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Detection of Lead (Pb) and Cadmium (Cd) Concentrations and Hazards in Some Baby Food Samples

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Abstract

This study was conducted to detect the concentration of lead and cadmium in baby foods. (18) samples were examined, which are the most available from various local markets in the city of Baghdad (at a rate of (9) samples of baby food consisting of cereals and (9) samples of baby food consisting of vegetables). All samples were examined using atomic flame absorptiometry (AAS-7000), and all results showed the presence of lead and cadmium, with the highest concentration values of lead in baby foods consisting of cereals (1.0986) and cadmium in baby foods consisting of vegetables (0.0015) ppm. Lead exceeded 100% limitations, and cadmium did not exceed that. The results reported on the risks of contamination were that the mean daily intake (g/kg/d) for lead (1.3538) and cadmium amounted to (0.010), and the target hazard quotient index was high for the index (THQ>10) for lead in most of the samples examined and reached (THQ<10) in some samples examined, while for cadmium all samples reached an index of (THQ<10). The study showed an increase in lead concentrations and perceptible risks and did not report an increase in cadmium concentrations outside the determinants, but it warns of imperceptible risks to the consumer. The study showed statistically significant differences between the levels of lead and cadmium and between the studied species, but did not show statistically significant differences between the origins at the level of significance (0.05). It has been shown that these products pose a risk to children when consumed, so these products must be banned, and ways must be found to reduce or prevent these pollutants with these products or find appropriate alternatives.

Keywords: Local Market, Baby Food, Heavy Metals, Atomic Flame Spectrometry.

1. Introduction

In recent years, the demand for the use of breast milk substitutes and foods whose sources varied in conjunction with the lactation period has increased to support the rapid growth rate of the child's life, and this has long-term consequences for the growth of organs and their functions and may lead to adverse health effects later in life [1]. Food products cannot be free of chemical pollutants, which mainly originate from the environment [2], the most important of which are heavy metals that are biologically transmitted to the bodies of living organisms through food chains [3] and there are other factors that help the transport of heavy metals, including technological treatments, unhealthy packaging stages, and preservatives in canning [4]. Heavy metals have a density of 5 mm/cm3 and more [5] and lead and cadmium have no beneficial role in the body because they are toxic heavy metals [6; 7] and dangerous even at low concentrations [5].

Young age groups are more sensitive than adults to these food contaminants due to their high cumulative rate of absorption by the digestive system, incomplete brain barrier, and high food consumption relative to body mass [8].

Prolonged or repeated exposure to lead causes organ damage, may impair fertility or the fetus, cause cancer, and lead to memory deterioration and reduced comprehension, especially when exposed to doses outside the permissible limits [9]. Lead has no recognized biological role and causes serious disorders of the central nervous system, liver, blood, gonads, cardiovascular, endocrine, digestive, and renal systems [10]. Cadmium has long-term effects that may cause cancer, and exposure to it is linked to carcinogenesis of body tissues and organs such as the stomach, intestines, breast, prostate, testicles, lungs, and esophagus [11] and causes fertility or fetal damage, organ damage, and suspected genetic defects [12]. Therefore, the authority required to conduct this study is to detect the presence of these minerals and assess the resulting danger to the health of consumers, especially vulnerable age groups, especially children, as they are among the groups most likely to consume these food products and are the most vulnerable to these dangerous metals.

2. Materials and Methods

2.1. Sample collection

Samples were collected in June 2021 from local markets and several areas of Baghdad city in 18 categories, including (9) samples of baby food consisting of cereals and (9) samples of baby food consisting of vegetables. It is the most available on the market and has different brands and origins.

2.2. Sample preparation

The samples were taken from each product and kept in sterile polyethylene bags measuring (10×10) cm to avoid contamination. and the samples were recorded sequentially, kept in appropriate cooling conditions, and transferred to the examination center as soon as possible.

2.3. Quality assurance

The equipment was washed to avoid contamination with the element being analyzed, and the glass utensils were cleaned well with distilled water and then with non-ionic water and soaked in hot nitric acid (HNO3) diluted at a concentration of 10% for 24 hours, rinsed several times with non-ionic water, and dried to ensure that they were free of metals [13].

2.4. Incineration and digestion

[14] method was ground each sample, weigh (5) g of it with an air-isolated sensitive balance, and place it in a lid inside a firing incinerator at 550 °C for (5) hours. Then each sample was digested by adding a mixture of HCl at a concentration of (10) ml and non-ionic water in a ratio of 1:1 and continuous stirring until digestion is complete, then placed over a hot plate until the solvent evaporates, then filtered with millipore filter paper (0.45), then cooled and placed in a volumetric vial with a capacity of (50) ml, and completing the volume with distilled water deionized in a ratio of 1:9 to the mark.

2.5. Sample Examination

All samples were examined in the atomic absorption laboratory at the Market Research and Consumer Protection Center, University of Baghdad, Al-Jadriyah Complex. The examination was carried out by a Flame Atomic Absorption Spectrometer (FAAS) Model (7000-AAS) from the Japanese company Shimadzu. AL Dabbagh (2013) [15] indicated in his study that this technique has a peculiarity and sensitivity in estimating the small amounts of elements, and this method depends on irritating the atoms of the element using gases such as acetylene and converting them to a vapor state to radiate light energy directly proportional to the concentration of the element in the sample. He prepared standard solutions with concentrations of (0.2, 0.4, 0.6, 0.8, and 1) µg / ml and measured the concentrations of lead and cadmium **(Table 1).** According to examination specifications, the work of a standard curved graph line was relied upon to compare with the samples examined.

Table 1. Examination Specifications

Element	Wavelength	Amperage	Slit width	Used Gas
Lead	Nm 228.8	MA 0.40	cm10	Acetylene
Cadmium	Nm 283.3	MA 0.40	cm10	Acetylene

2.6. Calculation of mineral concentrations

The concentrations of all metals in all samples were calculated in the same way according to the equation indicated by Belay (2014) [16], as follows:

C. (ppm) = [C. (mg/kg or mg/l) ×V.] / W

C. (ppm) represents the concentration of the metal in the sample, C. (mg/kg or mg/l) the concentration of the metal in the sample (device reading), (V) the sample volume in the flask (5 ml^3), and (W) the weight of the sample before incineration (5) g.

2.7. Calculation of the number of samples above the permissible limit and percentages

The number of samples was calculated above the permissible limit and percentage as indicated by [15] by studying it as follows:

Number of samples above the permissible limit = (total number of samples - number of samples within the permissible limits)

Percentage of samples above the allowed limit = (number of samples above the permissible limits / total number of samples) × 100%.

2.8. Calculation of pollution hazard values (non-carcinogenic hazards) in baby foods

2.8.1. Estimated Daily Intake

The value of (EDI) (d/g/kg) estimated daily intake according to the inputs in **Table 2** is calculated according to the equation [17; 18; 19; 20; 21] referred to in their study as follows:

EDI = [C.×FIR] / Bwa

Table 2. Recommended maximum estimated daily intake (EDI) and Reference food Dose oral (RfDo).

Soruce	Cadmium	lead	Working element
(USEPA, 2002) [22]	1.00	3.60	EDI (d/g/kg)
(GSODS, 2013) [23] ;(USEPA, 2016) [24]	0.001	0.002	RFDo (mg/kgld)

The food intake rate (FIR) is (50) d/g written on the product packaging. [25], as noted by [21] in their study. The mean weight of a 13 kg year-old child (1-2) years was calculated, and BWA represents the mean weight of a person by age and weight [25]. [20] referred to it in their study, Reference Food Dose Oral (RFDo), C represents the concentration of element (g) in the food product.

2.8.2. Target hazard quotients

This estimate is based on the risk-based concentrations provided by USEPA. Table using standard risk analysis, target hazard quotients (THQ) are an indicator ranging from (1_10), ($THQ \geq 1$) indicates the occurrence of non-carcinogenic adverse health effects in the long term, while THQ<1) indicates no significant health damage [26], referred to by [20; 27; 28] in their study as follows:

THQ=EDI/RfDo

2.9. Statistical analysis

The means and standard deviation of the obtained data were calculated. Apply one-way analysis of variance (LSD/ANOVA) to find out significant differences at the probability level ($p<0.05$).

3. Results and Discussion

The results of **Table 3** showed a variation in the concentrations of Pb between samples according to the product and its origin and that the concentrations of Pb exceeded the concentrations of Cd in all tests. It was also noted that the concentrations of samples examined for ready-made baby foods consisting of cereals exceeded the concentrations of samples of children's foods made of vegetables for the element Pb, while for the element Cd, a variation appeared in those concentrations between the types.

Table 3. Concentration of lead and cadmium and hazard of contamination in baby prepared foods.

Samples*	**Concentration of elements (ppm)**		**Estimated daily intake (EDI)** (d/g/kg)		**Target hazard quotient (THQ)** indicator	
	Pb	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**
Fs1	1.2453	0.0007	4.7896	0.0027	31.1325	0.0350
Fs2	0.3651	0.0007	1.4042	0.0027	9.1275	0.0350
Fs3	0.5310	0.0012	2.0423	0.0046	13.2750	0.0600
Fs4	0.3778	0.0015	1.4531	0.0058	9.4450	0.0750
Fs5	0.2667	0.0008	1.0258	0.0031	6.6675	0.0400
Fs6	1.0382	0.0006	3.9931	0.0023	25.9550	0.0300
Fs7	1.1337	0.0006	4.3604	0.0023	28.3425	0.0300
Fs8	1.4363	0.0007	5.5242	0.0027	35.9075	0.0350
Fs9	0.9127	0.0007	3.5104	0.0027	22.8175	0.0350
Fv10	0.7065	0.0009	2.7173	0.0035	17.6625	0.0450
Fv11	1.0986	0.0005	4.2254	0.0019	27.4650	0.0250
Fv12	0.8891	0.0006	3.4196	0.0023	22.2275	0.0300
Fv13	0.5311	0.0007	2.0427	0.0027	13.2775	0.0350
Fv14	0.5336	0.0006	2.0523	0.0023	13.3400	0.0300
Fv15	0.5745	0.0011	2.2096	0.0042	14.3625	0.0550
Fv16	0.4280	0.0006	1.6462	0.0023	10.7000	0.0300
Fv17	0.3897	0.0006	1.4988	0.0023	9.7425	0.0300
Fv18	1.0013	0.0005	3.8512	0.0019	25.0325	0.0250

***(1-9) Baby ready-made food consisting of grains, (10-18) Prepared baby food consisting of vegetables.**

It was noted through the results of **Table 3** that there is a variation in the concentrations of samples of elements between the types of baby foods and between the samples, as well as the variation between the elements in this study, which may be due to the variation in the components of these foods and their sources. [29] stated that crop plants have different abilities to absorb and accumulate heavy metals in their body parts and that there is a significant difference in mineral absorption and transition between plant species and even between varieties of the same plant species. This explains the different concentrations in these foods for the elements studied.

[30] indicated that the increase in the content of nutritional compositions is due to the absorption of heavy metals in the soil by different plants, such as vegetables, fruits, and cereals, or to the deposition of these minerals on the surfaces of plant parts, especially leaves. The results of the current study showed that the concentrations of all elements in grain-based foods are higher than those based on vegetables, and this is consistent with the results of their study.

The results of the current study (**Table 3**) indicated that Pb concentrations exceeded the determinants and Cd concentrations did not exceed the permissible determinants globally or locally. The appearance of these elements in ready-made baby food is fundamentally harmful to the body, and the continuous exposure to these concentrations by eating the same foods exposes children to health risks, especially since the nutritional requirements are large compared to their weight. This means that the increase in the accumulated elements is associated with the effectiveness of absorption by the intestine, targeting the kidneys, liver, and other vital organs, and this is consistent with what [31] indicated in his study of samples of ready-made foods obtained from local markets, stressing the necessity of the importance of quality of industry and origin.

At a probability level of 0.05, there were differences in the amounts of Pb and Cd in the samples that were studied. However, there were no significant differences in the amounts of these elements in the samples based on where they came from, which may be because of the presence of these elements and the difference in their concentrations.

Table 4 shows that the highest and lowest Pb levels in samples of baby foods made from cereals were 1.4363 ppm and 0.2667 ppm, respectively, with a mean of 0.9127 ppm. The highest and lowest Pb levels in samples of baby foods made from vegetables were 1.0986 ppm and 0.3897 ppm, respectively, with a mean of 0.5745 ppm. Cd in samples of baby foods prepared from cereals was (0.0015, 0.0006) ppm and the mean was (0.0007), and Cd in samples of baby foods prepared from vegetables was (0.0011, 0.0005) ppm and the mean was (0.0006). The number of samples above shows the permissible concentration (9) for each lead in children's foods consisting of cereals and vegetables was 100%, while cadmium did not exceed the concentrations of the limitations by 0%.

Table 4. Concentrations, mean and standard deviation in baby food.

	Concentrations of elements (ppm)			
	Baby foods prepared from vegetables		**Baby food prepared from cereals**	
	Lead	**Cadmium**	**Lead**	**Cadmium**
Highest concentration	1.4363	0.0015	1.0986	0.0011
Lowest concentration	0.2667	0.0006	0.3897	0.0005
Mean concentrations	0.9127	0.0007	0.5745	0.0006
Standard deviation	0.4340	0.0003	0.2562	0.0002
Number of samples examined	9	9	9	9
Number of samples above	9	0	9	0
allowed N%	%100	%0	%100	%0
Parameters	0.02	0.05	0.02	0.05

It was noted from **Table 4** that the rates of concentrations of elements in baby food consisting of cereals are greater than the rates of concentrations of elements and means in baby food consisting of vegetables, as shown in **Table 3**, and within the permissible global and local limits [32] and standard specification No. (1103) IQS first update (2020) issued by the Iraqi Ministry of Planning [33]. It was found that there was an increase in the permissible limits in lead-based cereal-based formulas compared to vegetable-based formulas in the current study. [34] confirmed in their study that this may be due to the range of processed substances with which the grains are treated for the purpose of making them more receptive to children.

The results of this study are consistent with many studies, such as the study of [35] they found that the highest concentration of lead was 0.2179 ppm, which are lower concentrations than we found in the content of the foods examined in the current study. [36] study of baby food with the highest mean concentration of lead (0.1190) ppm, while the results of [37] study are lower than the findings of the current study of Pb and Cd, as the highest concentrations of Pb and Cd (0.018, 0.023) ppm, respectively, for cereal-based baby foods and vegetable-based (0.002, 0.015) ppm, respectively. In other foods related to children, high concentrations of Pb and Cd were found, including milk and juices, and this indicates the danger of these elements to children [21; 42; 43; 44].

Table 5 shows (EDI) in ready-made baby food reached the highest and lowest values of Pb as follows: (1.0258, 5.5242) ppm respectively, and the mean was (2.8759) ppm, and Cd (0.0019, 0.0058) ppm and the mean was (0.0029) when examining 18 samples, and one of them exceeded the permissible limit in Pb but did not exceed the permissible limit for Cd in prepared baby foods. The results of **Table 5** also show that the highest and lowest values of the target risk quotient were in Pb (6.6675.35.9075) and the mean was (18.6933) and in Cd (0.0250.0.0750), and the mean was (0.0378).

Table 5. Pollution hazards of lead and cadmium in prepared baby food

Hazard	Element	mean±S.D	Range (ppm)
Daily intake (EDI)	Pb	1.3538±2.8759	1.0258-5.5242
(g/kg/d)	Cd	0.0010± 0.0029	0.0019-0.0058
Target hazard quotient	Pb	8.7996±18.6933	6.6675-35.9075
(THQ) indicator	Cd	0.0132±0.0378	0.0250-0.0750

Table 5 showed that there was an increase in the daily intake values of lead concentrations and no increase in cadmium concentrations. Harmful effects on the consumer may occur in the long term from the element cadmium despite the fact that its concentrations do not exceed the permissible limits, in addition to the harmful health effects on the body from the element lead due to exceeding the permissible concentrations. Health harms are felt when the index is (1< THQ) and health harms are imperceptible when the index is (THQ<1). The results of the current study are lower than those of [38; 39; 40; 41].

4. Conclusions

It is concluded from the current study that there is pollution with lead and cadmium and levels of perceptible and imperceptible risk to consumer health in ready-made baby food. Most of them are from different international origins, including locally made. Children must be protected from them because they pose a danger when consumed, so these products must be prevented, and the necessary ways must be found to reduce or eliminate them, find appropriate alternatives to these foods, and find appropriate solutions to get rid of these contaminants of heavy metals in these products.

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