Study of the Presence of Lead in a Series of Foods of Plant Origin

MIHAI APOSTU, GLADIOLA TANTARU, MADALINA VIERIU*, NELA BIBIRE, ALINA DIANA PANAINTE
Grigore T. Popa University of Medicine and Pharmacy Iasi, Faculty of Pharmacy, Department of Analytical Chemistry, 16 Universitatii Str., 700115 Iasi, Romania

The objective of the study was to evaluate the presence of lead in several food products of plant origin. An atomic absorption spectroscopic quantitative method for the analysis of Pb^{+2} was developed and validated using an Analytik Jena ContrAA 300 apparatus equipped with an air-acetylene flame and a high-resolution continuum source. The analyzed food products were wheat, wheat flour, onions, corn, corn flour, carrots, beans, potatoes and cabbage grown in three geographical areas, on three soil types. The results obtained were in line with the limits laid down in Commission Regulation (EC) No 1881/2006 - Consolidated acts as far as the maximum admissible level of Pb^{+2} in foods.

Keywords: lead, food products, soil types, AAS

The toxicity of heavy metals is a less common medical condition, yet clinically relevant, which improperly treated may result in significant morbidity and mortality. Some heavy metals in small quantities are essential for the body in different biochemical processes but become toxic at higher levels [1-4]. Heavy metal poisoning may harm almost all organs. The severity of the damage depends on the metal involved, the pathway they enter the body, the age of the individual and the level of toxicity [5]. Heavy metals may enter the body orally, through ingestion of contaminated food [6-10] and water [11, 12].

Lead is a heavy metal that produces toxic effects after accumulation of more than 30ìg per deciliter of blood in subjects over age 15 [13, 14]. Its accumulation may cause disruption of hemoglobin synthesis [15, 16], kidney, gastrointestinal tract and reproductive system damage [17-21], plus acute or chronic effects on the nervous system [21, 22].

Given the high toxicity of this element, this study aims to estimate the lead content in different types of food of plant origin.

Experimental part

The conducted studies required the development and validation of a method for the quantitative determination of lead using atomic absorption spectroscopy (AAS). The foods analyzed were wheat, wheat flour, onions, corn, corn flour, carrots, beans, potatoes and cabbage grown in three geographical areas [23-30].

The study was carried out on an Analytik Jena ContrAA 300 apparatus equipped with an air-acetylene flame and a high-resolution continuum source. The procedure characteristics were optimized according to the manufacturer's recommendations (table 1).

Table 1
PROCEDURE CHARACTERISTICS

Metal	Pb
λ_{max} (nm)	217.00
Burner (mm)	50
Flame type	C_2H_2/air
Acetylene/air flow (L/h)	65

All reagents used were analytical grade, and the glassware was pretreated with 10% HNO_3 and rinsed with double-distilled water to prevent contamination. All necessary solutions used during determinations were prepared by diluting a 1.0 g/L Pb^{+2} commercial standard solution (Fluka, Germany) with double-distilled water and stored in polypropylene bottles.

The most important validation parameters of the AAS analysis method of Pb^{+2} are presented in table 2, and the calibration curve can be observed in figure 1. LOD and LOQ were calculated based on the standard deviation and the slope of the regression line.

Table 2
VALIDATION PARAMETERS

Cation	Pb^{+2}
Linearity range	2.0-10.0 μg/mL
Regression equation	y = 0.0147x + 0.0067
Correlation coefficient (R^2)	0.9991
Slope	0.0147 μg/mL
Standard deviation (σ)	0.001578
LOD	0.3220 μg/mL
LOQ	1.0734 μg/mL

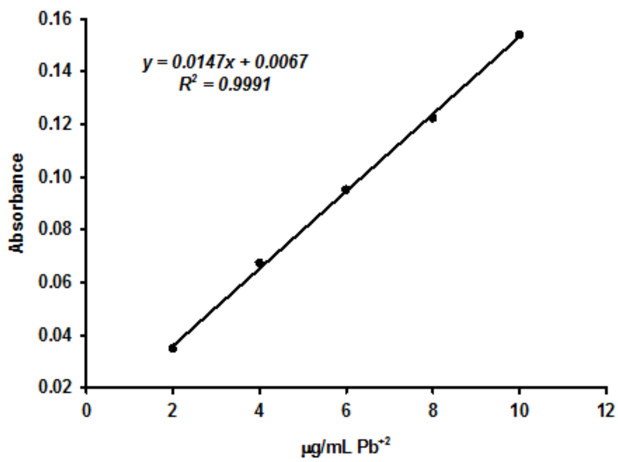

Fig. 1. Calibration curve

Digestion of the vegetal material: 20 g of vegetal material was mixed with 10 mL of concentrated HNO_3 and 2.5 mL of 70% $HClO_4$ and allowed to rest for 24h. The resulting mixture was heated on a water bath until complete mineralization. After cooling, double-distilled water was added and then it was heated to remove the nitrous vapor and to reach a low volume (0.5-1.0 mL). When the solution darkened or became yellow during disaggregation, a few drops of HNO_3 or $HClO_4$, respectively, were added. Then 5 mL double-distilled water and 10 mL of 5M HCl solution were added to the solution, and its volume was reduced

* email: vieriu_madalina@yahoo.com

again to 10 mL. In the end it was filtered and double-distilled water was added up to 50 mL.

Results and discussions

The accuracy of the assays, expressed as the consistency between the real value and the analytical result, was verified using the standard addition method. The results obtained and the calculated recovery is shown in table 3. The analysis of the results emphasized a recovery in between 97.50% and 103.00%.

For the assay of Pb^{+2} levels in foods, the following types of foods were analyzed: wheat, wheat flour, onions, corn, corn flour, carrots, beans, potatoes, cabbage. The results of the determinations were expressed as μg Pb^{+2}/1000 g of plant product (weighted arithmetic mean).

Food products were sampled from various localities in three areas, grouped by soil types:

- levigant soil in Moldavian Plain (soil I): Fantanele (Iasi), Plopeni (Suceava), Havarna (Botosani), Dorohoi (table 4);
- meadow soil in Siret and Barlad Valley (soil II): Marasesti, Bacau, Pascani, Focsani, Tecuci, Roman, Siret (table 5);
- forest brown soil in sub-Carpathian area and Suceava Plateau (soil III): Piatra Neam, Targu Neamt, Husi, Vladeni (Iasi) (table 6).

The average values of Pb^{+2} content as μg/1000 g of fresh vegetable product, by soil and food type, were plotted in figure 2 (1 - corn, 2 - wheat flour, 3 - wheat, 4 - corn flour, 5 - beans, 6 - cabbage, 7 - carrots, 8 - potatoes, 9 - onions).

Commission Regulation (EC) No 1881/2006 - Consolidated acts, recommends the maximum permitted level of Pb^{+2} in foods: 0.20 mg Pb^{+2}/1000 g fresh beans and cereals (wheat, corn), 0.10 mg Pb^{+2}/1000 g fresh onions, carrots, potatoes and 0.30 mg Pb^{+2}/1000 g fresh vegetables of the *Brassicaceae* family (cabbage) [31. None of the foods studied exceeded those recommended limits.

N°	Sample	μg Pb^{+2} added (a)	μg Pb^{+2} found (b)	b - a subtraction	Recovery (%)
1.	wheat	-	2,12	-	-
2.	wheat	1.00	3.14	1.02	102.00
3.	onions	-	2.02	-	-
4.	onions	1.00	3.05	1.03	103.00
5.	corn	-	2.60	-	-
6.	corn	2.00	4.55	1.95	97.50
7.	carrots	-	2.50	-	-
8.	carrots	2.00	4.54	2.04	102.00
9.	beans	-	2.10	-	-
10.	beans	3.00	5.08	2.97	99.00
11.	potatoes	-	2.25	-	-
12.	potatoes	3.00	5.30	3.05	101.66
13.	cabbage	-	2.00	-	-
14.	cabbage	4.00	5.98	3.98	99.50

Table 3
ACCURACY OF Pb^{+2} DETERMINATION IN FOODS

Table 4
Pb^{+2} LEVELS AS μg/1000 g PLANT PRODUCTS FROM LEVIGANT SOIL

N°	Sample	Dry product	Fresh product
1.	wheat	90.2	79.0
2.	wheat flour	126.0	114.0
3.	onions	90.0	10.9
4.	corn	135.1	110.0
5.	corn flour	76.2	57.7
6.	carrots	92.5	49.9
7.	beans	102.5	90.0
8.	potatoes	86.6	12.9
9.	cabbage	68.0	57.2

Table 5
Pb^{+2} LEVELS AS μg/1000 g PLANT PRODUCTS FROM MEADOW SOIL

N°	Sample	Dry product	Fresh product
1.	wheat	136.6	134.0
2.	wheat flour	142.3	127.1
3.	onions	45.7	10.2
4.	corn	153.0	123.5
5.	corn flour	146.2	133.4
6.	carrots	109.0	33.5
7.	beans	137.2	104.6
8.	potatoes	63.8	13.9
9.	cabbage	97.5	85.8

Table 6
Pb^{+2} LEVELS AS μg/1000 g PLANT PRODUCTS FROM FOREST BROWN SOIL

N°	Sample	Dry product	Fresh product
1.	wheat	185.6	154.7
2.	wheat flour	197.2	161.2
3.	onions	59.0	10.2
4.	corn	202.3	164.0
5.	corn flour	184.6	150.0
6.	carrots	115.0	44.7
7.	beans	158.7	130.0
8.	potatoes	72.2	17.2
9.	cabbage	109.0	83.6

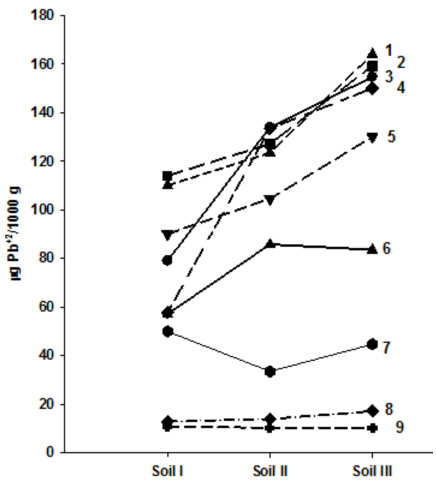

Fig. 2. The average values of Pb^{+2} levels

Conclusions

In the study it was established that the assimilation of Pb^{+2} by plant foods was very variable, even for the same type of food. Just as it was stated in literature, it varied based on the geochemical conditions, soil pollution, local level of industrialization, etc.

Pb^{2+} levels in fresh product, had the highest values for foods harvested from forest brown soil and meadow soil (except for carrots) while the lowest levels were found in levigant soils.

Out of all the products studied, cereals and beans contained the highest Pb^{+2} levels, unlike carrots, potatoes and onions that assimilated the least amount of cation.

None of the foods studied exceeded the limits recommended by the European Commission Regulation (EC) No 1881/2006 - Consolidated acts.

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