Assessment of health risk due to Pb, Cd, and Cr concentrations in imported cheese samples in Iraq markets

Ali Abid Abojassim*, Ruaa R. Muneam

Dept. of Physics, Faculty of Science, University of Kufa, Iraq

**Corresponding Author: ali.alhameedawi@uokufa.edu.iq*

Abstract

The aim of this study is to determine three heavy metals (Pb, Cd, and Cr) concentrations in cheese samples in Iraq markets that are produced in Iran and Turkey. The concentrations of Pb, Cd, and Cr were measured using atomic absorption spectroscopy. Human health risk parameters, such as Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), Hazard Index (HI), and Carcinogenic risk (CR) due to heavy metals were calculated in all cheese samples of the present study. The average value concentrations of Pb, Cd, and Cr in cheese samples made manufactured in Iran were 4.33±0.57 mg/kg, 0.135±0.03, mg/kg, and 0.183±0.12 mg/kg, respectively. While those which were made in Turkey, the values were found to be 3.89±0.63 mg/kg, 0.167±0.032 mg/kg, and 0.105±0.07 mg/kg, respectively. The average values of HI in Iranian and Turkish cheese samples were 0.526±0.07 and 0.483±0.26, respectively. While the average values of $CR \times 10^{-6}$ for Pb, Cd, and Cr in Iranian cheese samples were 0.006±0.0007, 1.13±0.0007, and 0.0056±0.7, respectively. But in Turkish cheese samples were 0.005±0.0008, 0.37±0.07, and 0.65±0.4, respectively. The heavy metal concentrations in the present study were found to be of no statistical significance, compared to the Iranian and Turkish cheese samples, where P-value was ($P > 0.05$). Most values for Pb, Cd and Cr concentrations were found to be higher than the allowed limits according to EU Regulations, while the health risk parameters were within the accepted worldwide average limits. Therefore, it can be concluded that most cheese samples have no health risks by consuming this cheese by consumers in Iraq.

Keywords: Atomic absorptions spectroscopy; carcinogenic risk; cheese; heavy metals; Iraq markets.

1. Introduction

Heavy metals are ubiquitous in nature and have become ecologically more interested as a result of human activities, therefore they have been recognized as a major source of ecological concern across the world (Mance, 2012). Due to their presence in tiny amounts in numerous environmental media (e.g., food, water, and air), heavy metals were regarded as trace elements. The incidence of heavy metals in both terrestrial and aquatic environments is critical. In food, heavy metals pollution is directly link to human health risk and also to other living organisms. Some heavy metals such as lead (Pb), cadmium (Cd), and chromium (Cr) are among the essential micronutrient metals required in minuscule quantities in the human body hardly more than a few mg/day (Arshad, 2020). Urbanization and development in industry and agriculture

led to the exposure of humans to these environmental pollutants which are absorbed by the human body via contaminated inhalation air, polluted drinking water, and contaminated food consumption (through the food chains). So, the heavy metals exposure present in food poses a threat to human health (Elmi, *et al*., 2019). Various challenges present in heavy metals determination due to matrix complexity and deficient concentration levels in which the elements appeared. Animals receive heavy metals mainly through water and food (Llobet, *et al*., 2003). Contaminated crops, trace element premises, and supplementary minerals, such as limestone and phosphate are mainly input Cd in animal food (Bilandžić, *et al*., 2011). Small amounts of Cr in animal food have a positive impact on cow milk production, enabling the animals' immune systems to defend against several illnesses (McNamara & Valdez, 2005). Recently, there has been an increasing trend in the consumption of cheese, including increased nutritional value and it has an important role especially in the different types of age groups; however, the data concerning the occurrence of essential and heavy metals in cheese available in the Iraqi market are scarce. Several studies in different countries have been determined the heavy metals in cheese or milk products samples using different technical such as atomic absorption spectrometer, inductively coupled plasma optical emission spectroscopy (Castro-González, *et al*., 2018; Singh, *et al*., 2020; Al Sidawi, *et al*., 2021; Karadjova, *et al*., 2000). Concerning heavy metals contaminations levels data in cheese products consumed in Iraq, it is not available. Thereby the determination of some heavy metals (Pb, Cd, and Cr) concentrations in cheese samples (imported from Iran and Turkey) in Iraq markets is the aim of the present study.

2. Materials and methods

2.1 Collection samples

In the present study, thirty kinds of cheese samples as truckles (cow source) from Iraq markets, validity duration Summer 2021 which were made in Iran (symbol IN) and Turkey (symbol T), were chosen. According to the producing country, type (soft or hard), and net weight of each product, the samples were divided into two groups as shown in Table 1.

2.1 Digesting samples

The samples were transferred to the laboratory for measurements after collection. Before measuring heavy metals in cheese samples, they must be digested. The method used for digesting samples under study is called the wet digestive method. Before digestion for heavy metals analysis, each cheese sample was dried at 70°C for 24 h. Each sample was digested with a mixture of HNO_3 and $HClO_4$ to provide a clear solution for analysis. (1 gram) of each cheese sample was weighed on an analytical balance and placed in a digestion tube, then (10 milliliters) of concentrated nitric acid HNO_3 (65%) was added and the mixture was stood overnight at room temperature, later the mixture was heated on a hot plate till boiling gently to oxidize all the materials that oxidized easily and the color of the mixture changed to brown. After cooling, (1 milliliter) of perchloric acid HClO4 (70%) was added so the mixture was gently boiled until dense white fumes raised and the color of the digestive mixture turned to clear, approximately (1 milliliter) rest. After cooling, the mixture was filtered and

quantitatively transferred to a volumetric flask, then (25 milliliters) of deionized water was added.

2.2 Atomic absorption spectrometer

An atomic absorption spectrometer model (AA-7000, Shimadzu) with a deuterium background corrector (BGC-D2) was used in this work. Pb, Cd, and Cr in samples were determined by using air/acetylene flame (Air-C_2H_2). The value of slit width was 0.7 nm and the values of lamp current for Pb and Cr elements was 10 mA, while for Cd element was 8 mA. The LOD (BGC-D2) for lead, cadmium, and chromium was 0.03- 0.1, 0.002- 0.008, and 0.005-0.02 ppm; the LOQ (BGC-D2) was 0.1 -0.4, 0.007 -0.03 and 0.02-0.07ppm, respectively. The calibration solution was prepared using the following formula ($C_1V_1=C_2V_2$), where $C_{1:}$ the concentration of lead standard solution (1000 ppm), $V_{1:}$ the volume needed to be diluted, C_2: the concentration of the working solution of Pb, and $V_{2:}$ the final solution of the working solution of Pb. To prepare (0.2 ppm in 100 mL) as the standard working solution of Pb, we need to apply the above formula twice to prepare two solutions of Pb with concentrations of 100 ppm then 10 ppm from 100 ppm. Therefore, the following approach is used to reduce volume estimation errors. The calibrating working solutions of the remaining elements (Cd and Cr) were prepared in the same manner as described previously. The concentrations needed for the working solution of the Pb were (0.2, 0.5, and 0.7) ppm, and (0.1, 0.2, and 0.5) ppm for Cd and Cr, respectively. Finally, AAS was used to determine the levels of Pb, Cd, and Cr where the wavelengths of Pb, Cd, and Cr were 283.3 nm, 228.8nm, and 357.9 nm, respectively (Rashid, et al. 2016).

2.3 Health risk parameters

Many health risk parameters that were calculated due to heavy metals (Pd, Cd, and Cr) in cheese samples such as Estimated Daily Intake (EDI), Target Hazard Quotients (THQ), Hazard Index (HI), and Carcinogenic risk (CR), as follows:

The equation (1) was used to determine EDI due to heavy metals in cheese samples which depend on the concentration of heavy metals in cheese (C_{metal}), the daily average consumption of cheese (W_{cheese}), and the weight of the human body (BW), as follows (Meshref, *et al*. 2014; Christophoridis, *et al*. 2019):

$$EDI\left(\frac{mg}{kg}per\ day\right)=\frac{C_{metal}\left(\frac{mg}{kg}\right)\times W_{cheese}\left(\frac{kg}{day}\right)}{BW\ (kg)} \qquad (1)$$

In the present study, the value of BW has been used is an adult person that has an average weight of 60 kg, while the value of W_{cheese} was 22 gm/day (Christophoridis, *et al*., 2019; Renner, 1993) .

The values of THQ in the samples were determined according to United States Environmental Protection Agency (USEPA) that depend on EDI and the oral reference dose (RfD), as the following equation (EPA, 1989a; Khalil, 2018):

$$THQ=\frac{EDI\ (\frac{mg}{kg}\ per\ day)}{RfD(\frac{mg}{kg}\ per\ day)} \qquad (2)$$

The values of RFD in the unit mg/kg per day for Pd, Cd, and Cr were 3.5×10^{-3}, 1×10^{-3}, and 3×10^{-3}, respectively (EPA, 2008; Zhuang, *et al*. 2009).
The values of HI due to all heavy metals in the present study can be calculated by the sum of THQ as following Equation (EPA, 2011).

$$HI\left(\frac{mg}{kg}per\ day\right) = \sum THQ \qquad (3)$$

The value of CR due to heavy metals exposure of populations was determined using the following equation based on the USEPA that depends on many parameters such as Exposure Frequency (EFr), Exposure Duration (ED), EDI, which stands for oral carcinogenic slope factor (CSFo), and Average Time (AT), described in (EPA, 2006; EPA 2010):

$$CR = \frac{EFr\left(\frac{days}{year}\right) \times ED(year) \times EDI(\frac{mg}{kg}\ per\ day) \times CSFo(\frac{mg}{kg}\ per\ day)}{AT(\frac{day}{year} \times\ 70\ year)} \times 10^{-3} \qquad (4)$$

In the present study, the values of EFr, ED, AT were 350 days/ years, 30 years, and 365 days/years × 70 years, respectively (EC, 2006). While, the value of CSFo in- unit mg/kg per day for Pb, Cd, and Cr was 0.0085, 15, and 41, respectively (EPA, 1989b).

2.4 Statistical analysis

Statistical analysis was performed using the SPSS statistical software package (SPSS for Windows version 20, SPSS Inc., Chicago, Illinois, USA).

3. Results

Heavy metals (Pb, Cd, and Cr) in cheese samples produced in Iran and Turkey that are available in Iraqi markets were determined using AAS techniques. Table 1 shows the concentrations of Pb, Cd, and Cr for 30 cheese samples (15 made in Iran and 15 made in Turkey). The results from Table 1, the Pb, Cd, and Cr concentrations in cheese samples that were produced in Iran were range from 0.93±0.30 mg/kg to 8.36±0.96 mg/kg with a mean value of 4.33±0.57 mg/kg, from ND to 0.434±0.13 mg/kg with a mean value of 0.135±0.03 mg/kg, and from ND to 0.523±0.24 mg/kg with an average value of 0.183±0.12 mg/kg, respectively. While, the concentrations of Pb, Cd, and Cr in cheese samples that were produced in Turkey were ranged from ND to 8.36±0.96 mg/kg with an average value of 3.89±0.63 mg/kg, from ND to 0.375±0.13 mg/kg with an average value of 0.167±0.032 mg/kg, and from ND to 1.05±0.34 mg/kg with a mean value of 0.105±0.07 mg/kg, respectively. The results show the maximum value of Pb concentrations in cheese samples produced from Iran and Turkey were in IN7(Sabah-Arab) and T14 (Alamera), respectively. The minimum value of Pb, Cd, and Cr concentrations of Iranian cheese samples was obtained in sample IN10 (Kala-Amal), while in Turkey cheese samples were obtained in sample T12 (Mersin-Village), respectively. Also, it was found most samples of cheese in the present study have ND (no detection) value, especially of Cr concentrations. Table 2 shows the results of EDI, THQ, and HI due to Pb, Cd, and Cr

concentration in 30 cheese samples products from Iran and Turkey country which were collected from Iraq markets. From Table 2, the average values with standard error (S.E) of EDI for Pb, Cd, and Cr concentration in Iran samples were 1.58±0.21 µg/kg per day, 0.05±0.01 µg/kg per day, and 0.07±0.04 µg/kg per day, respectively, while in Turkey samples in-unit µg/kg per day were 1.43±0.23, 0.06±0.01, and 0.04±0.02, respectively. Furthermore, the average values with standard error (S.E) of TQH for Pb, Cd, and Cr concentrations in cheese of Iranian samples were 0.45±0.06, 0.05±0.01, and 0.022±0.01, respectively, while in cheese of Turkish samples were 0.41±0.06, 0.06±0.01, and 0.013±0.008, respectively. Also, from Table 2, the range of the results of HI in two countries of the present study was 0.097-1.127 with an average of 0.526±0.07 and ND- 0.907 with an average value of 0.483±0.26. According to equation (4), it is found the values of Carcinogenic risk (CR) for all cheese samples of the present study are listed in Table 3. According to the results in Table 3, the highest value of $CR\times10^{-6}$ for Pb concentration for Iranian cheese samples was 0.012 in the IN9 and the lowest value was 0.001 in IN6 sample with an average value of 0.006±0.0007. Whilst, the values of Cd and Cr concentrations varied from ND to 0.980 with an average of 1.13±0.0007 and from ND to 11.302 with an average of 0.0056±0.7, respectively. Also, from Table 3, it can be noticed that the range values of Pb, Cd, and Cr concentrations for Turkish cheese samples were from ND to 0.011 with an average value of 0.005±0.0008, from ND to 0.848 with an average value of 0.37±0.07, and from ND to 6.458 with an average 0.65±0.4, respectively.

Table 1. Results of Pb, Cd, and Cr Concentration in different cheese products from Iran and Turkey.

No.	Name of brand cheese	Origin	Sample code	Type of cheese	Net weight (gm)	Concentrations of heavy metals (mg/kg or ppm)		
						Pb	Cd	Cr
1	Sabah (Cream)	Iran	IN1	soft	100	5.57±0.79	0.192±0.09	ND*
2	Kibi		IN2	soft	100	2.79±0.56	0.150±0.08	ND
3	Kiri		IN3	soft	100	4.64±0.72	0.350±0.12	0.523±0.24
4	Sabah (UF)		IN4	soft	300	4.64±0.71	0.050±0.04	ND
5	Labneh		IN5	soft	150	2.79±0.56	0.175±0.07	ND
6	Sabah (Bulgarian paneer)		IN6	soft	400	0.94±0.32	0.083±0.06	ND
7	Sabah (Arab)		IN7	soft	400	8.36±0.96	0.042±0.04	ND
8	Pinka		IN8	soft	120	1.86±0.45	0.150±0.08	0.392±0.21
9	Mimas		IN9	soft	100	8.36±0.90	0.075±0.05	1.83±0.45
10	Kala (Amal)		IN10	soft	100	0.93±0.30	ND	ND
11	Kala (Msdmr)		IN11	soft	100	5.11±0.76	0.067±0.05	ND
12	Kala (Maac)		IN12	soft	100	6.04±0.85	0.058±0.04	ND
13	Baf		IN13	soft	400	5.11±0.77	0.042±0.03	ND
14	Gouda		IN14	soft	150	3.25±0.60	0.158±0.09	ND
15	Sabah (Feta)		IN15	soft	225	4.64±0.69	0.434±0.13	ND
Average±S.E						4.33±0.57	0.135±0.03	0.183±0.12
16	Aynes	Turkey	T1	soft	250	5.57±0.79	0.258±0.10	ND
17	Muratbey (Shallal)		T2	hard	200	0.46±0.23	0.325±0.11	0.261±0.17
18	Muratbey (Braided)		T3	hard	200	6.04±0.82	0.008±0.02	ND
19	Lana		T4	hard	200	3.25±0.60	0.133±0.07	ND

20	Tulum (With black semsem)		T5	soft	250	4.64±0.72	0.325±0.12	ND
21	Tulum (With dill)		T6	soft	250	5.57±0.79	0.375±0.13	ND
22	Mersin (Circassian)		T7	soft	250	6.50±0.85	0.133±0.08	ND
23	Village (With olives and thyme)		T8	soft	250	3.25±0.60	ND	ND
24	Village (dill)		T9	soft	250	5.57±0.79	0.108±0.07	1.05±0.34
25	Village (With thyme)		T10	soft	250	1.39±0.39	0.300±0.10	ND
26	Village (With herbs)		T11	soft	250	ND	0.108±0.06	ND
27	Mersin (Village)		T12	soft	250	ND	ND	ND
28	Muratbey (Van herby)		T13	soft	200	4.64±0.72	0.200±0.09	ND
29	Alamera		T14	hard	200	8.36±0.96	ND	0.261±0.17
30	Manfoush		T15	soft	100	3.25±0.60	0.233±0.11	ND
Average±S.E						3.89±0.63	0.167±0.032	0.105±0.07
The worldwide average						0.02 (Additives, 1993; EC, 2006)	0.05 (E Regulation, 2001)	0.03 (E Regulation, 2001)

*ND is no detection.

Table 2. Results of EDI, THQ, and HI due to Pb, Cd, and Cr Concentration in different cheese products from Iran and Turkey.

No.	Sample code	EDI (µg/kg per day)			THQ			HI
		Pb	Cd	Cr	Pb	Cd	Cr	
1	IN1	2.04	0.070	ND	0.584	0.070	ND	0.654
2	IN2	1.02	0.055	ND	0.292	0.055	ND	0.347
3	IN3	1.70	0.128	0.192	0.486	0.128	0.064	0.679
4	IN4	1.70	0.018	ND	0.486	0.018	ND	0.505
5	IN5	1.02	0.064	ND	0.292	0.064	ND	0.356
6	IN6	0.340	0.031	ND	0.097	0.031	ND	0.128
7	IN7	3.06	0.015	ND	0.876	0.015	ND	0.891
8	IN8	0.68	0.055	0.144	0.195	0.055	0.048	0.298
9	IN9	3.06	0.028	0.67	0.876	0.028	0.224	1.127
10	IN10	0.340	ND	ND	0.097	0.000	ND	0.097
11	IN11	1.87	0.024	ND	0.535	0.024	ND	0.559
12	IN12	2.21	0.021	ND	0.632	0.021	ND	0.654
13	IN13	1.87	0.015	ND	0.535	0.015	ND	0.550
14	IN14	1.19	0.058	ND	0.340	0.058	ND	0.399
15	IN15	1.70	0.159	ND	0.486	0.159	ND	0.645
Average±S.E		1.58±0.21	0.05±0.01	0.07±0.04	0.45±0.06	0.05±0.01	0.022±0.01	0.526±0.07
16	T1	2.043	0.095	ND	0.584	0.095	ND	0.678
17	T2	0.170	0.119	0.096	0.049	0.119	0.032	0.200
18	T3	2.213	0.003	ND	0.632	0.003	ND	0.635
19	T4	1.192	0.049	ND	0.340	0.049	ND	0.389

20	T5	1.702	0.119	ND	0.486	0.119	ND	0.606
21	T6	2.043	0.138	ND	0.584	0.138	ND	0.721
22	T7	2.383	0.049	ND	0.681	0.049	ND	0.730
23	T8	1.192	0.000	ND	0.340	0.000	ND	0.340
24	T9	2.043	0.040	0.383	0.584	0.040	0.128	0.751
25	T10	0.511	0.110	ND	0.146	0.110	ND	0.256
26	T11	ND	0.040	ND	ND	0.040	ND	0.040
27	T12	ND	ND	ND	ND	ND	ND	ND
28	T13	1.702	0.073	ND	0.486	0.073	ND	0.560
29	T14	3.064	ND	0.096	0.876	ND	0.032	0.907
30	T15	1.192	0.086	ND	0.340	0.086	ND	0.426
Average±S.E		1.43±0.23	0.06±0.01	0.04±0.02	0.41±0.06	0.06±0.01	0.013±0.008	0.483±0.26
The worldwide average		3.57 (Tripathi, *et al*. 1999)	1.0 (Islam, *et al* l.,2014)	---	1(Islam, *et al*.,2014)	1(Islam, *et al*.,2014)	1 (Islam, *et al*.,2014)	1(Islam, *et al*.,2014)

Table 3. Results of CR due to Pb, Cd, and Cr Concentration in different cheese products from Iran and Turkey.

No	Sample code	CR×10^{-6}			No.	Sample code	CR×10^{-6}		
		Pb	Cd	Cr			Pb	Cd	Cr
1	IN1	0.007	0.434	ND	16	T1	0.007	0.584	ND
2	IN2	0.004	0.339	ND	17	T2	0.001	0.735	1.614
3	IN3	0.006	0.792	3.229	18	T3	0.008	0.019	ND
4	IN4	0.006	0.113	ND	19	T4	0.004	0.302	ND
5	IN5	0.004	0.396	ND	20	T5	0.006	0.735	ND
6	IN6	0.001	0.189	ND	21	T6	0.007	0.848	ND
7	IN7	0.011	0.094	ND	22	T7	0.008	0.302	ND
8	IN8	0.002	0.339	2.422	23	T8	0.004	ND	ND
9	IN9	0.012	0.170	11.302	24	T9	0.007	0.245	6.458
10	IN10	0.001	ND	ND	25	T10	0.002	0.678	ND
11	IN11	0.007	0.151	ND	26	T11	0.001	0.245	ND
12	IN12	0.008	0.132	ND	27	T12	ND	ND	ND
13	IN13	0.007	0.094	ND	28	T13	0.006	0.452	ND
14	IN14	0.004	0.358	ND	29	T14	0.011	ND	1.614
15	IN15	0.006	0.980	ND	30	T15	0.004	0.528	ND
Average±S.E		0.006±0.0007	1.13±0.0007	0.0056±0.7	Average±S.E		0.005±0.0008	0.37±0.07	0.65±0.4
The worldwide average (EPA, 2010; EPA, 1989c)		10^{-4}-10^{-6}			The worldwide average (EPA, 2010; EPA, 1989c)		10^{-4}-10^{-6}		

4. Discussion

Concentration results of Pb of all cheese samples collected from Iraq markets was higher than the worldwide average which equals 0.02 mg/kg according to European (EC, 2006) and Codex standards (Additives, 1993), except samples T11 and T12 (ND). Also found that twenty-two of Cd concentrations results in samples of the present study was higher than the worldwide average (0.05 mg/kg) for cheeses according to EU Regulation (E Regulation, 2001). While the results values of Cr concentrations for most samples were less than that of the worldwide average limit (0.03 mg/kg) for cheeses according to EU Regulation (E Regulation, 2001). From Table 1, it is found that the average concentration of the measured heavy metals is of two order higher in magnitude in Iraq than that of the worldwide. This difference can be attributed to many cusses. For instance, these include the cheese preparation process, processing equipment, accidental contamination during storage or packing process. The average value of Pb and Cr concentrations in cheese samples of Iranian is higher than that of cheese samples of Turkish, but T-test confirmed the presence of non-significant concentrations between Iranian and Turkish samples statistically ($P > 0.05$). While, the average value of Cd concentrations in Iranian cheese samples is lower than that of Turkish cheese samples, but T-test confirmed the presence of no significant difference in the concentration mg/kg in samples of the present study between Iranian and Turkish samples statistically ($P > 0.05$). Figure.1 shows the relation of average values for Pb, Cd, and Cr concentrations in the sample of the present. So, from Figure.1 the descending order of Iranian cheese samples and Turkish cheese samples were Pb > Cr > Cd and Pb > Cd > Cr, respectively according to the average value. The results in Table 2 show that the EDI values for the studied cheese samples were within the upper intake of world toxic heavy metals of Pb and Cd are 3.57 and 1.0 µg/kg/day, respectively (Tripathi, *et al*. 1999). Also, all values of TQH in Table 2 were less than 1 which means the cheese of the present study is safe. The minimum and maximum values in the Iranian samples were obtained in samples IN10 and IN9, while in Turkish samples were obtained in samples T14 and T12, respectively. The internal exposure by heavy metals is controlled by the hazard Index (HI), which is equal to or higher than 1, it indicates the potential health risk (Islam, *et al*. 2014), therefore the results of HI values in all cheese samples products from Iran were less than 1, except sample IN9. Statistically, the data of HI for each of the Iranian and Turkish samples has not been significant at $p > 0.05$. The range of the CR values of the worldwide average limit for heavy metals in food is 10^{-4}-10^{-6} according to Environmental Protection Agency (EPA, 2010; EPA, 1989c). Therefore, the results of CR due to Pb and Cd concentrations for the studied cheese samples have lower values than the worldwide range value, while the values of CR due to Cr concentrations for some samples IN3, IN8, IN9, T2, T9, and T14 which have higher than the world acceptable range. On the basis of these results of health risk parameters due to heavy metals (Pd, Cd, and Cr) in cheese samples such as Estimated Daily Intake (EDI), Target Hazard Quotients (THQ), Hazard Index (HI), and Carcinogenic risk (CR), it could be said that for most samples there is very little chance of potential health risks through consuming these cheese types. The heavy metals transferred through water and food chains to animals. It is accumulation in dairy animals adversely affects their health and milk production. The heavy metal contaminants enter animal systems due to pollution of air, water, soil, and consumption of contaminated feed; improper manufacturing practices and use of contaminated equipment

also contribute to the contamination of milk with heavy metals. Also, the heavy metals contamination during manufacturing of cheese, potential factors of seasonality, and the chemical affinity of heavy metals with certain ingredients are attributed to the high recorded values and heavy metals variations in some cheese samples. Our measured average value of heavy metal (Pb, Cd, and Cr) concentrations of the investigated cheese samples are compared with the previous studies as presented in Table 4. The average value of concentrations for Pb and Cd in the current study are higher than the values determined in Mexico, India, Georgia, Bulgaria, Iraq, Iran, Turkey and Bangladeshi, while the average value of Cr concentrations were higher than India, Georgia, Bulgaria, Iraq, Turkey and lower than in Iran and Bangladeshi, as illustrated in Table 4. From Table 4, it is found that the current study reports a significantly higher Pb and Cd concentrations than those of the same heavy metals for the same food type made by Iran. These may be due to many reasons such as the difference between the local and imported samples, and storage method of samples in Iraqi markets. From the results of the health risk parameters due to heavy metals in the present study such as Pb, Cd, and Cr in most cheese samples produced from Iran and Turkey were within the worldwide average limit. So, this study indicates that there are no high health risks of cheese samples that consumption by Iraqi people.

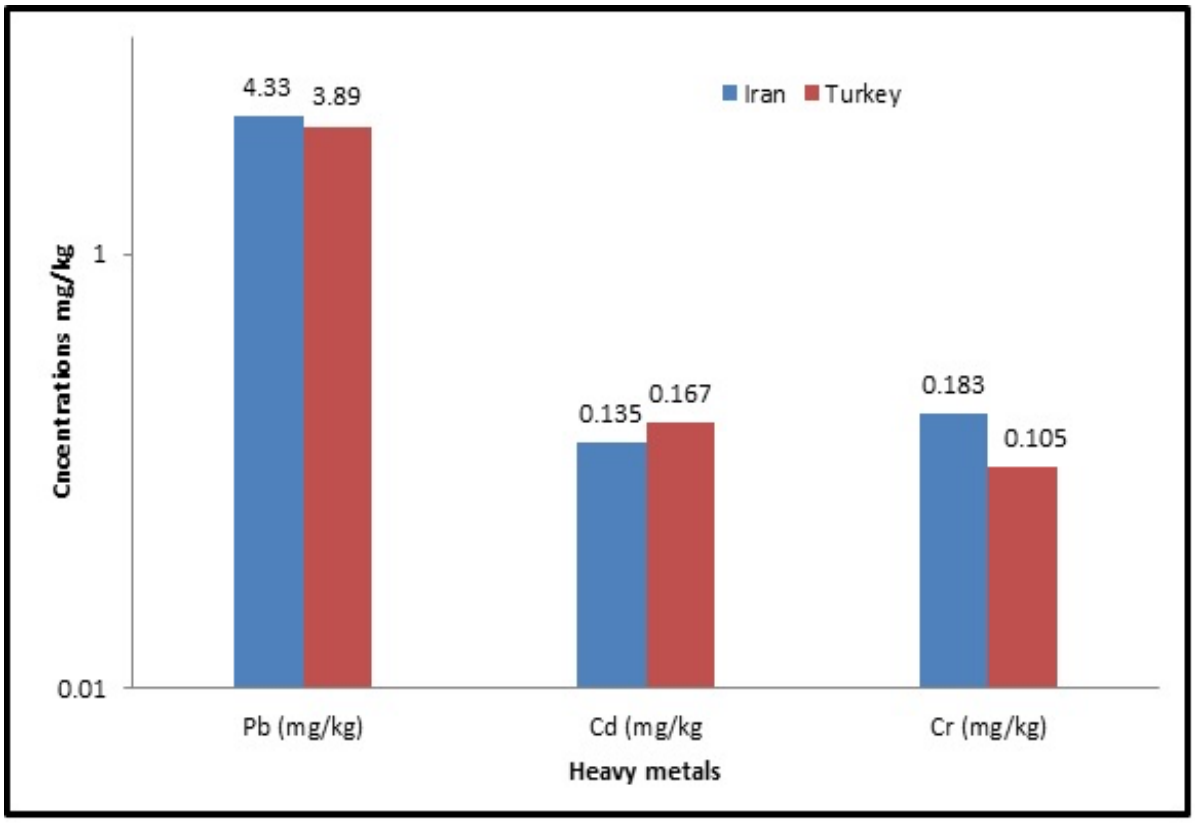

Fig.1. The relation of average values for Pb, Cd, and Cr concentrations in the sample of the present study as a function of the country of productions.

Table 4. Comparison of the average concentrations of Pb, Cd, and Cr in cheese samples of Various countries.

No.	Country	Average of concentrations mg/kg			Reference
		Pb	Cd	Cr	
1	Mexico	0.11	---	0.02	Castro-González, *et al*. 2018)
2	India	0.006	0.01	---	(Singh, *et al*. 2020)
3	Georgia	0.258	0.007	0.079	(Al Sidawi, *et al*. 2021)
4	Bulgaria	0.0012	0.0039	---	(Karadjova, *et al*. 2000)
5	Bangladeshi	0.025	0.042	0.886	(Anwarul & Sanjida, 2021)
6	Iraq (Basrah)	0.12	---	---	(Najla & Al-Kaabi, 2020)
7	Iraq (Baghdad)	0.05	---	0.006	(Amir & Al-Azzawi, 2016)
8	Turkey	0.67	---	0.32	(Durali, 2006)
9	Iran	0.015	0.0012	---	(Yasser & Fakhari, 2016)
	Present study				
10	Iran	4.33	0.135	0.183	---
	Turkey	3.89	0.167	0.105	

5. Conclusions

From the results of the health risk parameters due to heavy metals in the present study such as Pb, Cd, and Cr in most cheese samples produced from Iranian and Turkish were within the world limit. So, this study indicates that there are no high health risks of cheese samples that consumption by Iraqi people.

ACKNOWLEDGMENTS

Acknowledges all those who have contributed to this research. Special thanks to the staff of the Department of Physics at the University of Kufa.

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Submitted : 05/03/2022
Revised : 29/03/2022
Accepted : 04/04/2022
DOI : 10.48129/kjs.19245