiments. Unfortunately, these issues have rarely considered by Iranian studies that were reviewed in the present paper. Of the seven studies,

Table 2: Iranian studies conducted on the determination of essential elements in tea

Concentration of investigated essential elements metals mg/kg					**Tea origin**	***n***	**Year**	**Author and reference**
Mg	**Zn**	**Cu**	**Fe**	**Mn**				
1861	24.1	49.39	188.1	608.3*	Iranian	11	2010	Salahinejad and Aflaki[7]
1724	22.2	40.19	139.6	439.9**				
2021	26.88	58.48	307.9	647.3***				
1987	27.26	23.21	146.9	469.3	Indian			
1799	21.2	19.84	115.5	436.2				
2182	23.12	26.64	212.2	549.9				
2029	28.31	168.14	168.14	488.8	Ceylon			
1540	23.37	35.79	94.93	333.8				
2716	32.24	39.57	310.1	655.4				
-	-	-	-	-	NM	45	2008	Hamidi Ravari and Daaneshpajooh[29]
1810±502	21±3	17±0						
2405±632	31±9	21±0						
-	-	22.54±0.92	-	-	Indian	15	2008	Karimi *et al*.,[28]
-	-	31.18±0.13	-	-	Mixed of imported tea			
-	-	28.36±2.46	-	-	Sri Lanka			
-	-	17.59±3.09	-	-	Kenya			
-	-	32.8±3.84	-	-	Iranian			
182.9	40.3	29.3	92.6	182.9	Iranian	30	2007	Ansari *et al*.,[16]
155.2	34.1	19.6	17.2	155.2				
214.2	47.4	36.7	194	214.2				
-	-	-	-	-	NM	31	2007	Moghaddam *et al*.,[26]
-	19.8	-	-	-				
-	97.8	-	-	-				
-	-	23.85±9.8	-	-	NM	44	1389	Malakootian *et al*.,[17]
-	-	10.5±1.14	-	-				
-	-	37.5±1.36	-	-				

*The average concentration of the tested element, **The minimum concentration of the tested element, ***The maximum concentration of the tested element, *n*=the number of the tested samples, NM=The origin of tea was not mentioned two were found to be accredited; the first one was carried out by Salahinejad and Aflaki in 2010[7] and the second one was performed by Karimi *et al*. in 2008.[28] Using their data, HQ and HI indexes were calculated and presented in Tables 3-5. In the computation of HQ and HI indices, the average concentration of a chemical compound is, usually, taken into account. As in the study conducted by Salahinejad and Aflaki the minimum and maximum concentration of the elements were presented as well as their average amount, HQ and HI indices were computable based on the maximum concentration of the tested elements, in addition to the their mean amount [Table 3]. Furthermore, in Salahinejad and Aflaki paper, tea samples were categorized based on their origins (Iranian, Indian, Ceylon), thus, the data on the elements concentrations were also presented in the same way as shown in Tables 3 and 4 for the five tested toxic elements in that study, HQ values are ordered as 1>lead>aluminum>nickel>cadmium> chromium. For the essential elements, however, as it was shown in Table 4, the following pattern is revealed: 1>manganese>copper>iron>zinc. Higher HQ for manganese than other essential elements may be alarming since the excessive manganese ingestion was associated with its accumulation in brain, dysfunction of the basal ganglia system. Moreover, some implications including neurological disorders and desperation have been related to high manganese intake via food chain.[29,31]

In the second selected study carried out by Karimi *et al*.,[28] examined tea samples were categorized according to the country of origin [Table 5]. The HQ values for the tested elements are obtained in the following order: Mercury<arsenic<copper<aluminum<lead<l. All of the values are below 1. Comparing the HI values that are presented in Table 5, it is revealed that Iranian tea had a higher HI index than that of other types. Based on the given study results, aluminum concentration in Indian tea was very similar to that of reported for Indian tea in other studies abroad.[18] It is interesting to note that despite the data on the abundance of aluminum in tea, the assayed indexes in the present study suggests that the health hazards associated with the ingested amount of aluminum through tea consumption in Iranian society is less than that of lead.

In line with this result, Shen and Chen reported the highest HQ value for lead among several tested elements in tea samples in China.[6] Lead is one of the most prevalent toxic elements in

Table 3: HQs and HIs calculated results according to the Salahinejad and Aflaki study for toxic metals in three different tea sample groups

HQ			***RfD* mg/kg/day**	**Element**
Ceylon	**Indian**	**Iranian**		
0.05	0.04	0.06[1]	1.4E-3[6]	Pb
0.08	0.05	0.09[2]		
0.02	0.02	0.03	1E-3[6,27]	Cd
0.03	0.03	0.03		
0.01	0.01	0.02	2E-2[23]	Ni
0.02	0.01	0.03		
0.02	0.02	0.02	3E-3[6]	Cr
0.02	0.02	0.03		
0.04	0.03	0.05	1E-0[27]	Al
0.06	0.06	0.07		
0.14	0.12	0.18[3]		$\sum$HQ=HI
0.21	0.17	0.25[4]		

[1]HQs (mean) were calculated based on the mean concentration of each tested element in each type of tea, [2]HQs (max) were expressed based on the maximum concentration of each tested element in each type of tea, [3]HIs ($\sum_1^5 \text{HQ mean}$) were calculated based on the mean concentration of each tested element in each type of tea, [4]HIs ($\sum_1^5 \text{HQ max}$) were expressed based on the maximum concentration of each tested element in each type of tea. HQ=Hazard quotient, HI=Hazard index

Table 4: HQs and HIs calculated results according to the Salahinejad and Aflaki study the essential element in three different originated tea sample groups

HQ			***RfD* mg/kg/day**	**Metal**
Ceylon	**Indian**	**Iranian**		
0.17	0.17	0.2[1]	16E-2[23]	Mn
0.21	0.21	0.23[2]		
0.01	0.01	0.01	0.7E-0[23]	Fe
0.02	0.02	0.02		
0.04	0.02	0.06	4E-2[23,27]	Cu
0.04	0.03	0.07		
0.004	0.004	0.003	3E-1[23,27]	Zn
0.004	0.005	0.004		
0.2	0.2	0.3[3]		$\sum$HQ=HI
0.21	0.21	0.3[4]		

[1]HQs (mean) were calculated based on the mean concentration of each tested element in each type of tea, [2]HQs (max) were expressed based on the maximum concentration of each tested element in each type of tea, [3]HIs ($\sum_1^5 \text{HQ mean}$) were calculated based on the mean concentration of each tested element in each type of tea, [4]HIs ($\sum_1^5 \text{HQ max}$) were expressed based on the maximum concentration of each tested element in each type of tea. HQ=Hazard quotient, HI=Hazard index

Table 5: HQs and HIs calculated results according to Karimi *et al.*(year) study in three different originated tea sample groups

HQ					*RfD* mg/kg/day	Metal
Iranian	Kenya	Sir Lanka	Mixed	Indian		
0.08	0.07	0.07	0.06	0.05[1]	1.4E-3[6]	Pb
0.004	0.002	0.004	0.004	0.004	7.14E-4[27]	Hg
0.02	0.02	0.01	0.02	0.01	3E-4[6]	As
0.07	0.04	0.03	0.03	0.04	1E-0[27]	Al
0.04	0.02	0.02	0.02	0.02	4E-2[23,27]	Cu
0.23	0.15	0.14	0.22	0.12[2]	$\sum$HQ=HI	

[1]HQs were calculated based on the mean concentration of each tested element in each type of tea, [2]HIs were calculated based on the mean concentration of each tested element in each type of tea. HQ=Hazard quotient, HI=Hazard index

different kinds of food including vegetables, crops, meat products.[23-25] Lead excessive intake may result in memory deterioration and behavioral disturbance.[5,32] There are other risk assessment studies in the literature in which the principal contribution of lead to HI was reported when the potential hazards of heavy metals were evaluated through different food articles other than tea.[33]

Considering the extraction process of the elements in brewed tea[7,18,19,34] we examined whether the difference between the elements concentrations in the tea infusion and the dried form led us to overestimate the presented risk. As illustrated by some studies, for instance, for lead, the extraction range of 0-58.6%[6,7] was reported in two different studies. For manganese, the given range was reported as 25-55%.[7] Applying such a reduction factor on the concentration of essential elements that was reported by Salahinejad, the computed HI may tends to the lower values. On the other hand, in our risk estimation, per capita tea consumption in Iran was taken into consideration; the estimated risk could be far more for those who are high tea consumers. Furthermore, in this study, the equation used for the investigated indices was adopted from Shen and Chen that in their study duration of exposure to each element through black tea consumption was considered as 50 years.[6] Longer lifetime exposure period (70 years) was considered by another study;[10] accordingly, present estimated risk could be higher if longer period of exposure is used in HQ calculation.

For a comprehensive risk assessment, implementation of some certain data on the tea consumption and preparation pattern in the society is essential. Since such information has not scientifically been documented in Iran, it can be suggested that more accredit risk evolution of elements intake through tea consumption is to be carried out in the future studies.

CONCLUSIONS

In this study, a systematic review on the scientific literature reveals that the risk of hazards related to essential elements through the consumption of tea in Iran is more than the toxic metals and manganese has principal impact on the formation of the estimated risk. For toxic elements, however, although the result of this study confirmed their limited effect on human health by utilization of tea in an Iranian society, their intake from other sources have to be taken into consideration when more realistic risk estimation is intended and more concern should be paid on lead and cadmium.

REFERENCES

1. Wong MH, Zhang ZQ, Wong JW, Lan CY. Trace metal contents (Al, Cu and Zn) of tea: Tea and soil from two tea plantations, and tea products from different provinces of china. Environ Geochem Health 1998;20:87.
2. Ipeaiyeda AR, Dawodu MO. Leaching of manganese, iron, copper and zinc from tea (*Camellia sinensis*) in tea mugs. Electron J Environ Agric Food Chem 2011;10:2240-7.
3. Othman A, Al-Ansi S, Al-Tufail M. Determination of lead in saudi arabian imported green tea by ICP-MS. E J Chem 2012;9:79-82.
4. Yemane M, Chandravanshi BS, Wondimu T. Levels of essential and non-essential metals in leaves of the tea plant (*Camellia sinensis* L.) and soil of Wushwush farms, Ethiopia. Food Chem 2008;107:1236-43.

5. Marbaniang DG, Baruah P, Decruse R, Dkhar ER, Diengdoh DF, Nongpiur CL. Study of trace metal (Cr, Mn, Fe, Co, Ni, Cu, Zn and Cd) composition in tea available at Shillong, Meghalaya, India. Int J Environ Prot 2011;1:13-21.
6. Shen FM, Chen HW. Element composition of tea leaves and tea infusions and its impact on health. Bull Environ Contam Toxicol 2008;80:300-4.
7. 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;134:109-17.
8. Ebadi A, Zare S, Mahdavi M, Babaee 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;4:270-2.
9. Shokrzadeh M, Saberyan M, Saeedi Saravi S. Assessment of lead (Pb) and cadmium (Cd) in 10 samples of Iranian and foreign consumed tea leaves and dissolved beverages. Toxicol Environ Chem 2008;90:879-83.
10. Sofuoglu SC, Kavcar P. An exposure and risk assessment for fluoride and trace metals in black tea. J Hazard Mater 2008;158:392-400.
11. Sajilata MG, Bajaj PR, Singhal RS. Tea polyphenols as nutraceuticals. Compr Rev Food Sci Food Saf 2008;7:229-54.
12. Davies MJ, Judd JT, Baer DJ, Clevidence BA, Paul DR, Edwards AJ, *et al*. Black tea consumption reduces total and LDL cholesterol in mildly hypercholesterolemic adults. J Nutr 2003;133:3298S-302.
13. Vinson JA, Zhang J. Black and green teas equally inhibit diabetic cataracts in a streptozotocin-induced rat model of diabetes. J Agric Food Chem 2005;53:3710-3.
14. Huang MT, Xie JG, Wang ZY, Ho CT, Lou YR, Wang CX, *et al.* Effects of tea, decaffeinated tea, and caffeine on UVB light-induced complete carcinogenesis in SKH-1 mice: Demonstration of caffeine as a biologically important constituent of tea. Cancer Res 1997;57:2623-9.
15. Qin F, Chen W. Lead and copper levels in tea samples marketed in Beijing, China. Bull Environ Contam Toxicol 2007;79:247-50.
16. Ansari F, Norbakhsh R, Daneshmandirani K. Determination of heavy metals in iranian and imported black tea. Environ Health Sci Eng 2007;4:243-8.
17. Malakootian M, Meserghani M, Daneshpazhoo M. A survey on Pb, Cr, Ni, and cu concentration in Tehran consumed black tea. Rafsanjan Univ Med Sci 1390;2:138-43.
18. Karak T, Bhagat RM. Trace elements in tea leaves, made tea and tea infusion: A review. Food Res Int 2010;43:2234-52.
19. Szymczycha-Madeja A, Welna M, Pohl P. Elemental analysis of teas and their infusions by spectrometric methods. TrAC Trends Analyt Chem 2012;35:165-81.
20. Seenivasan S, Manikandan N, Muraleedharan NN, Selvasundaram R. Heavy metal content of black teas from south India. Food Control 2008;19:746-9.
21. Seenivasan S, Manikandan N, Muraleedharan NN. Chromium contamination in black tea and its transfer into tea brew. Food Chem 2008;106:1066-9.
22. Mohammed MI, Sulaiman MA. Analysis of some metals in some brands of tea sold in Kano, Nigeria. Bayero J Pure Appl Sci 2011;2:34.
23. Monica H, Liana A, Despina B, Ioan G, Iosif G. Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County, Romania. Chem Cent J 2011;5:64.
24. Tsafe AI, Hassan LG, Sahabi DM, Alhassan Y, Bala BM. Evaluation of heavy metals uptake and risk assessment of vegetables grown in Yargalma of Northern Nigeria. J Basic Appl 24. Sci Res 2012;2:6708-14.
25. Orisakwe OE, Nduka JK, Amadi CN, Dike DO, Bede O. Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern, Nigeria. Chem Cent J 2012;6:77.
26. Moghaddam MA, Mahvi AH, Asgari AR, Yonesian M, Jahed GH, Nazmara SH. Determination of aluminum and zinc in Iranian consumed tea. Environ Monit Assess 2008;144:23-30.
27. Cao H, Qiao L, Zhang H, Chen J. Exposure and risk assessment for aluminium and heavy metals in Puerh tea. Sci Total Environ 2010;408:2777-84.
28. Karimi G, Hasanzadeh MK, Nili A, Khshayarmanesh Z, Samiei Z, Nazari F, *et al*. Cocentrations and health risk heavy metals in tea samples marketed in Iran. Phamacologyonline 2008;3:164-74.
29. Hamidi Ravari EM, Daaneshpajooh M. Measuring the lead, arsenic, cupper, selenum, sodium, potasium, nickle, and magnesium ions in black tea. Kashan Univ Med Sci 2009;13:242-5.
30. Shekoohiyan S, Ghoochani M, Mohagheghian A, Mahvi AH, Yunesian M, Nazmara S. Determination of lead, cadmium and arsenic in infusion tea cultivated in north of Iran. Iranian J Environ Health Sci Eng 2012;9:37.
31. Bowman AB, Kwakye GF, Herrero Hernández E, Aschner M. Role of manganese in neurodegenerative diseases. J Trace Elem Med Biol 2011;25:191-203.
32. Valadez-Vega C, Zúñiga-Pérez C, Quintanar-Gómez S, Morales-González JA, Madrigal-Santillán E, Villagómez-Ibarra JR, *et al.* Lead, cadmium and cobalt (Pb, Cd, and Co) leaching of glass-clay containers by pH effect of food. Int J Mol Sci 2011;12:2336-50.
33. Hough RL, Breward N, Young SD, Crout NM, Tye AM,

Moir AM, *et al*. Assessing potential risk of heavy metal exposure from consumption of home-produced vegetables by urban populations. Environ Health Perspect 2004;112:215-21.
34. Achudume AC, Owoeye D. Quantitative assessment of heavy metals in some tea marketed in Nigeria-Bioaccumulation of heavy metals in tea. Health 2010;2:1097-100.

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