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Assessment of Carcinogenic and Non-carcinogenic Health Risks for Selected Heavy Metals of Egyptian and Saudi Arabia Cheeses in Iraqi Markets

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ABSTRACT

The atomic absorption technology is used to study differences in concentration in heavy metals (Pb, Cd and Cr) between Egyptian and Saudi Arabia of cheese samples available in Iraqi markets. Carcinogenic risk (CR) and Non-carcinogenic, Estimated Daily Intake (EDI), Target Hazard Quotients (THQ) and Hazard Index (HI)) health risks due to Pb, Cd and Cr concentrations were determined in all samples of the present study. The average value of EDI for Pb, Cd and Cr in Egyptian samples was 1.34±0.24, 0.05±0.01 and 0.07±0.026 µg/kg/day; while in Saudi Arabia samples was 1.57±0.21, 0.05±0.01 and 0.07±0.035 µg/kg/day, respectively. Further, the average value of HI for Egyptian and Saudi Arabia samples was 0.457±0.07 and 0.522±0.06, respectively. In addition, the average values of CR × 10^{-6} for Pb, Cd and Cr in Egyptian samples were 0.005±0.0008, 0.303±0.08 and 1.25±0.44, while in Saudi Arabia samples were 0.006±0.0007, 0.314±0.09 and 1.16±0.59, respectively. Statistically there no significance of heavy metals as well as health risk parameters in cheese samples between Egyptian and Saudi Arabia. Thus, it can be concluded that all samples of cheese obtained from Egyptian and Saudi Arabia in Iraq markets had no health risk according to Pb, Cd, and Cr concentrations.

Key words : Heavy metal, carcinogenic health risk, Egyptian cheese, Saudi Arabia cheese, Iraq markets

INTRODUCTION

One of the main threats to the biological system and human health particularly is exposure to heavy metals. The effect of these metals on human health has been investigated (Kumar *et al.*, 2020). Recent studies have shown that heavy metals can cause breast cancer (Lamine *et al.*, 2020). These are carcinogenic effects on humans and animals, in general. The exposure of humans and other organisms to heavy elements has increased as a result of their recent use, particularly in industrial areas. These elements are transmitted to humans through natural sources where elements are naturally found in the earth's crust and are transferred to water, air and food (Abojassim and Rua, 2020). The normal way exposed to heavy metals is through air and food. Polluted food is damaging when it is eaten. Milk and dairy products especially cheese, for example, are a major source of many heavy metal types such as lead (Pb), chromium (Cr), arsenic (As), nickel (Ni), cadmium (Cd) that have detrimental effects on human health (Kumar *et al.,* 2020). Lead is one of the most hazardous metals on humans, causing disorders in the nervous system, abortion in pregnant women, high blood pressure, kidney damage, atrophy in the nervous system of children and lack of attention in children (Dorothy, 2019). While Cd has an important health risk for living organisms such as hypertension, cancer and infertility, affecting the heart muscle, respiratory problems and osteoporosis (Abojassim and Rua, 2020). But, Cr has hazardous health on human such as liver dysfunction, thrombocytopenia, renal failure and dermatitis (Kazemi *et al.*, 2022). Heavy metals in cheese may be transferred to human body by the food chain of cow as : soil-forage-milk-cheese to human. 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. Measurements of heavy metal concentrations in cheese samples provide an obvious picture of environmental and chemical contamination

of the exposed persons by many researchers around the world (Castro-González *et al.*, 2018; Singh *et al.*, 2020; Al Sidawi *et al.*, 2021). Therefore, the aim of the present study was to measure the heavy metals in Egypt and Saudi Arabia that are available in Iraqi markets using the Flame Atomic Absorption Spectrometry. In addition, it was to determine carcinogenic and non-carcinogenic health risks in all the samples.

METHODOLOGY

All the 20 cheese samples collected from Iraqi market were prepared in the nuclear and environmental laboratory at the University of Kufa. The preparation of samples included drying the cheese samples for about 48 h at 70°C. One g cheese samples were digested in 1 ml H_2O_2 and 10 ml HNO_3 for 24 h. Next day, the samples are heated at a temperature of 200°C for 1 h. One ml of $HCLO_4$ and deionized water was added till the total volume reached 25 ml. The samples were filtered using 0.45 µm filter paper. Pb, Cd and Cr concentrations were measured using AAS-7000 (SHIMADZU model) at 283.3, 228.8 and 357.9 nm wave length, respectively (Rashid *et al.*, 2016).

The non-carcinogenic parameters were estimated daily intake (EDI), target hazard quotients (THQs) and hazard index (HI), while the carcinogenic parameter was carcinogenic risk (CR), which were determined according to the following equations (Ullah *et al.*, 2017; Christophoros *et al.,* 2019; Karamian, 2020).

$$EDI\left(\frac{mg}{kg}per\ day\right)=\frac{C_{metal}\left(\frac{mg}{kg}\right)\times W_{c\ heese}\left(\frac{kg}{day}\right)}{BW\ (kg)} \quad ...(1)$$

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

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

$$CR=\frac{EFr\left(\frac{days}{year}\right)\times ED(year)\times EDI(\frac{mg}{kg}\ per\ day)\times CSFo(\frac{mg}{kg}\ per\ day)}{AT(\frac{day}{year}\times\ 60\ year)}\times 10^{-3} \quad ...(4)$$

Where, C_{metal} was heavy metals concentration, W_{cheese} was daily consumption rate (take 22 g/ day), BW was the average of human weight (60 kg), RfD was the value of reference dose which equalled 3.5×10^{-3}, 1×10^{-3} and 3×10^{-3} for Pd, Cd and Cr, respectively, while of EFr, ED, CSFo and AT were exposure frequency (350 days/year), exposure duration (30 years), carcinogenic slope factor (equalled 0.0085, 15 and 41 for Pb, Cd and Cr, respectively), and average time, respectively (Zeng *et al.*, 2015). Statistical analysis was performed using the SPSS statistical software package (SPSS for Windows version 20, SPSS Inc., Chicago, Illinois, USA).

RESULTS AND DISCUSSION

Table 1 shows the heavy metals concentration in cheese samples that are used by Iraqi people and manufactured in Egyptian and Saudi Arabia countries. For Egyptian samples (Table 2), the values of Pb were found to range from 0.92 to 6.96 with an average value of 3.66±0.67 mg/kg, the values of Cd ranging from 0.008 to 0.391 with an average value of 0.134±0.03 mg/kg, and the values of Cr were found ranging from ND to 0.523 mg/kg with an average value of 0.203±0.07 mg/kg, while for Saudi Arabia (Table 2), the results of Pb, Cd and Cr concentrations ranged from 1.39 to 7.42 with an average value of 4.27±0.57 mg/kg, from ND to 0.441 with an average value of 0.138±0.04 mg/kg and the values of Cr ranged from ND to 0.914 with an average value of 0.188±0.09 mg/kg, respectively. The highest value obtained for Pb for Egyptian and Saudi Arabia countries was E8 (Pride with olives) and S2 (Almarai), for Cd was E2 (Gold dairy), and S6 (Nadec), and for Cr was E1 (La Vachequirit-Triangles), and S6 (Nadec), respectively. While the lowest value obtained for Pb for Egyptian and Saudi Arabia countries was E4 (La Vachequirit-Simply) and S9 (Salim- bloc), for Cd was E6 (Elfarawda) and S4 (Feta- bloc).

The average value of heavy metals (Pb, Cd and Cr) emission from cheese samples varied from one sample to another due to the nature of the animal's feed such as fertilized food, the type of food, water conditions as well as agricultural and manufacturing processes used to produce them. The results of Pb concentrations in all samples were higher than the permissible limit at 0.002 mg/kg (Alimentarius, 2015; Hossain *et al.*, 2018), and Cd concentrations were higher than the permissible limit at 0.005 mg/kg (Sujka *et al.*, 2019) except samples of E6 and S4, while nine samples had Cr concentrations lower than the permissible limit at 0.003 mg/kg (Sujka *et al.*, 2019). The average value of heavy metals for

Table 1. Results of lead, cadmium and chromium concentration

S. No.	Cheese name	Origin	Sample code	Concentrations of heavy metals (mg/kg or ppm)		
				Pb	Cd	Cr
1.	La Vachequirit-Triangles	Egyptian	E1	1.39	0.191	0.523
2.	Gold dairy		E2	3.25	0.391	ND
3.	Abu El Walad		E3	6.03	0.091	ND
4.	La Vachequirit-Simply		E4	0.92	0.016	ND
5.	La Vachequirit-original		E5	4.64	0.141	ND
6.	Elfarawda		E6	1.85	0.008	0.392
7.	Smeds		E7	2.78	0.108	0.130
8.	Pride with olives		E8	6.96	0.066	0.522
9.	Pride with cream		E9	5.10	0.191	0.261
	Average±S. E.			3.66±0.67	0.134±0.03	0.203±0.07
10.	Smeds	Saudi Arabia	S1	4.17	0.058	0.392
11.	Almarai		S2	7.42	0.091	ND
12.	Almarai-full fat		S3	6.03	0.175	ND
13.	Feta- bloc		S4	3.71	ND	0.130
14.	Almarai-cheddar		S5	4.17	0.116	ND
15.	Nadec		S6	3.25	0.441	0.914
16.	Puck		S7	2.78	0.191	ND
17.	Salim-Triangles		S8	5.57	0.05	0.261
18.	Salim-bloc		S9	1.39	0.125	ND
	Average±S. E.			4.27±0.57	0.138±0.04	0.188±0.09
	Allowed limit			0.002	0.005	0.003

ND – No detection.

Table 2. Results of non-carcinogenic of health risks

S. No.	Sample code	EDI (µg/kg/day)			THQ			HI
		Pb	Cd	Cr	Pb	Cd	Cr	
1.	E1	0.511	0.070	0.193	0.146	0.070	0.065	0.280
2.	E2	1.192	0.144	ND	0.340	0.144	ND	0.484
3.	E3	2.213	0.034	ND	0.632	0.034	ND	0.666
4.	E4	0.340	0.006	ND	0.097	0.006	ND	0.103
5.	E5	1.702	0.052	ND	0.486	0.052	ND	0.538
6.	E6	0.681	0.003	0.144	0.195	0.003	0.048	0.246
7.	E7	1.021	0.040	0.048	0.292	0.040	0.016	0.348
8.	E8	2.554	0.024	0.192	0.730	0.024	0.064	0.818
9.	E9	1.873	0.070	0.096	0.535	0.070	0.032	0.637
Average±S. E.		1.34±0.24	0.05±0.01	0.074±0.026	0.383±0.07	0.05±0.009	0.05±0.01	0.457±0.07
10.	S1	1.532	0.021	0.144	0.438	0.021	0.048	0.507
11.	S2	2.724	0.034	ND	0.778	0.034	ND	0.812
12.	S3	2.213	0.064	ND	0.632	0.064	ND	0.697
13.	S4	1.362	ND	0.048	0.389	ND	0.016	0.405
14.	S5	1.532	0.043	ND	0.438	0.043	ND	0.481
15.	S6	1.192	0.162	0.335	0.340	0.162	0.112	0.614
16.	S7	1.021	0.070	ND	0.292	0.070	ND	0.362
17.	S8	2.043	0.018	0.096	0.584	0.018	0.032	0.634
18.	S9	0.511	0.046	ND	0.146	0.046	ND	0.192
Average±S. E.		1.57±0.21	0.05±0.01	0.07±0.035	0.448±0.06	0.05±0.01	0.023±0.01	0.522±0.06
Allowed limit		3.57	1	0	1	1	1	1

ND–No detection.

cheese samples was found to be in the following order : Pb > Cr > Cd (Table 1). The high concentrations of lead due to the source of environmental pollution were found in the animal (cow) feeds, which entered the human food (cheese) cycle through contaminated produce. There was a poor non-significant correlation (r=0.252) for Pb; a negative non-significant correlation (r = - 0.302) for Cd; and a moderate positive non-significant correlation (r=0.635) Cr concentrations. Therefore, there was no significant difference in Pb, Cd and Cr concentrations of Egyptian cheese samples with Saudi Arabia of cheese samples.

The range with average values of EDI for Pb, Cd and Cr concentrations in Egyptian samples was 0.340 to 2.554 with 1.34±0.24; 0.003 to 0.144 with 0.05±0.01 and ND to 0.193 with 0.074±0.026 µg/kg per day, respectively (Table 2). While the range with average values of EDI for Pb, Cd and Cr concentrations in Saudi Arabia samples was 0.511 to 2.724 with 1.57±0.21, ND to 0.162 with 0.05±0.01 and ND to 0.144 with 0.07±0.035 µg/kg per day, respectively (Table 2). Further, THQ for Pb, Cd and Cr concentrations in Egyptian samples was 0.097 to 0.730 with an average value of 0.383±0.07, 0.003 to 0.144 with an average value of 0.05±0.009 and ND to 0.065 with an average value of 0.05±0.01, respectively, while the results of THQ for Pb, Cd and Cr concentrations in Saudi Arabia samples were 0.146 to 0.778 with an average value of 0.448±0.06, ND to 0.162 with an average value of 0.05±0.01 and ND to 0.048 with an average value of 0.023±0.01, respectively. Similarly, HI due to Pb, Cd and Cr concentrations in Egyptian and Saudi Arabia samples ranged from 0.103 in sample E4 to 0.818 in sample E8 with an average value 0.457±0.07 and from 0.192 in sample S9 to 0.812 in sample S2 with an average value 0.522±0.06, respectively (Table 3). The CR x 10^{-6} for Pb concentrations in Egyptian and Saudi Arabia samples 0.001 to 0.009 with an average value 0.005±0.0008 and 0.002 to 0.010 with an average value 0.006±0.0007; for Cd concentrations were 0.019 to 0.886 with an average value 0.303±0.08 and ND to 0.999 with an average value 0.314±0.09 and for Cr concentrations were ND to 3.230 with an average value 1.25±0.44 and ND to 5.650 with an average value 1.16±0.59, respectively.

EDI for Pb and Cd concentrations was within allowed limits 3.57 µg/kg/day for Pb and 1.0 µg/kg/day for Cd (Ismail *et al.*, 2017). All values of THQ and HI for all samples were less than the acceptable limit at 1 (Rashid *et al.*, 2016). The data of carcinogenic health risks (CR) due to three heavy metals emitted from cheese samples in the present study were compared with world reports by Environmental Protection Agency (Popovic *et al.*, 2018) at ranges 10^{-4}-10^{-6}. It was found that the results of CR for Pb, Cd, and Cr concentrations were lower than the above range for all samples concentrations (Table 3).

There was no significant difference in EDI, THQ, HI and CR of Egyptian cheese samples with Saudi Arabia of cheese samples. Finally, from a carcinogenic and non-carcinogenic health risks point of view, it was found that all cheese samples (Egyptian and Saudi Arabia) did not pose any significant health hazard for the presence of heavy metals contents, and it was considered safe for human consumption.

Table 3. Results carcinogenic of health risks

S. No.	Sample code	CR×10^{-6}		
		Pb	Cd	Cr
1.	E1	0.002	0.435	3.230
2.	E2	0.004	0.886	ND
3.	E3	0.008	0.207	ND
4.	E4	0.001	0.038	ND
5.	E5	0.006	0.320	ND
6.	E6	0.002	0.019	2.422
7.	E7	0.004	0.245	0.807
8.	E8	0.009	0.151	3.229
9.	E9	0.007	0.434	1.614
Average±S. E.		0.005±0.0008	0.303±0.08	1.25±0.44
10.	S1	0.005	0.132	2.422
11.	S2	0.010	0.207	ND
12.	S3	0.008	0.396	ND
13.	S4	0.005	ND	0.807
14.	S5	0.005	0.264	ND
15.	S6	0.004	0.999	5.650
16.	S7	0.004	0.434	ND
17.	S8	0.007	0.113	1.614
18.	S9	0.002	0.283	ND
Average±S. E.		0.006±0.0007	0.314±0.09	1.16±0.59
Allowed limit		10^{-4} to 10^{-6}		

ND–No detection.

CONCLUSION

The average values of Pb, Cd and Cr concentrations in most samples were higher than the acceptable limit according to European, Codex standards and EU Regulation. While the results of non-carcinogenic health risks for Pb, Cd and Cr concentrations in all cheese samples in the present study were within acceptable limits according to EU Regulations and other reports. In addition, it was found that carcinogenic health risks for Pb, Cd, and Cr were lower than world limits. There were no statistically significant differences in all results in the present study between Egyptian and Saudi Arabia cheeses in Iraqi Markets.

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