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Assessment of non-carcinogenic and carcinogenic risk due to Heavy metals in Powder Milk Samples for Adults in Kerbela Governorate

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Abstract

In this study, six heavy metals like cobalt (Co), chromium (Cr), selenium (Se), zinc (Zn), lead (Pb), and cadmium (Cd) in adult powder milk samples were measured using atomic absorption spectrometry. Powder milk samples were collected from local markets in Karbala Governorate, Iraq. The non-carcinogenic risk parameters such as Estimation daily intake (EDI), Target Hazard Quotient (THQ), and Hazard Index (HI) due to all heavy metals of the present study as well as carcinogenic risks such as Cancer risk (CR) due to Pb and Cd were determined. The results showed that the average values of Co, Cr, Se, Zn, Pb, and Cd for all samples of powder milk in parts per million (µg/kg) were 91.3±10.9, 38.3±3.8, 92.9±7.5, 78.5±1.1, 57.8±4.6, and 0.9±0.1,respectively. While the average values of Hazard Index (HI) and total cancer risk parameters were 0.008±0.0006 and 4.4E-07±3.5E-08, respectively. According to the safe limits of heavy metals recommended by WHO and EPA, the results of Pb concentration in most samples were high. While, the values of health risk parameters did not exceed the permissible limits.

Keyword: heavy metals, adults of powder milk,total cancer risk, and Kerbalamarkets.

Introduction

Many foods that are a part of a typical human diet, such yogurt, ice cream, and curds, require milk. It may be stored and consumed in moderation, making it a nutritious choice for kids, teens, and new babies [1]. Many nations' diets, especially the less developed ones, place a high value on milk and its byproducts. It is not unusual for people in these countries to give their newborns this type of food on a daily basis. We regularly absorb large amounts of heavy metals from the food we eat, the drinks we drink, and the air we breathe [2]. It is possible to eat milk that has been contaminated with heavy metals from drinking water or animal feed [3]. Because some heavy metals may readily go from grass to animals and subsequently to milk, milk is susceptible to contamination[1].Despite occasionally being ill-defined, the term "heavy metal" often refers to metals with specific weights of greater than 5 g/cm^3[4]. Similarly, a number of heavy metals provide essential trace nutrients to both humans and animals[1]. Certain heavy metals, such as

zinc and copper, work with enzymes as activators and cofactors. They can function as prosthetic groups in metalloproteinase enzymes, imparting catalytic characteristics, or they can combine to create complexes with substrates and other enzymes. These essential trace metal nutrients are involved in electron transport, redox reactions, and structural functions related to the processing of nucleic acids[5]. Heavy metals, including Cd, Hg, As, and others, have a harmful impact on enzymes that are sensitive to metals, which can inhibit an organism's development or cause it to die. In an alternate classification, heavy metals including mercury, silver, lead, and nickel are categorized as class B metals according to their coordination chemistry. These metals are extremely poisonous and regarded as non-essential trace elements[6]. These heavy metals do not easily undergo metabolism or swiftly dissolve in the environment; instead, they display persistence and bioaccumulation. These kinds of metals become accumulated in the ecological food chain through absorption by primary producers and subsequent consumption at different levels by consumers. The issues arise here if the requirements set forth by international health organizations are not met during the production of milk powder. Because of living circumstances, newborns in Iraq are specifically given powdered milk, which is made from plant and animal sources, particularly soybeans, either as a supplement or a replacement to breast milk [6]. Heavy metals are essentially persistent pollutants in the environment that can be harmful to human health. As a result of direct human exposure to toxic metals due to urbanization, industrialization, and increasing population emissions, all of this causes the presence of toxic heavy metals in milk, endangering human health. Symptoms that accompany an increase in heavy metals in human bodies include low human body weight, immaturity of the kidneys and liver, decreased ability to remove toxins, and a weak central nervous system, which makes humans particularly vulnerable to toxic pollutants [5].A common biomarker for determining the presence of dangerous metals and making conclusions about the contamination that results in the food chain is cow milk [7]. Several studies of heavy metals in milk in the world [8-10]. This study aims to determine heavy metals (Co, Cr, Se, Zn, Pb, and Cd) and some health risk parameters in powder milk used by adults in Iraq.

2. Materials and Methods

2.1. Sample Collection

Twenty-five different samples of powdered adults were collected from the different markets of Karbala Governorate / Iraq from various existing sources, and then the samples were prepared to examine the concentrations of heavy metals within them at the University of Karbala in a laboratory. Faculty of Medicine, Chemistry Branch. Table 1 represents the name of the powdered milk samples used, the symbol for each sample, and the origin of each sample.

Table 1. Information of Powder milk samples in the present study

No.	Sample name	Sample code	Origin
1	Dialac	PMA1	Vitnam
2	Nido	PMA2	France
3	Jannat full fat	PMA3	Holand
4	Ishtar	PMA4	Jordan
5	almaraei	PMA5	Sudia
6	Sama Milk	PMA6	Holand
7	Dano	PMA7	Denmark
8	Almalika	PMA8	Iraq
9	Fresh	PMA9	Sudia

10	Janat low fat	PMA10	Holand
11	Altai	PMA11	Sweden
12	Alwaled aldhaki	PMA12	United arab
13	Anchor	PMA13	Neusland
14	Almudhish	PMA14	jordan
15	Mahmoud	PMA15	Imaratunited
16	ANGELA	PMA16	United arab
17	alwaladalmudhash	PMA17	Neusland
18	milak	PMA18	Erland
19	Al Youmi Plus	PMA19	Sudia
20	Pook	PMA20	United arab
21	Nader	PMA21	Sudia
22	ealamalmudhsh	PMA22	Iraq
23	Tazaj	PMA23	oman
24	Alsaker	PMA24	Neusland
25	Nawras	PMA25	holand

2.2. Samples digestion

Work was done to measure the heavy elements by taking (3) grams of powdered milk for each type separately using an accurate balance and adding it to (3) ml of ionized water. They were mixed well using a vortex device, then taking (1) ml of the solution, (1) ml of the modified solution was added to the milk solution and left for (24) hours in a special tube. Then the solution was shaken well through the vortex device again for (40) seconds, and then the solution was filtered through a filter with a diameter of (45%) microns, then put an amount of (20) microns using a pipette, then take the filtered solution and placed in an atomic absorption spectrometer, through which the concentration of the following heavy elements (Co, Cr, Se, Zn, Pb, and Cd) was measured for each type of milk.

2.3. Analysis of the heavy metals

Instrumental analysis of Co, Cr, Se, Zn, Pb, and Cd was conducted by air acetylene Flame Atomic Absorption Spectrophotometer (Shimadzu model AA-6300). The values of wavelength in nm for Co, Cr, Se, Zn, Pb, and Cd were 240.73, 422.7, 196.03, 360.12, 217.00, and 228.80, respectively.

2.4. Health risk assessment

The Estimation daily intake (EDI), Target Hazard Quotient (THQ), and Hazard Index (HI) were computed to assess the non-carcinogenic hazards linked to the consumption of heavy metals in powdered milk. The EDI was computed using the formula specified in equations (1-3) [11-14].

$$EDI\ (\mu g/kg\ \ per\ day) = \frac{C(\frac{\mu g}{kg}) \times D(\frac{kg}{day})}{BW(kg)} \qquad (1)$$

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

$$HI = \mathrm{THQ}_1 + \ \mathrm{THQ}_2 + \cdots + \mathrm{THQ}_n = \sum_{1}^{n} \mathrm{THQ}_n \ (3)$$

Where, C is the concentration of heavy metals in powder milk (µg/kg), D is the daily consumption of powder milk for each kg, BW is the average body weight, and RfD is the oral

reference dose in µg/kg per day. The value of D in adults is 13 kg/year[15]. Moreover, the values of RfDfor each heave metal were Co =30, Cr = 3, Se=5, Zn = 300, Pb = 4, and Cd = 1 [16].
The carcinogenic hazards associated with the ingestion of heavy metals in powdered milk were assessed by calculating the cancer risk over time and the cumulative cancer risk of these metals. The EDI was computed using the formula specified in Equation (4) [17,18].

$$CR = EDI\left(\frac{\mu g}{kg}\ per\ day\right) \times CSF\ (\frac{\mu g}{kg} per\ day)^{-1} \qquad (4)$$

Where, CSF stands for cancer slope factor. The slope factors for oral cancer were 8.5E-06 for Pb and 3.8E-04 for Cd [17]. The overall cancer risk resulting from the intake of canned milk, which contains many carcinogenic heavy metals, was determined by adding up the individual risks posed by each heavy metal. This calculation was performed using a specific Equation (5) [17,18]:

$$\text{Total cancer risks} = \mathrm{CR}_1 + \mathrm{CR}_2 + \cdots + \mathrm{CR}_n = \sum_{1}^{n} \mathrm{CR}_n \ (5)$$

3. Resultand discussion

Table 2 shows the results of six heavy metals (Co, Cr, Se, Zn, Pb, and Cd) of a sample of powder milk in the present study. From Table 2, the minimum values of concentration for Co, Cr, Se, Zn, Pb, and Cd in all samples of powder milk in the present study were 20 µg/kg ,4.3µg/kg,33.3µg/kg 62.6 µg/kg, 6.3 µg/kg and 0.1 µg/kg, respectively, while, the maximum values were 183.5 µg/kg, 94.5 µg/kg, 148.9µg/kg, 86.5 µg/kg, 100.6 µg/kg, and 2.9 µg/kg, respectively. Also, it is found that (Table 2), the minimum values of concentration for Co, Cr, Se, Zn, pb, and Cd in all samples of powder milk in the present study were 20 µg/kg ,4.3µg/kg,33.3µg/kg 62.6 µg/kg, 6.3 µg/kg and 0.1 µg/kg, respectively, while, the maximum values were 183.5 µg/kg, 94.5 µg/kg, 148.9µg/kg, 86.5 µg/kg, 100.6 µg/kg, and 2.9 µg/kg, respectively. Moreover, the average value with standerd error of concentration (in unit µg/kg) for Co, Cr, Se, Zn, Pb, and Cd in all samples in the present study were91.3±10.9, 38.3±3.8, 92.9±7.5, 78.5±1.1, 57.8±4.6, and 0.9±0.1, respectively.According to the/WHO in 2012 [19] and FAO/WHO in 2014 [20], the global average for the heavy metal Co, Cr, Se, Zn, Pb, and Cd in unit ppb in food is 190, 300, 500, 920, 20, and 2.6, respectively. So, it was noticed that the results in Table (2) for the Co, Cr, Se, Zn, and Cd concentrations for all samples within the global average, while, the results of Pb concentrations for most samples were high.The increase in the lead concentration, in the milk samples under study, can be attributed to the plants that are already used in the manufacturing cows' feed. In this regard, plants can absorb the lead from the soil and the corresponding fertilizers.

Table 2.Results of heavy metals Concentration in milk powder samples.

No.	Sample code	Concentrations of heavy metals (ppb or µg/kg)					
		Co	Cr	Se	Zn	pb	Cd
1	PMA1	183.5	23.5	134.6	84.5	41.3	1.2
2	PMA2	49.6	31.2	131.3	81.5	58.2	0.8
3	PMA3	132.3	38.6	134.7	80.3	70.1	0.5
4	PMA4	154.5	20.7	58.8	76.6	95.8	0.6
5	PMA5	163.4	32.1	47.3	82.6	50.4	1.2
6	PMA6	41.8	4.3	127.1	62.6	6.3	0.1
7	PMA7	118.5	71.6	126.7	82	98.8	1.7
8	PMA8	154.3	94.5	126.5	79.4	95.8	0.8

9	PMA9	62.5	45.5	63.7	82.1	61	0.8
10	PMA10	124.5	40.6	126.1	82.3	62.5	0.3
11	PMA11	156.4	27.1	104.7	81.1	59.4	1.6
12	PMA12	124.9	35.2	136.1	84.3	69.3	0.4
13	PMA13	37	29.7	58.3	76.8	56.1	0.3
14	PMA14	30.2	28.5	65.5	81.6	35	0.8
15	PMA15	47.9	23.9	43.1	86.5	27.3	0.5
16	PMA16	120.6	45.7	64.8	83.5	73.9	1.3
17	PMA17	20	18	133.1	78.8	35.8	0.2
18	PMA18	25.1	22.8	67.9	80.8	41.9	1.5
19	PMA19	27.2	48.9	35.3	80.4	46.9	2.9
20	PMA20	39.7	54	61.8	67.1	33.4	1.4
21	PMA21	150	48.8	77.6	66.7	41.6	1.5
22	PMA22	37.7	11.8	93.5	71.1	50.9	0.3
23	PMA23	25.9	43.1	33.3	81.3	72.9	1.8
24	PMA24	116.1	62.2	122.8	74.7	61.4	0.4
25	PMA25	141.1	57.4	148.9	75	100.6	0.2
Average±S.E		91.3±10.9	38.3±3.8	92.9±7.5	78.5±1.1	57.8±4.6	0.9±0.1
Safe limit [19,20]		190	300	500	920	20	2.6

Table 3 shows the results of the estimation of daily intake due to the number of heavy metals in powdered milk in the present study consumption by adults. From Table 3, the average values of estimation daily intake due to Co, Cr, Se, Zn, Pb, and Cd concentrations (µg/kg per day) were 0.047±0.005, 0.019±0.002, 0.047±0.003, 0.040±0.0006, 0.029±0.002, and 0.00048±0.00006, respectively. It noted that the results of the estimation of daily intake (µg/kg/day) due to heavy elements present in the children's powder milk used in this research, and according to the weight of the child and the amount that the children eat, is within the permissible limits of world toxic heavy metals of Co, Cr, Se, Zn, Pb, and Cd which are 30, 3, 5, 300, 4, and 1, respectively [21], which means that all powder samples are safe.

Table 3. Results of Estimation daily intake milk powder samples.

No.	Sample code	Estimation daily intake (µg/kg per day)					
		Co	Cr	Se	Zn	pb	Cd
1	PMA1	0.095	0.012	0.069	0.044	0.021	0.0006
2	PMA2	0.026	0.016	0.068	0.042	0.030	0.0004
3	PMA3	0.068	0.020	0.069	0.041	0.036	0.0003
4	PMA4	0.080	0.011	0.030	0.040	0.049	0.0003
5	PMA5	0.084	0.017	0.024	0.043	0.026	0.0006
6	PMA6	0.022	0.002	0.066	0.032	0.003	0.0001
7	PMA7	0.061	0.037	0.065	0.042	0.051	0.0009
8	PMA8	0.080	0.049	0.065	0.041	0.049	0.0004
9	PMA9	0.032	0.023	0.033	0.042	0.031	0.0004
10	PMA10	0.064	0.021	0.065	0.042	0.032	0.0002
11	PMA11	0.081	0.014	0.054	0.042	0.031	0.0008
12	PMA12	0.064	0.018	0.070	0.043	0.036	0.0002

13	PMA13	0.019	0.015	0.030	0.040	0.029	0.0002
14	PMA14	0.016	0.015	0.034	0.042	0.018	0.0004
15	PMA15	0.025	0.012	0.022	0.045	0.014	0.0003
16	PMA16	0.062	0.024	0.033	0.043	0.038	0.0007
17	PMA17	0.010	0.009	0.069	0.041	0.018	0.0001
18	PMA18	0.013	0.012	0.035	0.042	0.022	0.0008
19	PMA19	0.014	0.025	0.018	0.041	0.024	0.0015
20	PMA20	0.020	0.028	0.032	0.035	0.017	0.0007
21	PMA21	0.077	0.025	0.040	0.034	0.021	0.0008
22	PMA22	0.019	0.006	0.048	0.037	0.026	0.0002
23	PMA23	0.013	0.022	0.017	0.042	0.038	0.0009
24	PMA24	0.060	0.032	0.063	0.039	0.032	0.0002
25	PMA25	0.073	0.030	0.077	0.039	0.052	0.0001
Average±S.E		0.047±0.005	0.019±0.002	0.047±0.003	0.040±0.0006	0.029±0.002	0.00048±0.00006
Safe limit [22]		30	3	5	300	4	1

Table 4 shows the results of the Target Hazard Quotient (THQ) and the Hazard Index (HI) due to the six heavy metals (Co, Cr, Se, Zn, Pb, and Cd) in powdered milk in the current study consumption by adults. The average values THQ resulting from the concentrations of Co, Cr, Se, Zn, Pb, and Cd in the milk were 0.0015±0.0001, 0.0066±0.0006, 0.0095±0.0007, 0.0001±0.00003, 0.0074±0.0005, and 0.0004±0.00003, respectively. While, the results of HI due to Co, Cr, Se, Zn, Pb, and Cd concentrations in all samples of the present study ranged from 0.001 in sample PMA6 (Sama Milk, made in Holand) to 0.014 in sample PMA7 (Dano, made in Denmark), with an average value 0.008±0.0006. It noted that the results of the Target Hazard Quotient and Hazard Index due to heavy elements present in the adult powder milk used in this research were within the permissible limits of world toxic heavy metals, which is equal to or higher than 1 [23,24].

Table 4. Results of Target Hazard Quotient and Hazard Index in milk powder samples.

Sample code	Target Hazard Quotient						Hazard In
	Co	Cr	Se	Zn	pb	Cd	
PMA1	0.0032	0.0040	0.0139	0.0001	0.0053	0.0006	0.006
PMA2	0.0009	0.0054	0.0135	0.0001	0.0075	0.0004	0.008
PMA3	0.0023	0.0066	0.0139	0.0001	0.0090	0.0003	0.009
PMA4	0.0027	0.0036	0.0061	0.0001	0.0124	0.0003	0.013
PMA5	0.0028	0.0055	0.0049	0.0001	0.0065	0.0006	0.007
PMA6	0.0007	0.0007	0.0131	0.0001	0.0008	0.0001	0.001
PMA7	0.0020	0.0123	0.0131	0.0001	0.0127	0.0009	0.014
PMA8	0.0027	0.0163	0.0131	0.0001	0.0124	0.0004	0.013
PMA9	0.0011	0.0078	0.0066	0.0001	0.0079	0.0004	0.008
PMA10	0.0021	0.0070	0.0130	0.0001	0.0081	0.0002	0.008
PMA11	0.0027	0.0047	0.0108	0.0001	0.0077	0.0008	0.008
PMA12	0.0021	0.0061	0.0140	0.0001	0.0089	0.0002	0.009

PMA13	0.0006	0.0051	0.0060	0.0001	0.0072	0.0002	0.007
PMA14	0.0005	0.0049	0.0068	0.0001	0.0045	0.0004	0.005
PMA15	0.0008	0.0041	0.0044	0.0001	0.0035	0.0003	0.004
PMA16	0.0021	0.0079	0.0067	0.0001	0.0095	0.0007	0.010
PMA17	0.0003	0.0031	0.0137	0.0001	0.0046	0.0001	0.005
PMA18	0.0004	0.0039	0.0070	0.0001	0.0054	0.0008	0.006
PMA19	0.0005	0.0084	0.0036	0.0001	0.0060	0.0015	0.008
PMA20	0.0007	0.0093	0.0064	0.0001	0.0043	0.0007	0.005
PMA21	0.0026	0.0084	0.0080	0.0001	0.0054	0.0008	0.006
PMA22	0.0006	0.0020	0.0096	0.0001	0.0066	0.0002	0.007
PMA23	0.0004	0.0074	0.0034	0.0001	0.0094	0.0009	0.010
PMA24	0.0020	0.0107	0.0127	0.0001	0.0079	0.0002	0.008
PMA25	0.0024	0.0099	0.0154	0.0001	0.0130	0.0001	0.013
rage±S.E	0.0015±0.0001	0.0066±0.0006	0.0095±0.0007	0.0001±0.00003	0.0074±0.0005	0.0004±0.00003	0.008±0.0
limit 24]	1	1	1	1	1	1	1

Table 5 shows the results of cancer risk due to Pb and Cd concentration as well as total cancer risk for selecting samples of the present study. From Table 5, the average values of cancer risk due to Pband Cd concentrations were 2.5E-07±1.9E-08 and 1.9E-07±2.7E-08, respectively. While, the results of the total cancer risk due to Pb and Cd concentrations ranged from 5E-08 in sample PMA6 (Sama Milk, made in Holand) to 8E-07 in sample PMA7 (Dano, made in Denmark), with an average value of 4.4E-07±3.5E-08. It noted that the results of the cancer risk and total cancer risk due to Pb and Cd elements present in the adult powder milk used in this research were within the permissible limits of world toxic heavy metals, which is equal to the range 1.00E-06 to 1.00E-04 [25, 26].

Table 5. Results of Cancer risk and total Cancer risk in milk powder samples.

No.	Sample code	Cancer risk		Total cancer risk
		pb	Cd	
1	PMA1	2E-07	2E-07	4E-07
2	PMA2	3E-07	2E-07	4E-07
3	PMA3	3E-07	1E-07	4E-07
4	PMA4	4E-07	1E-07	5E-07
5	PMA5	2E-07	2E-07	5E-07
6	PMA6	3E-08	2E-08	5E-08
7	PMA7	4E-07	3E-07	8E-07
8	PMA8	4E-07	2E-07	6E-07
9	PMA9	3E-07	2E-07	4E-07
10	PMA10	3E-07	6E-08	3E-07
11	PMA11	3E-07	3E-07	6E-07
12	PMA12	3E-07	8E-08	4E-07
13	PMA13	2E-07	6E-08	3E-07

14	PMA14	2E-07	2E-07	3E-07
15	PMA15	1E-07	1E-07	2E-07
16	PMA16	3E-07	3E-07	6E-07
17	PMA17	2E-07	4E-08	2E-07
18	PMA18	2E-07	3E-07	5E-07
19	PMA19	2E-07	6E-07	8E-07
20	PMA20	1E-07	3E-07	4E-07
21	PMA21	2E-07	3E-07	5E-07
22	PMA22	2E-07	6E-08	3E-07
23	PMA23	3E-07	4E-07	7E-07
24	PMA24	3E-07	8E-08	3E-07
25	PMA25	4E-07	4E-08	5E-07
Average±S.E		2.5E-07±1.9E-08	1.9E-07±2.7E-08	4.4E-07±3.5E-08
Safe limit [25, 26]		1.00E-06-1.00E-04		

Ensuring the safety of milk production is vital to promote increased consumption. Heavy metals like Co, Cr, Se, Zn, Pb, and Cd must be closely monitored due to their adverse impact on organ functions. Lead (Pb), a hazardous metal, induces several detrimental biochemical alterations. Despite lacking any biological purpose, even trace amounts of lead may result in severe permanent consequencesThe International Agency for Research on Cancer has categorized cadmium as a Group 1 carcinogen, meaning that it is a material that is known to cause cancer. Inorganic lead, on the other hand, is classified as a Group 2 carcinogen and is regarded a significant contaminant in food [27] Given the persistent nature of lead and cadmium, their potential transfer into the food chain poses significant risks, necessitating ongoing evaluation of their presence in milk and associated consumption risks. Excessive consumption of milk that contains high levels of heavy metals hurts the health of humans. This interpretation agreed with previous studies [29, 30].

4. Conclusion

The results of the concentrations of chromium (Cr), selenium (Se), zinc (Zn), and cadmium (Cd) in all of the powder milk samples for adults in the present study in Kerbala governorate were within the safe limit allowed by World Health Organization and European Regulation limits, while the most of the samples had lead (Pb) concentrations were high. Nonetheless, the findings of the current study's non-carcinogenic risk factors and carcinogenic hazards resulting from heavy metals in milk samples for adult age were all within the appropriate oral reference dosage. Thus, based on the study's findings, it can be said that there was no health danger associated with the amount of heavy metals in adult powder milk found in Kerbela City's Iraqi marketplaces.

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