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Determination of Cadmium and Lead Contents in Black Tea and Tea Liquor from Iran

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The aims of this research were to investigate the cadmium and lead content of several commercially available brands of tea (*Camellia sinensis* L) in Iran and to compare the release of cadmium and lead from them by infusion. Ten of the most widely consumed brands of Iranian and foreign black tea were purchased from local markets. Three samples of each brand were collected and analyzed. Cadmium and lead contents in the tea and tea infusions were determined by atomic absorption spectrometer after acid digestion. The results revealed that the minimum and maximum lead contents in studied tea were 0.66 ± 0.14 and 15.48 ± 0.58 μg/g for Sharzad and Sharyat tea, respectively. In addition, the minimum and maximum cadmium content was 0.09 ± 0.013 and 1.92 ± 0.38 μg/g for Ahmad and Sharyat tea, respectively. Cadmium content in Iranian tea was not significantly higher than in the foreign tea ($p > 0.05$), however lead was significantly higher than in the foreign tea ($p < 0.05$). Total cadmium contents of the dried tea Infusion that was released in the tea liquor was no detectable for all samples in the 15 min infusion, while relased 24.4 % (Sharyat tea) to 72 % (Sharzad tea) of the total lead content. The cadmium and lead contents increase in tea liquor with increasing of infusion time from 15 to 30 min. The present study suggests that tea may be a rich source of dietary heavy metal intake and metals content in tea liquor depend on infusion time. The levels of cadmium and lead determined in this study compared well with those reported for tea from some other parts of the world. Based upon the present safety standards, the tea versions selected in the present study were found to be safe for human consumption.

Key Words: *Camellia sinensis*, Cadmium, Lead, Iranian tea, Tea infusion.

INTRODUCTION

The tea plant (*Camellia sinensis* L) matures after 7 years of growth and, with careful field maintenance and regular pruning, can be plucked at a steady yield for

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up to 100 years. Favourable conditions for tea cultivation[1] include a suitable temperature (15-25 °C), high relative humidity (80-90 %) and high annual rainfall (1500-2000 mm). Tea plantations are found in northern Iran in Gilan and Mazandaran provinces where mist and high humidity ensure that the leaves grow slowly and remain tender. Most of the tea consumed in Iran is grown in these northern regions, but some tea is purchased from other countries, especially from India[2].

Black tea is one of the major teas that used for preparing drinking tea in the worldwide[2]. It is one of the most popular beverages in the world[3]. The tea plant takes up heavy metals from the soil and accumulates it in its leaves. Tea therefore can be a rich source of some essential dietary metals of human intake. Heavy metals contents of foods are of interest because of their essential or toxic nature. Some heavy metals such as iron, zinc, copper, chromium, cobalt and manganese are essential, while lead, cadmium, nickel and mercury are toxic at certain levels[4]. Various reports have discussed the potential health implications of trace metals in tea, since the tea bush is known to accumulate them. For example, cadmium accumulates readily in living systems. In humans, it has been implicated as the cause of renal disturbances, lung insufficiency, bone lesions, cancer and hypertension[5-7].

A few reports are available to confirm the presence of heavy metals such as Cd and Pb in tea[4,8-12]. The study showed that Cd and Pb contents in Indian black tea were 0.14 ± 0.06 and 0.81 ± 0.32 μg/g, respectively. The contents of copper and lead in tea were below the permissible limit under the food adulteration act (PFA) of India[11]. Other study in Saudia Arabia showed that Cd and Pb contents in tea and herb leaves were ranged 0.03-14.84 and non-detectable-0.37 μg/g, respectively. The concentrations of both the elements in liquor were too low to be detected using the available analytical techniques[8]. Onianwa *et al.*[4] reported that levels of Cd and Pb in five brands tea beverages in Nigeria were 0.13 ± 0.08 and 0.50 ±0.50 μg/g, respectively.

Unfortunately, a Cd and Pb content of consumed tea in Iran were not been studied. Only, one study determined aluminum and zinc contents in Iranian consumed tea[3]. Therefore, the objectives of this study were to investigate and monitor Cd and Pb contents of several commercially available brands of tea (*Camellia sinensis* L) in Iran and to compare the release of Cd and Pb from them by infusion. Finally, the results are compared with other related reports in this respect.

EXPERIMENTAL

Sampling and analytical methods: Ten of the most widely consumed brands of Iranian black tea were purchased from local bazaar markets. Three samples (30 altogether) of each brand were collected and analyzed. For determining Cd and Pb contents in tea, tea samples dried at 60 °C for 5 h, cooled to room temperature and then milled to 100 μm. 5.0 g dried and milled sample was digested by nitric acid and perchloric acid and analyzed by atomic absorption spectrometer technique.

Tea infusion procedure: Tea infusion was conducted with 15 and 30 min separately. The first step, about 10 g dried and milled sample was divided to 5 g. To each 5.0 g sample of tea was dried as above, the Iranian manner of tea infusion was

performed by addition of 50 mL of boiling deionized water and the mixture kept at 80 °C on a water bath for 15 min. The mixture was held for 5 min at room temperature and then filtered. At the end of the infusion period, the tea extract diluted to 100 mL with deionized water. The same tea samples used for making a second infusion with 15 min, using 50 mL of boiling distilled water each time and allowing infusing for a further 30 min. At the end of the infusion period, the tea liquor was diluted to 100 mL with deionized water.

The Cd and Pb contents were determined by atomic absorption spectrometer (Perkin-Elmer pure atomic spectrometry) after acid digestion. All samples were prepared and analyzed in triplicate.

RESULTS AND DISCUSSION

Cadmium and lead contents of Iranian and foreign black are given in Tables 1 and 2, respectively. The results show that the minimum and maximum Pb content in Iranian tea was 8.38 ± 0.42 and 15.48 ± 0.58 μg/g for Golkis and Sharyat tea, respectively. The minimum and maximum Pb content in foreign tea was 0.66 ± 0.14 and 5.43 ± 0.38 μg/g for Sharzad and Golestan tea, respectively. In general, the minimum and maximum Pb content in studied tea was 0.66 ± 0.14 mg/g and 15.48 ± 0.58 mg/g for Sharzad and Sharyat tea, respectively. Our results are similar to other studies in other countries. For example, Xie *et al.*[13] has found mean Pb contents in some Chinese black tea samples as 1.42 ± 0.8 μg/g. Narin *et al.*[14] have reported maximum lead in Turkish tea samples at the levels[15] of 27.3 ± 0.1 μg/g. Moreover, the results of literturereview have shown in Table-3. it shows cadmium and lead in black tea in other countries.

TABLE-1
TOTAL CONTENTS OF CADMIUM AND LEAD IN IRANIAN BLACK TEA (μg/g)

Tea brand name	Cadmium	Lead
Sharyat	1.92 ± 0.38	15.48 ± 0.58
Taberan	0.71 ± 0.06	12.84 ± 0.48
Golkis	0.35 ± 0.13	8.38 ± 0.42
Bamdad	0.13 ± 0.03	8.76 ± 0.42
Yellow Sedagat	0.25 ± 0.05	11.64 ± 0.5
Min	0.13 ± 0.03	8.38 ± 0.42
Max	1.92 ± 0.38	15.48 ± 0.58
Average ± SD	0.67 ± 0.51	11.42 ± 2.28

The minimum and maximum Cd content in foreign tea was 0.09 ± 0.013 and 0.94 ± 0.12 μg/g for Ahmad and Black Sedaghat, respectively. In general, the lowest and highest of Cd contents was 0.09 ± 0.013 and 1.92 ± 0.38 μg/g for Ahmad and Sharyat tea, respectively. Ferrara *et al.*[16] has reported cadmium levels of the analyzed samples were below detection limit by using flame atomic absorption spectroscopy. However, Narin *et al.*[14] have reported 2.0 ± 0.2 μg/g Cd in Turkish Lipton tea sample[15].

TABLE-2
TOTAL CONTENTS OF CADMIUM AND LEAD IN NON-IRANIAN BLACK TEA (µg/g)

Tea brand name	Cadmium	Lead
Black Sedaghat	0.94 ± 0.120	0.82 ± 1.20
Lepton	0.37 ± 0.100	3.07 ± 0.23
Sharzad	0.73 ± 0.090	0.66 ± 0.14
Golestan	0.53 ± 0.060	5.43 ± 0.38
Ahmad	0.09 ± 0.013	1.30 ± 0.18
Min	0.09 ± 0.013	0.66 ± 0.14
Max	0.94 ± 0.120	5.43 ± 0.38
Average ± SD	0.52 ± 0.300	2.30 ± 1.60

TABLE-3
LEVELS OF CADMIUM AND LEAD IN BLACK TEA IN SOME OTHER PARTS OF THE WORLD (µg/g)

Country	Cadmium	Lead	Ref.
Saudi Arabia- black tea	1.1 ± 0.5	1.7 ± 0.8	15
Turkey	2.0 ± 0.8	8.3 ± 0.1	15
Spain	ND	ND	15
Japan	ND	0.71 ± 0.02	15
China	ND	3.30 ± 1.42	15
India	ND	ND	15
South India	0.14 ± 0.06	0.81 ± 0.32	11
Nigeria- beverages (ppm)	0.13 ± 0.08	0.50 ± 0.50	8

In study by Sreenivasan *et al.*[11] have found that cadmium and lead in tea were 0.14 ± 0.06 and 0.81 ± 0.32 µg/g in tea samples collected from South India. Study in five tea clones of the *Camellia assamica* variety grown in Wushwush tea plantation farms, Ethiopia, showed that the contents of Pb and Cd were at levels too low to be detected[12].

Assessment of tea brands and herbs quality available in the retail market in the Kingdom of Saudi Arabia revealed that Cd and Pb had the lowest contents in both tea and herb leaves. Among tested tea brands, Chinese green tea possesses the highest contents of heavy metals. Contents of Cd and Pb reported 14. 84 and 0.18 µg/g in Chinese green tea, respectively. The concentrations of Pb and Cd were too low to be detected in beverage using the available analytical techniques. The solubility of studied heavy metals in both brew and infusion extracts varied widely and ranged from 0.0-48 %. The lowest rates of solubility were been listed for toxic heavy metals Pb and Cd. The amounts of heavy metals that one may take up through consumption of tea and herb beverages were found to match the acceptable daily intake that takes into account exposure from air, food and drinking water[8].

The results revealed that Cd content in Iranian tea was not significantly higher than in the foreign tea ($p > 0.05$), however Pb was significantly higher than in the foreign tea ($p < 0.05$). In addition, correlation coefficient between lead-cadmium were significant for all tea samples ($r = 95$ %).

The difference in metal concentrations may therefore be attributed to the tea products being produced in different tea estates with varying metal concentrations in the soils resulting in variation in elemental uptake by the tea leaves. Heavy metal such as cadmium and lead were entered soils and the tea plant from fertilizers and pesticides. Therefore, these contents are variable in tea depend on farm soil and fertilizers and pesticides applications. Moreover, differences in methods used in processing and storage could be contributory factors for this difference.

The availability of cadmium in soils was been influenced positively by the addition of rock phosphate. In tea, rock phosphate is been applied annually. Phosphatic fertilizers have 4.9-5.5 μg/g of Cd and 11.8-50.9 μg/g in zinc sources. Phosphate and zinc fertilizers were the sources of Cd in tea. Potassic fertilizers, phosphatic fertilizers, N-P-K blends, manganese, zinc, boron and magnesium sources contain lead. Zinc sulphate is given as a foliar spray to supply zinc. Zinc sulphate contaminated with lead, when foliar applied, Pb may enter the tea plant. Spraying of copper fungicides with heavy metal impurities may increase the accumulation of Pb and Cd in tea. Copper oxychloride is considered as one of the main sources Pb contamination. Tea soils are acidic and this condition favours solubility of heavy metals. Tea bushes adjacent to heavy traffic gets exposure to Pb and Cd through fallout from automobile exhaust and dust[11].

Cadmium and lead concentrations in tea liquor and extraction percent to tea infusion in relation to extraction time are been shown in Tables 4 and 5.

TABLE-4
CONTENTS OF CADMIUM IN TEA INFUSION AND PERCENTAGE EXTRACT TO TEA INFUSION IN RELATION TO EXTRACTION TIMES

Tea brand name	Infusion time = 15 min		Infusion time = 30 min	
	Conc. (mg/L)	Extraction (%)	Conc. (mg/L)	Extraction (%)
Black Sedaghat	ND	0.0	0.012	55.6
Lepton	ND	0.0	ND	0
Sharzad	ND	0.0	0.011	71
Golestan	ND	0.0	ND	0
Sharyat	ND	0.0	0.02	48.8
Taberan	ND	0.0	0.012	67.3
Golkis	ND	0.0	ND	0
Bamdad	ND	0.0	ND	0
Yellow Sedagat	ND	0.0	ND	0
Ahmad	ND	0.0	ND	0

As shown in Table-4, Cd was non-detectable in tea liquor for all samples at 15 min infusion time but there were a little amount in tea liquor at 30 min infusion time, while released 24.4 to 72 % of the total Pb content to infusion tea for Sharyat tea and Sharzad tea, respectively. The Cd and Pb concentrations increase in tea liquor with increasing of infusion time from 15 min to 30 min. Unlike other studies that have conducted in the different countries of the world[4]. In the present study,

TABLE-5
CONTENTS OF LEAD IN TEA INFUSION AND PERCENTAGE EXTRACT TO TEA INFUSION IN RELATION TO EXTRACTION TIMES

Tea brand name	Infusion time = 15 min		Infusion time = 30 min	
	Conc. (mg/L)	Extraction (%)	Conc. (mg/L)	Extraction (%)
Black Sedaghat	0.011	60.5	0.013	73.0
Lepton	0.023	36.7	0.034	52.7
Sharzad	0.010	72.0	0.012	75.0
Golestan	0.044	39.6	0.060	50.0
Sharyat	0.020	24.4	0.030	38.8
Taberan	0.040	38.6	0.060	58.0
Golkis	0.080	45.3	0.090	52.0
Bamdad	0.060	33.5	0.090	50.6
Yellow Sedagat	0.090	37.7	0.110	48.0
Ahmad	0.013	41.5	0.020	51.5

cadmium in tea infusion was below the detection in all samples (except in second infusion time) and lead concentration was more low. Onianwa *et al.*[4] has found that cadmium and lead concentrations were 0.13 ± 0.08 and 0.50 ± 0.50 ppm in Nigerian tea beverages, respectively. Present results showed that the solubility of metals in the first infusion were significantly (Pb: $p < 0.01$, Cd: $p < 0.05$) higher than the second infusion. Similar findings have been reported by Ahmadimoghaddam *et al.*[3], where the solubility of Al and Zn in the first infusion was significantly higher than the second infusion.

In the present study, tea infusions were prepared using distilled water. However, tea for consumers may be prepared with water from various sources containing different elemental concentrations such as cations (Ca^{2+} and Mg^{2+}) and this may affect elemental concentrations in the tea infusion.

Due to the lack of information specifying the acceptable contents of heavy metals in tea leave, the maximum allowable and safe concentration of each metal in tea leaves is urgently needed. Occasional check and frequent analyze foodstuff is also with intention to avoid many risk that arise from intake beyond the tolerance limits standards.

Overall, the study shows that the levels of the cadmium and lead studied are generally within safe limits and compare well with levels in similar foods from other parts of the world. The data here obtained will be valuable in complementing available food composition data and estimating dietary intakes of heavy metals in Iran.

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