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ORIGINAL ARTICLE

Determination of the Concentration of Heavy Metals and Their Assessment of Related Potential Health Risk for Dry Black Teas in Kashan, Iran

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KEYWORDS

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ABSTRACT: Tea is one of the most popular beverages being widely used by all families, especially among Iranians. Thus, the presence of any contaminants in tea can be dangerous for the health of consumers. The present study aimed to evaluate the concentration of heavy metals and their potential health risk in the dry black teas available in Kashan shops. This cross-sectional study was carried out on 31 brands of dry black tea purchased randomly from shops in Kashan, Iran in 2019. After the preparation of samples, the concentration of some heavy metals was determined by ICP-OES (Inductively Coupled Plasma/Optical Emission Spectrophotometer)based on the procedure described in the Standard Method. The evaluation carcinogenic risk was performed using related formula. Based on results of this study, the mean concentration of Fe, Zn, Cu, Ni, Cr, Pb, As and Cd was 83.42, 21.47, 19.46, 4.04, 0.72, 0.66, 0.4 and 0.04 $Mgkg^{-1}$ of dry black tea, respectively. According to their associated potential health risk assessment, THQ of some heavy metals including As, Cu, Cr, Ni, Pb, Fe, Zn and Cd was 0.064, 0.023, 0.011, 9.76×10^{-3}, 9.11×10^{-3}, 5.76×10^{-3}, 3.46×10^{-3} and 1.88×10^{-3} $Mgkg^{-1}day^{-1}$ and HI was less than one (0.129). Regarding the findings, it can be concluded that, the concentration of Cu, Ni and Cr in all samples of dry black tea was compatible with the Iranian and WHO standard level, while for Cd, Pb, As, Zn and Fe in some samples were more than the Iranian and WHO standard level. In addition, risk assessment analysis indicated that the consumption of the studied black tea had no carcinogenic potential risk for consumers.

INTRODUCTION

Besides water, tea is the most widely used and popular non-alcoholic beverage in Iran and around the world because of its taste, aroma and properties [1]. Tea is a major beverage in the Iranian food basket [2]. 75% of the 2.5 million tons

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of tea produced annually in many countries is black tea[3]. Approximately, 34000 hectares of agricultural lands in Gilan and Mazandaran provinces have been allocated to this crop, accounting for about half of the domestic tea production[4]. Iran is a large tea-producing country having the highest per capita consumption in the world (1.6 kg/year) [5].The presence of some elements such as Calcium, Cobalt, Chromium, Copper, Iron, Potassium, Magnesium, Manganese, Sodium, Nickel, Vanadium and Zinc, being essential for human health, add to the nutritional value of tea [6].

Tea is a rich source of manganese and contains a lot of Potassium which is useful for patients with hypertension. Based on the epidemiological studies, tea consumption prevents many diseases such as cancer due to the polyphenolic substances [7], immune disorders [8], Parkinson and cardiovascular diseases [5]. In addition, Tea decreases blood cholesterol and diabetes [9] and protects liver [10] and contains caffeine [11]. Nowadays, chemical contaminators in food and beverages have been widely discussed as a global concern [12]. The rapid expansion of urbanization and industrialization during the recent decades has led to the increase of heavy metals and similar contaminators in tea and other foods[13]. Several countries have passed strict laws to restrict the presence of heavy metals in food and drinks[14]. Among the possible contaminants found in tea are the heavy metals having a high biological half-life and accumulating in different parts of the human body[15] as well as affecting various organs including kidneys and liver[16]. Therefore, it is significant to check the amount of heavy metals in foods and beverages. Nowadays, monitoring the amount of heavy metals is highly important because such metals (Lead, Cadmium and Mercury) come from atmospheric dust and precipitation [17] and are present in soil during plant's growth due to industrial activities and fossil fuels and increased use of fuel, fertilizers and insecticides [18, 19]. Lead, Arsenic, Cadmium and Mercury accumulate in tea, both at the time of growth and during the processing at the factory [6]. The accumulation of heavy metals in tea leaves is related to the acidophilic nature of this plant because the dissolution of metals in acidic soil is higher than other soils[20]. A number of countries have recently reported that toxic metals in some teas have exceeded the maximum permissible level which has received widespread worldwide attention [17]. Therefore, the analysis of heavy metals in various tea samples has been carried out in some countries, including China [21], Turkey [22], Saudi Arabia [23], Ghana [1], India [14], Italy [24] and Iran [2, 5, 25-27]. Considering the hygienic importance of tea, the properties of essential or toxic elements and the significant share of tea in daily consumption(on average one liter of tea is consumed by a person per day in Iran), it is critical to determine the concentration of various elements in tea products [5, 28]. Since being poisoned with Arsenic, Cadmium, Chromium, Lead and Mercury, in comparison with other metals, is more dangerous, they are of particular importance. Copper, Zinc and Iron are also essential elements in the human body, but their high levels are considered toxic to humans [29].

Since no study has been conducted to determine the concentration of heavy metals in black tea sold in Kashan shops, it was decided to conduct a cross-sectional study to evaluate the concentration of some heavy metals and assess their potential health risk.

MATERIALS AND METHODS

This cross-sectional study was carried out on 93 samples of 31different brands (24 boxed brands and 7 bulk brands) of dry tea available in Kashan shops in 2019. Samples were selected randomly from the shops for a period of three months. After digestion, samples were analyzed for heavy metals of Lead, Chromium, Cadmium, Copper, Zinc, Arsenic, Iron, and Nickel by ICP apparatus at the Chemistry Laboratory of Health Faculty of Kashan University of Medical Sciences [26, 30].

Assessment of potential Human Health risk

Non-Carcinogenic risk assessment (NCRA)

Non-carcinogenic risk assessment was performed using the Target Hazard Quotient(THQ) method introduced by

USEPA 2007[31]. The estimation of daily intake(EDI) and THQ were calculated using equations 1 and 2.

$$EDI = (EF \times ED \times FI \times MC)/(BW \times AT) \quad (1)$$

$$THQ = EDI/RfD \quad (2)$$

EDI is the Estimated Daily Intake of each element ($Mgkg^{-1}day^{-1}$)

EF represents the exposure frequency of the intended element (365 $day.year^{-1}$)

ED represents the exposure duration for an adult (54 years)

FI represents the daily consumption of tea per each Iranian (4.39 g per $person^{-1}.day^{-1}$) [5]

MC represents the mean concentration of each metal in tea ($Mgkg^{-1}$ dry weight)

BW represents the mean body weight of consumers (70 kg)

AT represents the average life time (70 years × 365 days)

RfD represents the oral reference dose ($Mgkg^{-1}bwday^{-1}$) as shown in Table1.

Table 1. RfD value for the elements in the study[32-35]

Element	RfD ($Mgkg^{-1}$ $Bwday^{-1}$)
Pb	3.5×10^{-3}
As	3×10^{-4}
Cd	1×10^{-3}
Cr	3×10^{-3}
Ni	2×10^{-2}
Cu	4×10^{-2}
Fe	0.7
Zn	3×10^{-1}

RfD for each element as the maximum daily intake may cause adverse health effects[32, 36].United States Environmental Protection Agency has set RfD for Lead because there is no unique threshold below which a non-harmful intake could be allowed[35].

Finally, the cumulative non-carcinogenic risk of TTHQ (Total Target Hazard Quotient) or HI (Hazard Index) was calculated using the THQ of each metal according to equation 3. The sum of all the THQs for each element is referred to as the Hazard Index(HI).

$$TTHQ = HI(\text{Hazard Index}) = THQ_1 + THQ_2 + THQ_3 + \ldots + THQ_n \quad (3)$$

Based on the USEPA guidelines for assessing the related conservative potential health risk, $HI=TTHQ<1$ indicates that: exposed dose is less than negative reactions and there is no significant risk of non-carcinogenic effects for the exposed individuals, But if $HI=TTHQ\geq1$, it will indicate that exposed dose is more than negative reactions and most likely, heavy metals have negative effects on human health or there is a high or moderate risk of human side-effect occurrence [32, 37].

Carcinogenic risk assessment (CRA)

The assessment of potential carcinogenic health risk of lifetime of heavy metals was calculated using the Incremental Lifetime Cancer Risk(ILCR) based on equation 4 [38, 39].

$$ILCR = EDI \times CSF \quad (4)$$

CSF: Cancer Slope Factor (CSF) as which shown in the Table 2.

EDI: Estimated Daily Intake for each element ($Mgkg^{-1}day^{-1}$) which is calculated by using Formula 1.

Table 2. CSF value for the elements in the study[30, 35, 40, 41]

Element	Oral CSF (Mgkg^{-1}day^{-1})
Pb	0.0085
As	1.5
Cd	15
Cr	0.5
Ni	0.91
Cu	-
Fe	-
Zn	-

Based on the USEPA guidelines, the acceptable or tolerable carcinogenic risk(CR) ranges from 10^{-6} to 10^{-4}. In general, if CR<10^{-6}, the risk of cancer will be considered negligible; however, if CR>10^{-4}, the risk of cancer will be considered unacceptable by most international regulatory organizations[42].

After performing the experiments, the data were analyzed using SPSS 16 software. Kolmogorov test was used for normality analysis and one sample T-test and middle instability test were used for comparison with standard.

RESULTS

In the present study, the concentration of heavy metals in 31 different brands of dry tea in Kashan stores was measured (Table3).The concentrations more than standard are shown in Bold letters.

Table 3. Mean of heavy metals concentrations and comparison with standard in dry tea (Mg kg^{-1})

brand	Lead	Chrome	Cadmium	Copper	Zinc	Arsenic	Iron	Nickel
A1	**1.59**	0.85	**0.11**	25.05	**25.36**	**0.18**	**134.1**	7.28
A2	0.51	1.49	0.02	21.39	**24.39**	0.07	**76.87**	3.50
A3	0.93	0.61	0.02	19.18	**29.31**	0	**71.47**	2.11
A4	0.54	0.70	0.02	25.19	**24.56**	0.08	**60.35**	3.83
A5	0.65	0.84	0	22.16	**24.64**	**0.2**	**140.4**	6.30
A6	0.96	0.84	0.05	30.77	**21.80**	0.05	**94.35**	5.53
A7	0.24	0.40	0	11.83	**19.61**	**0.18**	**72.35**	2.18
A8	0.27	0.62	0	20.07	**14.04**	**1.15**	**52.45**	3.99
A9	0.06	0.29	0	15.03	8.61	**1.69**	**70.3**	2.26
A10	**3.26**	0.39	**0.12**	26.09	11.28	**1.22**	**65.12**	4.14
A11	0.14	0.84	0	23.47	**24.42**	**0.17**	**63.32**	3.65
A12	0.13	0.33	0	20.3	**20.45**	**0.26**	**61.75**	2.2
A13	0.24	0.7	0	15.12	11.96	**1.48**	**109.85**	4.76
A14	0.1	0.29	0	13.93	**16.70**	0.11	**54.05**	1.74
A15	0.05	0.37	0	13.43	**20.72**	0.11	**71.22**	2.78
A16	0.38	0.97	0.08	18.61	**23.54**	**2.15**	**134.47**	7.52
A17	0.45	0.64	0	26.94	12.34	**1.36**	**61.3**	3.58
A18	0.71	2.31	0	21.32	11.93	**0.69**	**86.32**	4.39
A19	0.50	0.36	0	15.85	**34.37**	0.09	**55.2**	4.43
A20	0.37	0.65	0	17.57	**30.52**	**0.19**	**62.9**	4.59
A21	0.26	0.67	0	19.31	**30.03**	0.14	**114.87**	5.80

Table 3. Continued.

A22	0.26	1.27	0.01	15.45	**23.16**	0.07	**102.37**	2.70
A23	0.69	0.82	0.002	22.80	**25.52**	0.13	**127.95**	7.62
A24	0.37	0.38	0.02	17.77	**23.15**	0.06	**70.3**	2.49
A25	0.75	0.66	0.01	25.08	**26.98**	0.11	**53.02**	3.41
A26	0.27	0.62	0	21.32	**26.60**	0.05	**30.2**	3.49
A27	**2.54**	0.85	**0.35**	19.09	**20.46**	0.08	**140.6**	5.39
A28	0.12	0.65	0	10.3	**16.70**	**0.21**	**85.27**	2.64
A29	0.09	0.28	0	13.44	**18.04**	0.12	**43.32**	1.66
A30	**1.54**	0.78	0.06	23.39	**19.43**	0	**105.07**	3.25
A31	**1.48**	0.67	**0.32**	11.89	**24.84**	0	**115**	6.06
Iranian standard	1	-	0.1	50	-	0. 15	-	-
WHO standard	10	-	3	-	14	2.2	26	-
China standard	5	5	1	30	-	2	-	-
Japan standard	-	-	-	-	-	20	-	100

Table 4 presents the minimum, maximum, mean and standard deviation of heavy metal concentrations in dry tea samples and their comparison with standard. As can be seen in the information of this table, the lowest mean concentration was related to Cadmium as 0.04 $Mgkg^{-1}$ and the highest mean concentration was related to Iron as 83.42 $Mgkg^{-1}$. Daily intake for metals (EDI), THQ and ILCR in tea samples was calculated and summarized in Table 5.

Table 4. Mean and standard deviation of heavy metal concentrations and comparison with standard in dry tea ($Mgkg^{-1}$)

Heavy metal	Concentration		Mean concentration	Standard deviation	Standard	P.value
	Minimum	Maximum				
Lead	0.05	3.26	0.66	0.74	1[a]	0.016
Chrome	0.28	2.31	0.71	0.40	5[b]	<0.001
Cadmium	0	0.35	0.04	0.08	0.1[a]	0.001
Copper	10.3	30.77	19.46	5.04	50[a]	<0.001
Zinc	8.61	34.37	21.47	6.29	14[c]	<0.001
Arsenic	0	2.15	0.4	0.59	0.15[a]	0.025
Iron	30.2	140.6	83.42	30.96	26[c]	<0.001
Nickel	1.66	7.62	4.04	1.70	100[d]	<0.001

[a] Based on the Iranian standard(ISIRI); [b] Based on Chinese standard; [c] Based on WHO standard; [d] By Japanese standard

Table 5. Calculation of EDI and THQ and TTHQ=HI and ILCR for heavy metals in the present study.

Heavy metal	Mean concentration ($Mgkg^{-1}$)	EDI ($Mgkg^{-1}day^{-1}$)	THQ	ILCR
Lead	0.66	3.19×10^{-5}	9.11×10^{-3}	2.71×10^{-7}
Cadmium	0.04	1.88×10^{-6}	1.88×10^{-3}	2.76×10^{-5}
Arsenic	0.4	1.92×10^{-5}	0.064	2.88×10^{-5}
Nickel	4.04	1.95×10^{-4}	9.76×10^{-3}	1.77×10^{-4}
Chrome	0.71	3.45×10^{-5}	0.011	1.72×10^{-5}
Zinc	21.47	1.04×10^{-3}	3.46×10^{-3}	-
Iron	83.42	4.03×10^{-3}	5.76×10^{-3}	-
Copper	19.46	9.4×10^{-4}	0.023	-
TTHQ=HI		0.129 < 1		

The results of this study indicated that THQ for all metals as well as HI(0.129) were lower than acceptable risk level (1.0) (Table 5) and the results were as follows:

$THQ_{Cd} < THQ_{Zn} < THQ_{Fe} < THQ_{Pb} < THQ_{Ni} < THQ_{Cr} < THQ_{Cu} < THQ_{As}$

Among these values, THQ_{As} was higher than the others; thus, Arsenic had a higher share in HI.The carcinogenic risk for Arsenic, Cadmium, Chrome, Nickel and Lead in this study were found to be 2.88×10^{-5},2.76×10^{-5}, 1.72×10^{-5},1.77×10^{-4} and 2.71×10^{-7}, which are within the acceptable USEPA range (between $10^{-4} – 10^{-6}$) except Lead.

Based on Table 6, the EDI of all the elements in this study was significantly lower than ADI(Acceptable Daily Intake) and RDI(Recommended Daily Intake) determined by the US Department of Agriculture for a 70 kg adult (Table 6).

Table 6. Comparison of EDI for a person weighing 70 kg with ADI and RDI indexes[43]

Heavy metal	EDI ($Mgkg^{-1}day^{-1}$)	EDI ($Mg70kg^{-1}day^{-1}$)	ADI ($Mgday^{-1}$)	RDI ($Mgday^{-1}$)
Lead	3.19×10^{-5}	0.0022	<0.2	-
Cadmium	1.88×10^{-6}	0.0001	<0.1	-
Arsenic	1.92×10^{-5}	0.0013	<0.13	-
Nickel	1.95×10^{-4}	0.0136	<1	-
Chrome	3.45×10^{-5}	0.0024	0.05–0.2	-
Zinc	1.04×10^{-3}	0.0725	-	8–11
Iron	4.03×10^{-3}	0.2821	-	8–18
Copper	9.4×10^{-4}	0.0657	-	0.7–0.9

DISCUSSION

This study was conducted to determine the concentration of some heavy metals in dry tea in 31 different tea brands available in stores of Kashan. The comparison of the results of this study showed that in the case of dry tea, the concentration of Chromium, Nickel and Copper were in accordance with the standard of maximum permissible concentration and therefore do not pose a danger to the consumers.

However for the other metals such as Cadmium in 12.9% of the samples, Lead in 16.13% of the samples, Arsenic in 41.93% of the samples, Zinc in 83.87% of the samples and Iron in all the samples, were more than the maximum permissible concentration[44, 45] and may pose a threat to the consumers (Table 3). In general, heavy metals enter the environment through air, water, soil and food and consequently into the body of living things [46, 47].

Todays as well as preparing foods and beverages in the homes, reverse osmosis (RO) technique has been used for many purposes such as industrial processes. The effect of this type of water treatment on heavy metals in the conditioned water is a matter which requires more research [48, 49].

The concentration of Chromium in all samples was lower than the standard ($5Mgkg^{-1}$) [50] and since no standard has been assigned for this metal in tea in Iran and WHO, it was decided to be based on the China standard by searching through other articles about the Chromium standard in tea. The mean chromium concentration in dry tea(0.71 ± 0.40 $Mgkg^{-1}$) in the present study was lower than the mean Chromium concentration in Khorramabad ($8.2Mgkg^{-1}$), Poland ($1.09\pm0.74Mgkg^{-1}$), Taiwan ($7.92Mgkg^{-1}$), North India ($4.76\pm1.27Mgkg^{-1}$), Saudi Arabia ($9.8\pm4.5Mgkg^{-1}$), Egypt ($6.1\pm3.5Mgkg^{-1}$), China ($1.47\pm0.7Mgkg^{-1}$) and Turkey ($13\pm1.7Mgkg^{-1}$) [4, 14, 25, 32, 51-54].

More than standard Nickel absorption through consumption of tea is dangerous and harmful to humans[55]. However, there is not sufficient law for the amount of Nickel in tea[56].The maximum permissible concentration of Nickel in tea is not available in the Iranian standards as well as in WHO. Nickel concentration in all the samples was lower than the maximum standard of Japan (100 $Mgkg^{-1}$) and the United States (150 $Mgkg^{-1}$) [57].The mean concentration of Nickel in dry tea in the present study (4.04±1.70 $Mgkg^{-1}$) was higher compared to the studies in Poland (3.59±1.62 $Mgkg^{-1}$) and Northern India(2.53±1.01 $Mgkg^{-1}$) while it was lower than the studies in Saudi Arabia(16.8±4.5 $Mgkg^{-1}$), Egypt (6.5±1.4 $Mgkg^{-1}$), China (9.44±3.55 $Mgkg^{-1}$) and Turkey (23.3±9.6 Mg kg^{-1}) [4, 14, 51-54].

The accumulation of Copper in soil depends on the acidity of the soil. Therefore, the acidification of soil is directly related to the increase of Copper accumulation in the tea leaf[58]. Based on the WHO guidelines, Copper yield level in water is 1 Mgl^{-1}[59], while generally the goal is to achieve a concentration less than 0.2 Mgl^{-1}. Concentration of Copper in the range of 0.2 to 0.3 Mgl^{-1} makes the tea tasteless. A concentration of 5 Mgl^{-1} or less causes a bitter metal taste [60]. In the present study, the concentration of Copper in all samples was in accordance with the standard (less than 50 Mg kg^{-1}) [44]. In a study conducted in North of Iran and in Khorramabad (Lorestan), the concentration of Copper in dry tea was (10.22±2.44 $Mgkg^{-1}$) and (15.9 $Mgkg^{-1}$) [25, 26], which was lower than the results of our study (19.48±5.04 $Mgkg^{-1}$). This is probably due to the different concentrations of Copper in soils of other regions and provinces. In the present study, the selected tea samples were not from a specific geographical location and included all the tea samples available in Kashan stores, both locally produced and some brands imported from abroad. The mean concentration of Copper in the present study was lower than the studies in Turkey (42.07±0.41 $Mgkg^{-1}$) and North India (24.07±2.25 $Mgkg^{-1}$) while it was higher than the studies in Saudi Arabia (18.1±6.9 Mg kg^{-1}), Taiwan (0.3 $Mgkg^{-1}$), Egypt (17.3±1.7 $Mgkg^{-1}$) and China (10.7±3.42 $Mgkg^{-1}$) [4, 14, 32, 52, 53 and 61].

The US Department of Health and Human Services(US) determines that Cadmium and some Cadmium-based compounds are probable or suspected carcinogens [59]. The adsorption of Cadmium is largely dependent on Iron; the lower the Iron, the higher the Cadmium adsorption [60]. The mean concentration of Cadmium in dry tea in the present study was (0.04±0.08 $Mgkg^{-1}$) which was lower than the mean concentration of Cadmium in the studies in North of Iran (0.21±0.008 $Mgkg^{-1}$), Khorramabad (0.134 $Mgkg^{-1}$), Poland(0.052±0.06 $Mgkg^{-1}$), Ghana (0.36 $Mgkg^{-1}$), Taiwan (0.07 $Mgkg^{-1}$), India (0.14±0.06 $Mgkg^{-1}$), Saudi Arabia (1.1 ±0.5 $Mgkg^{-1}$), Turkey (2.3±0.4 $Mgkg^{-1}$) and China (0.06±0.01 $Mgkg^{-1}$) while higher than the studies in Egypt (0 $Mgkg^{-1}$) [1, 4, 14, 25, 26, 32, 52-54, 62]. Cadmium is a human carcinogen and is clearly a multi-tissue and strong animal carcinogen. Repeated application of phosphate fertilizers results in traces of some elements, especially the gradual accumulation of Cadmium in agricultural soils [63].

Nowadays, Lead is one of the most widely used metal in various industries and a potential toxin and one of the most commonly known pollutants in the environment whose concentration in commercial tea leaves has raised concerns for both consumers and producers. The permissible concentration of Lead for food and beverages in Europe is 5, China is 20, Australia, Canada and India is 10 $Mgkg^{-1}$[56, 64]. The mean concentration of Lead in dry tea in the present study was(0.66±0.74 $Mgkg^{-1}$) which was higher compared with the results of researches in North of Iran (0.44±0.14 $Mgkg^{-1}$), Ghana (0.16 $Mgkg^{-1}$), Khorramabad (0.21 $Mgkg^{-1}$), Egypt (0.4±0.2 $Mgkg^{-1}$), but was lower Compared with the studies' results in Poland (0.95±0.23 $Mgkg^{-1}$), Taiwan (2.01 $Mgkg^{-1}$), North India(0.81±0.32 $Mgkg^{-1}$), Saudi Arabia (1.7±0.8 $Mgkg^{-1}$), Turkey (17.9±7.1 $Mgkg^{-1}$) and China (0.93±0.19 $Mgkg^{-1}$), it [1, 4, 14, 25, 26, 32, 52-54, 62].

The main source of Lead in the tea plant can be related to the soil in which the plant grows because the soil of the tea fields in which the soil Lead is more accessible for root absorption is essentially acidic [65]. The result of a study in India stated that the most contamination of tea regard to heavy metals was from groundwater used for irrigation of tea fields. The results indicated that the groundwater had a high concentration of Cd, Mg levels were at awarning level but Cu and Zn were at acceptable levels based on the WHO [66]. Essentially, sources of heavy metals entering tea fields are through soil, surface water, chemical fertilizers, insecticides, landfill disposal, geographical locations of agricultural lands and industrial activities, especially mining [18, 67]. Among these parameters, soil is considered as a rich source of heavy metals in tea fields [68]. Based on the monitoring of pesticide residues (25 pesticides) in tea brands consumed in Tehran's best-selling markets, it was concluded that about 30% of the samples were contaminated with uncontrolled pesticides [2].

Crystal Arsenic is very dangerous for human health and can lead to cancer even in a very low level [69]. The mean Arsenic concentration in dry tea in the present study was (0.4±0.59 $Mgkg^{-1}$). Which was lower than studies in Ghana (1.66 $Mgkg^{-1}$) but higher than Taiwan (0.01 $Mgkg^{-1}$) and China (0.29±0.07 $Mgkg^{-1}$) [1, 32 and 53]. Cadmium and Arsenic may be found in plant growth stages due to additives, fertilizers and sewage sediments [70].

Zinc plays an important role in various cell processes such as growth, brain development and part of the teeth, muscles and bone formation [71] and is a vital element for all the living organisms [72]. The maximum permissible concentration of Zinc in tea is not in the Iranian standard, but it is expressed in accordance with the standards of the World Health Organization (14 $Mgkg^{-1}$) [45]. The results of the present study showed that Zinc concentration in 83.87% of the samples was above the standard limit (14 $Mgkg^{-1}$) [45].

The mean concentration of Zinc in dry tea was (21,47±6.29 $Mgkg^{-1}$) which was lower compared to the studies in Iran (50.70±18.30 $Mgkg^{-1}$), Poland (26±4.9 $Mgkg^{-1}$), Turkey (22.65 ± 0.55 $Mgkg^{-1}$), Saudi Arabia (65.7±31.3 $Mgkg^{-1}$) and Egypt (26.7±3.5 $Mgkg^{-1}$) but it was higher compared to the studies in Ghana (0.2 $Mgkg^{-1}$), Taiwan(1.2 $Mgkg^{-1}$) and China (13.5±2.6 $Mgkg^{-1}$) [1, 4, 32, 52, 53, 61, 62, 73]

Heavy metals can replace other minerals in the body; for example, if zinc is deficient in food, cadmium is replaced [72].

Iron is an inseparable part of many proteins and enzymes that maintains health, regulates cell growth and differentiation, is involved in oxygen transport, facilitates the oxidation of carbohydrates and is an essential element for human health [60]. Individuals susceptible to anemia should avoid drinking too much tea [74]. The minimum Iron in food is 10-60 $Mgday^{-1}$ [59, 75]. Iron concentration of 1 Mgl^{-1} may cause an unpleasant taste, which is significant in coffee and tea [60].

The maximum permissible concentration of Iron in tea according to the World Health Organization standard is $26Mgkg^{1}$ [45].Based to the results, the concentration of Iron in all samples was higher than the standard level (26 $Mgkg^{-1}$) [45]. The mean Iron concentration in dry tea (83.42±30.96 $Mgkg^{-1}$) in the present study was lower than the mean Iron concentration in the studies in Khorrmabad (135.2 $Mgkg^{-1}$), Poland (184±91 $Mgkg^{-1}$), Turkey (193.69±0.51 $Mgkg^{-1}$), Saudi Arabia (250.5±199 $Mgkg^{-1}$) and Egypt (213.3±47.1 $Mgkg^{-1}$), but higher than the studies in Ghana (6.15 $Mgkg^{-1}$) and Taiwan (0.9 $Mgkg^{-1}$) [1, 4, 25, 32, 52, 61 and 62].

The difference in the concentration of heavy metals is attributed to the geographical, seasonal variations, and chemical properties of the regions during tea plant growth [71].The desired concentrations of these elements depend on the type of element, age, and gender of the consumer[76].

Some of these metals, including Lead, Cadmium and Chromium, are not degradable; thus, they tend to transport to plants from soil [77]. Essential metals such as Copper, Iron, and Zinc will have a critical role in the body's maintenance of natural functions if auxiliary elements are present [52].

Health risk assessment was only performed for adults because children rarely have the habit of drinking tea. There are many variables which determine the existence or inexistence of health risks of heavy metals caused by tea consumption including per capita tea consumption, frequency of tea consumption, the weight of consumers and etc.

THQ results in the present study were consistent with some of the previous studies and contradictory with some others. In this study, HI was lower than the study in Taiwan (6.7×10^{-1}). They predicted that black tea consumption would have a harmful effect and black tea should still be monitored to maintain public health. In this study, only THQ_{As} was higher than the study in Taiwan while THQ of other metals calculated in their studies (Chromium, Lead and Cadmium) was higher than the results of this study [32].

In a study in Ghana, the THQ values for each metal through tea consumption were below one, indicating that the daily adsorption of each metal may not pose a potential health risk to a normal adult. Arsenic revealed a relatively higher content than other metals which was consistent with the present study [1].

The difference between THQ values in the present study and other studies may be due to the parameters affecting THQ(metal concentration, consumer's body weight, share of each tea in per capita consumption, etc.) and their variations in different geographical areas [78].

A study by Karak et al. on Zn, Fe, and Cu in Indian and North African tea reported that consuming three tea cups of 200 ml daily(600 ml tea as the product of 24g dry tea) not only has no adverse effects on human health, but also has beneficial effects because it provides part of the average daily consumption of beneficial micronutrients in body. The results clearly showed that the THQ values were lower than one in all three different times of brewing the tea. Therefore, it was concluded that the presence of these elements in the studied teas with an average daily consumption of 600 ml tea had no risk of carcinogenicity for human [79].

Furthermore, a research was carried out about Al, Mn, Zn, Cu, Ni, Cr, Pb, As and Hg on young and mature leaves in China. Finally, it was found that EDI for all samples in young leaves was less than RfD and the HI for young leaves was less than one (0.272), but in mature leaves, except EDI_{Mn} in one sample, EDI of other metals was lower than RfD and the HI in 38.46% of the samples was above one, indicating that the consumption of mature tea leaves could increase heavy metals in the human body[53].

CONCLUSIONS

In Iran, tea has been unofficially considered as a national and favorite beverage. The results of this study indicated that the concentrations of Copper, Nickel and Chromium in all samples was compatible with the Iranian and WHO standard level, while for Cadmium, Lead, Arsenic, Zinc and Iron in some samples were more than the Iranian and WHO standard level.

However, by evaluating the potential carcinogenic and non-carcinogenic health risk of heavy metals in this study and based on the findings, it can be concluded that the drinking the average amount of the selected teas in the study(4 cups of tea per day) can have no toxic effects on humans.

This study can be an alarming guideline for consumers, manufacturers and healthcare professionals because of high concentrations of heavy metals. It is hoped that regulatory authorities in the near future develop a comprehensive tea guideline to minimize the human health risk and make millions of tea lovers enjoy their morning cup of tea without thinking about the harms.

SUGGESTION

The frequent review and analysis of foodstuffs with the aim of avoiding the risks of consumption beyond the standards is recommended. As tea is an essential part of the daily lives of many Iranians, studies should continue to ensure that public health is maintained. However, for toxic metals, because of their low content, safety judgments require more sensitive equipment. Therefore, studies should continue to maintain public health.

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