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Original Article

Occurrence of Lead and Cadmium in some Baby Foods and Cereal Products

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Abstract

Lead and cadmium poisoning can cause health problems, especially in the case of children. In this research, the distribution of the two heavy metals of high concern for human health was measured in several baby-food products; lead and cadmium were determined using atomic absorption spectrophotometry, measurements being performed using a Shimadzu AA-6300 double beam atomic absorption spectrophotometer with graphite furnace, equipped with deuterium lamp for background correction. 63 different baby-food and cereal products were investigated for their lead and cadmium content; in 49.21% from the samples were recorded levels of lead concentrations in the range 0.32-10.64 $\mu g.kg^{-1}$, for the other 50.79% lead being under the limit of detection (LOD), while for cadmium more than 85% from samples ranged between 0.3 to 10.37 $\mu g.kg^{-1}$ and for less than 15% of samples cadmium was under LOD. In milk powder, lead levels ranged from 0.85 to 7.26 $\mu g.kg^{-1}$, with 68% samples under LOD, while cadmium concentrations ranged from 0.1 to 4.75 $\mu g.kg^{-1}$, 18% samples having cadmium under LOD. Cereal based-products proved to be contributing most to infants' and small children's exposure with the studied heavy metals; however, none of the obtained data is higher than the maximum allowed levels according to Commission Regulation (EC) No 1881/2006.

Keywords: heavy metals, contamination, baby food, lead, cadmium, AAS.

1. Introduction

Lead and cadmium poisoning can cause brain damage and other problems, especially in the case of children, hence the European Commission established maximum levels for these elements in foodstuffs [17]. Infants are especially sensitive to heavy metals' toxicity as a result of rapid growth, immaturity of internal organs and the vulnerability of the central nervous system; their small mass and developing systems, including brain development may show adverse health effects from even low levels of contamination on a chronic exposure [4, 9, 13, 18, 19].

Heavy metal content surveys of baby foods are of growing concern mainly because of the need to monitor infants' exposure to such elements from the diet [7, 12, 14]. Contaminated food is the most important source of lead and cadmium exposure; especially vegetables with a high leaf area such as spinach or lettuce can contain high lead levels when grown in a contaminated environment; cadmium is easily absorbed by vegetables, reaching quite high concentrations in wheat, rice, oysters, mussels, etc. [13]. Foods, baby foods formula, milk, powder milk and water provide significant exposure routes for metal contaminants [7, 9, 16, 19]; these exposure vectors may contain metals from plants grown in contaminated soil or introduced during the manufacturing process [3, 5, 10].

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High concentrations of these heavy metals in milk and in the milk powder can be a consequence of contaminated cattle fodder or of animal ranches around polluted area [2, 6].

Short-term exposures to low levels of such elements may have no immediate negative health effects, but their accumulation after long-term exposures can adversely influence the physiological functions, especially in the case of vulnerable individuals such as infants and children. Lead is toxic for brain, kidney and reproductive system and can also cause impairment in intellectual functioning and infertility; chronic exposure is usually associated with renal and hepatic tissue damage and function impairment, while lead exposures in school-aged children has been associated with aggressive behavior and attention disorders.

Chronic cadmium exposure has negative effect on kidneys, heart, lungs, bones, gonads, the main long-term effect of exposure to low cadmium concentration being emphysema and kidney insufficiency, reproduction problems, cardiovascular diseases and hypertension; the teratogenic and mutagenic effects of cadmium were also proved [4, 9, 15].

As both lead and cadmium occurs in baby foods at trace levels, analytical techniques with high sensitivity are required for their detection, such as electrothermal atomic absorption spectrometry [8, 14], inductively coupled plasma-atomic emission spectrometry [1], microchip electrophoresis [11].

In this research, the distribution of lead and cadmium was measured in several commercially-available baby-food products using electrothermal atomic absorption spectrometry, being then compared with maximum allowed amounts.

2. Material and Method

Nitric acid was from Merck, while hydrogen peroxide, cadmium and lead standards for atomic absorption spectroscopy were from Fluka, both standard solutions containing 1000 mg/L metal in nitric acid. Ultrapure water with a specific resistance of 18.2 Mµ/ cm was obtained from a Direct Q 3UV Smart (Millipore).

Baby foods samples of different brands were purchased from local supermarkets. Around 0.5 g homogenized samples were accurately weighed and transferred in Teflon reaction vessels, then 5 mL of HNO_3 65% and 3 mL of H_2O_2 were added; wet digestion using a Berghoff Microwave Digestion System MWS-3+ was used in all cases to obtain clear solutions. After cooling, the digested solutions were transferred in 5 mL volumetric flask and diluted with 1% HNO_3. To prevent contamination with lead and cadmium, all glassware was thoroughly washed with nitric acid, then rinsed with ultrapure water.

Measurements were performed using an AA-6300 – Shimadzu double beam atomic absorption spectrophotometer (Shimadzu Corporation, Japan) with graphite furnace atomization, equipped with deuterium lamp for background correction and hallow-cathode lamps for each of the studied elements, as well as with an ASC-6100F autosampler, data acquisition and processing software. Calibration curves were prepared using five concentrations, the linear correlation coefficients obtained ranging between 0.9900-0.9958. The standard operation conditions were those recommended for each metal in the instrument's method; all measurements were carried out in triplicates.

Instrument control, spectrophotometric data acquisition and analysis were accomplished using WizAArd software (Shimadzu Corporation, Japan); data were processed in Excel 2003 (Microsoft).

3. Results and Discussions

63 different baby-food products were investigated for their lead and cadmium content, tabs 1 and 2 summarizing the obtained results; from these, cereal based-products proved to be contributing most to exposure of infants and small children with the studied heavy metals.

Table 1. Cadmium concentrations [$\mu g.kg^{-1}$]

Sample type	Average	Min	Max	Nr. of samples	Nr. of samples < LOD
Cereals	4.21	0.30	10.37	15	3
Cereals with fruits	3.71	2.43	4.46	3	0
Cereals with yoghurt	3.21	1.93	5.29	3	0
Cereals with milk	4.40	2.08	6.88	3	0
Cereals with honey	1.89	1.62	3.79	4	1
Cereals with rice	2.92	0.98	5.23	4	0
Milk powder	1.94	0.10	4.75	22	4
Baby foods (misc.)	3.11	0.99	8.66	9	1

Cadmium was more frequently observed in cereals based samples as compared to other baby foods.

In 49.21% from the samples were recorded levels of lead concentrations in the range 0.32 - 10.64 μg.kg^{-1}, for the other 50.79% lead being under LOD. For cadmium more than 85% from samples ranged from 0.1 to 10.37 μg.kg^{-1} while for less than 15% of samples cadmium was under LOD.

Table 2. Lead concentrations [μg.kg^{-1}]

Sample type	Average	Min	Max	Nr. of samples	Nr. of samples < LOD
Cereals	3.24	3.88	10.64	15	9
Cereals with fruits	2.47		7.42	3	2
Cereals with yoghurt	2.87	0.32	8.29	3	1
Cereals with milk	0.63		1.90	3	2
Cereals with honey	1.08		4.31	4	3
Cereals with rice	5.71	3.16	9.70	4	0
Milk powder	1.03	0.85	7.26	22	15
Baby foods (misc.)	0.35		3.16	9	8

In milk powder lead levels ranged from 0.85 to 7.26 μg.kg^{-1}, with 68% samples under LOD, while cadmium concentrations ranged from 0.1 to 4.75 μg.kg^{-1}, 18% samples having cadmium levels under LOD.

From the analyzed samples, both cadmium and lead concentrations were simultaneously under LOD for 2 cereal brands, 4 milk powder brands and 1 baby food brand.

4. Conclusions

Heavy metals, such as lead and cadmium, can be hazardous to human health, especially in the case of sensitive populations such as children. Therefore foods that provide significant exposure should be closely monitored to ensure that concentrations of elements that might be hazardous should be very low.

This study concluded that although most of all investigated baby food brands contain lead and cadmium, none of the measured concentrations is higher than the maximum allowed levels according to Commission Regulation (EC) No 1881/2006 (20 μg.kg^{-1} in infant formulae and 200 μg.kg^{-1} in cereals for lead and 100 μg.kg^{-1} in cereals for cadmium).

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