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Research Article

Assessment of Health Risks for Heavy Metals in Imported Coffee Samples Available in Iraqi Markets

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Abstract

The objective of the present study was to measure the heavy metal concentrations of Cr, Cd, and Pb in different foreign-brand instant coffee samples sold in Iraqi markets using a flame atomic absorption spectrophotometer (AA-7000). Furthermore, the indicator risks of human health, such as Daily Intake Estimate (DIE), Target Hazard Ratio (THR), Hazard Indicator (HI_n), and Risk of Cancer (RC), were evaluated for the whole analytical samples. The concentrations of Pb and Cr in the coffee samples, expressed in mg/kg, exhibited average values of 0.047 ± 0.008 and 0.030 ± 0.012, respectively. Cadmium (Cd) was not detected (N.D.) in any of the samples. The average value of HI_n in coffee samples was 0.005 ± 0.001. The average values of the concentrations were 0.00004 ± 0.00001 for Pb, and for Cr was 0.10843 ± 0.043, but for Cd was N.D. Although certain concentration levels of Pb and Cr exceeded the limit regulations of the EU, the health risk indicators remained at internationally acceptable ranges. Accordingly, the main coffee samples examined do not pose any health risks to Iraqi consumers.

1. Introduction

Coffee is one of the favored beverages after tea, but its consumption is different geographically in the world [1]. The coffee product is found in about one hundred forms; its cup consumption presently differs based on the geographical location [2]. Nowadays, many recipes have been invented containing a mixture of tea with milk or even coffee with milk, which can also be drunk as frozen beverages [3]. Heavy metals enter human food through the food chain and destroy living tissues due to the accumulation of these contaminants in the tissues, causing serious problems. In addition to the above, potential contamination may occur due to packaging, canning and storage mechanisms [4]. When heavy metals contaminate living organisms, they cannot decompose [5]. So, some of the important heavy elements (Pb, Cd, and Cr) that are toxins for the health of consumers were selected. The investigation was done on 10 imported dry samples of coffee from Iraqi markets, which were considered the most consumed samples in Iraq.

2. Materials and Methods

Sample Collection

Ten different coffee brands were collected from Iraqi markets in January 2025 for this study. All samples were analyzed in the analytical laboratory. The selected samples are listed in Table 1.

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Table 1: Samples in this study

No	Code	Sample Name	Provenance
1	c1	Espresso	Produced and packed in Jordan
2	c2	Prince	Produced and packed in Jordan
3	c3	Shubar	Produced and packed in India
4	c4	Mac Gold	Produced and packed in Malesia
5	c5	Mahmood Classic	Product in Switzerland and packed in Turkey
6	c6	Nes Cafe Gold	Product in UK and packed in Switzerland
7	c7	Alameed	Packed in Jordan
8	c8	Najjar	Packed in Lebanon
9	c9	Brazelian coffee	Packed in Brazil
10	c10	Ridha Alwan/ Espresso	Packed in Iraq

Sample Preparation and Detection

Each sample must be prepared before detection. The first step was drying the samples for one day at 70 °C previous to the digestion process [6]. The digestion procedure for the samples was performed following the protocol described in our previous study [7].

3. Health Risk Parameters

The non-carcinogenic and carcinogenic risks related to the metals (Cr, Cd, and Pb) in the analyzed coffee samples were assessed. By equation (1), the DIE were calculated, which referred to the consumption ratio intake per day because of the content of each examined heavy metal (Pd, Cd, and Cr) in each coffee sample in units of By equation (1), the DIE were calculated, which referred to the consumption ratio intake per day because of the content of each examined heavy metals (Cr, Cd, and Pb) in each coffee sample in units of ($\frac{mg}{kg}$ / day) [8, 9].

$$DIE = \frac{C_{metal} \times W_{sample}}{BW} \tag{1}$$

where C_{metal} is each milligram per kilogram of the heavy metal concentrations in each sample, W_{sample} is the daily drank kilograms amount from each coffee sample, and BW is the human body weight in kilograms taken in this study as 60. While the values of the ingestion rates (W_{sample}) of daily grams per person of each coffee sample were taken as [4].

Based on Environmental Protection Agency (EPA) guidelines and using the Daily Intake Estimate (DIE) along with the oral toxicity reference dosage (Rf_D), in units of (mg daily per kg) for each heavy metal which equals to 3.5×10^{-3}, 1×10^{-3} and 3×10^{-3} for Pb, Cd, and Cr, respectively [10, 11], equation (2) calculates the values of Target Hazard Ratio (THR) in all of the samples which considered safely for the community if their values less or equal than to 1 [12, 13]:

$$THR = \frac{DIE}{R_{fd}} \tag{2}$$

The non-carcinogenic Hazard Indicator (HI_n) in this study is the summation of the Target Hazard Ratio (THR) for each heavy metal, as shown in equation (3) [14].

$$HI_n = THR_{Pb} + THR_{Cd} + THR_{Cr} \tag{3}$$

Standing for USEPA guidelines, the Risk of Cancer (RC) values resulting from the population's heavy metal exposure were calculated by the use of the parameters outlined in equation (4) [15].

$$RC = \frac{EF_r \times ED \times DIE \times CSF_O}{AT \times 70year \times 1000} \tag{4}$$

where daily Exposure Frequency per year (EF_r) was 350, Exposure Duration (ED) equals 30 years, and Average Time (AT) over 70 years is 365 days per year [16], carcinogenesis oral factor slope (CSF_o) for Pb is 0.0085, but for Cd and Cr are 15 and 41 in units of mg/kg per day [17].

4. Results and Discussions

In the present study, Table 2 displays the concentrations of heavy metals (lead, cadmium, and chromium) in 10 coffee samples, which were analyzed using the AA-7000 spectroscopy method. The concentrations of Pb, Cd, and Cr in the coffee samples, reported in mg/kg, ranged from not detected (N.D.) to 0.080 for Pb, were below detection limits for Cd, and ranged from N.D. to 0.081 for Cr. The average concentrations were 0.047 $\pm$ 0.008 mg/kg for Pb, not detected for Cd, and 0.030 $\pm$ 0.012 mg/kg for Cr, respectively. The highest concentrations of Pb and Cr were found in sample C4 (Mac Gold). When compared to the European and Codex standards [18, 19], the permissible limit for Pb is 0.02 mg/kg, while the EU Regulation [20] sets the maximum allowable Cr content at 3% mg/kg. In contrast, Cd was undetectable in all coffee samples, consistent with the EU Regulation limit of 0.05 mg/kg for Cd. These samples were cultivated in

different countries and underwent various processes, including harvesting, packing, exporting, and storage, any of which could contribute to heavy metal contamination.

Table 2: Pb, Cd, and Cr Contents (H. M. C.) results in the present coffee samples

No	codes	H. M. C. (mg/kg)		
		(Pb)	(Cd)	(Cr)
1	C1	0.052	(N.D.)	0.027
2	C2	0.023	(N.D.)	0.081
3	C3	0.052	(N.D.)	0.081
4	C4	0.080	(N.D.)	0.081
5	C5	(N.D.)	(N.D.)	(N.D.)
6	C6	0.023	(N.D.)	(N.D.)
7	C7	0.080	(N.D.)	0.027
8	C8	0.052	(N.D.)	(N.D.)
9	C9	0.052	(N.D.)	(N.D.)
10	C10	0.052	(N.D.)	(N.D.)
Ave.± S.D.		0.047±0.008	(N.D.)	0.030±0.012

*(N.D.) is for no detectable.

Table 3 presents the DIE, THR, and HI_n results based on the concentrations of Cr, Cd, and Pb in whole coffee samples. The average DIE values in µg/kg per day were 0.0101± 0.002 for Pb, 0.0064 ± 0.003 for Cr, but for Cd was undetectable (N.D.) in the coffee samples were. Correspondingly, the average THR values were 0.003 ± 0.000 for Pb, N.D. for Cd, and 0.002 ± 0.001 for Cr. Regarding the Pb, Cd, and Cr content, the HI_n values varied from not detected (N.D.) in sample C5 (Mahmood Classic) to 0.011 in sample C4 (Mac Gold), with an average of 0.005 ± 0.001. The DIE and THR values for all samples fell within the internationally accepted limits for Pb, Cd, and Cr in coffee, as established by WHO and FAO [21]. The hazard indicator (HI_n), the internal exposure to heavy metals, was found to be < 1 in all the examined coffee samples; therefore, no potential health risks [22].

Table 3: DIE, THR, and HI_n values associated with Cr, Cd, and Pb concentrations in the analyzed coffee samples

No	codes	DIE			THR			HI_n
		(Pb)	(Cd)	(Cr)	(Pb)	(Cd)	(Cr)	
1	C1	0.0113	(N.D.)	0.0059	0.003	(N.D.)	0.002	0.005
2	C2	0.0050	(N.D.)	0.0176	0.001	(N.D.)	0.006	0.007
3	C3	0.0113	(N.D.)	0.0176	0.003	(N.D.)	0.006	0.009
4	C4	0.0173	(N.D.)	0.0176	0.005	(N.D.)	0.006	0.011
5	C5	0.0000	(N.D.)	(N.D.)	(N.D.)	(N.D.)	(N.D.)	(N.D.)
6	C6	0.0050	(N.D.)	(N.D.)	0.001	(N.D.)	(N.D.)	0.001
7	C7	0.0173	(N.D.)	0.0059	0.005	(N.D.)	0.002	0.007
8	C8	0.0113	(N.D.)	(N.D.)	0.003	(N.D.)	(N.D.)	0.003
9	C9	0.0113	(N.D.)	(N.D.)	0.003	(N.D.)	(N.D.)	0.003
10	C10	0.0113	(N.D.)	(N.D.)	0.003	(N.D.)	(N.D.)	0.003
Ave.±S.D		0.0101 ± 0.002	(N.D.)	0.0064 ±0.003	0.003 ±0.000	(N.D.)	0.002 ±0.001	0.005 ±0.001

Table 4 shows the Risk of Cancer (RC) values for whole coffee samples analyzed in this study. The $CR10^-6$ for Pb ranged between 0.00004 and 0.00006, with an average of 0.00004 ± 0.00001, while Cd was not detected. For Cr, CR values ranged from not detected to 0.29571, with an average of 0.10843 ± 0.043. These CR values are within the EPA's acceptable limits for heavy metals in food, which range from 10^-6 to 10^-4. 16,22 Based on the evaluated health risk indicators (DIE, THR, HI_n, and RC) for Cr, Cd, and Pb in the coffee samples, it can be concluded that consuming any of these coffee types poses no potential health risk.

Table 4: Results of RC due to Cr, Cd, and Pb Concentration in the studied coffee samples

No	code	RC×10-6		
		(Pb)	(Cd)	(Cr)
1	C1	0.00004	(N.D.)	0.09857
2	C2	0.00002	(N.D.)	0.29571
3	C3	0.00004	(N.D.)	0.29571
4	C4	0.00006	(N.D.)	0.29571
5	C5	0.00000	(N.D.)	(N.D.)
6	C6	0.00002	(N.D.)	(N.D.)
7	C7	0.00006	(N.D.)	0.09857
8	C8	0.00004	(N.D.)	(N.D.)
9	C9	0.00004	(N.D.)	(N.D.)
10	C10	0.00004	(N.D.)	(N.D.)
Ave.±S.D		0.00004±0.00001	(N.D.)	0.10843±0.043
World limit [16, 22]			10^{-6} - 10^{-4}	

5. Conclusions

The results of this study show that the levels of the heavy metals Cr, Cd, and Pb in some samples slightly exceeded the global benchmark values set by the EC Commission, EU regulatory, and Codex Alimentarius standards. Nevertheless, the indicator risks of human health Daily Intake Estimate (DIE), Target Hazard Ratio (THR), Hazard Indicator (HI_n), and Risk of Cancer (RC) were whole within internationally accepted safety limitations. Based on the findings, the coffee samples consumed by the Iraqi population do not present any significant health risks related to heavy metal contamination.

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