HEAVY METAL LEVELS IN FOOD INGESTED IN NATAL, RN, BRAZIL

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ABSTRACT

The levels of Cadmium, Lead, Copper, Chromium, Nickel and Zinc were determined through atomic absorption spectrophotometry in the most consumed food in the Northeast of Brazil (according to the POF survey of 2008-2009): beans, rice, and solution of coffee. The results were compared to the maximum limits of tolerance (LMs) stablished by law, and revealed that only Zinc was above the LMs, while the other metals were within the limits. Zinc is also a micronutrient essential for the proper functioning of the human body and its toxicity depends on its total daily intake. Therefore, this study points to the relevance of food frequency consumption as a factor to be taken into consideration towards intoxication by food ingestion.

KEYWORDS: Food Contamination. Toxic metals. Daily intake.

NÍVEIS DE METAIS PESADOS EM ALIMENTOS CONSUMIDOS EM NATAL/RN/BRASIL

RESUMO

Foram determinados os níveis de Cádmio, Chumbo, Cobre, Cromo, Níquel e Zinco em alimentos mais consumidos no nordeste do Brasil (segundo o levantamento da POF 2008-2009): feijão e arroz e solução de café. Utilizou-se a espectrofotometria de absorção atômica. Os resultados foram comparados aos respectivos limites máximos de tolerância (LMs) estabelecidos por lei para os referidos alimentos. Os resultados revelaram que apenas os níveis de Zinco estavam acima LMs, enquanto os demais estavam de acordo com os níveis estabelecidos pela legislação. O zinco é também um micronutriente indispensável para o bom funcionamento do corpo e sua toxicidade depende de sua ingestão diária total. Portanto, este estudo aponta para a questão da frequência de consumo alimentar de uma população como fator importante a ser observado quanto a elevação do grau de contaminação por ingestão de alimentos.

Palavras-chave: Contaminação de Alimentos. Metais tóxicos. Ingestão diária.

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1 INTRODUCTION

The chemical contamination of food occurs since production until the costumer's table. This is due to the exposition level to residual contaminants in water, soil, and air, occurring directly, indirectly and/or accidentally by various biological, physical and chemical agents(MINISTÉRIO DA SAÚDE, 2013; FAO, 2011; FORSYTHE, 2002; SILVA JR., 1995).

The effects of the chemical contaminants in the human organism may be triggered after a long period (chronic), by the continuous accumulation through time, or in after a short period (acute), when the symptoms appear rapidly a few hours after the excessive exposition to highly toxic products (STOPPELLI; MAGALHÃES, 2005).

Some of the main chemical hazards found in food are toxic metals, being the most frequent intoxications triggered by the accumulation of aluminum, arsenic, barium, beryllium, cadmium, lead, mercury and nickel—highly reactive and bioaccumulative chemical elements. Some of the effects in the organism are skin rashes (eczema), gastrointestinal, respiratory, neurologic and cardiovascular diseases, besides effecting the bone narrow, kidneys, brain and reproductive system and even leading to several types of cancer (EVANGELISTA, 2005; CHAVES, 2004; MUSTRA, 2009; VIRGA; GERALDO; SANTOS, 2007).

These metals accumulate in the bone and fat tissue, leading to changes in cell structures, suppressing the immune system and causing important lesions. It is known that one of the main toxic metal's access ways to the human body is through the ingestion of vegetables containing high concentrations of these elements (GUERRA, 2011).

The intoxication by metals expresses itself in many ways, and the toxicity degree also varies greatly. Some of them are essential to life, and others may lead to death. A study about toxic metal effects to human health provided a long list of symptoms, such as irreversible nervous and cerebral alterations, pulmonary fibrosis and edema, kidney diseases, systemic hypertension (high blood pressure), decrease in antibody production, anemia, decrease of testosterone, gastrointestinal bleeding, hematuria (presence of red blood cell in urine), acute renal failure, hepatic intoxication, headache, nausea, vomit and diarrhea, skin reaction due to contact, respiratory diseases, throat irritation, coughing, weakness, generalized pain and others (ESTEVES et al., 2000; MELO, 2008; TAVARES, 2010; WORLD HEALTH ORGANIZATION, 2004; RESIMAPI, 2011).

The ingestion of food containing toxic metals has been a concern once it represents a danger to public health. Therefore, researches aiming on the chemical control of food provide technical support to the inspection and/or investigation of epidemics, besides evaluating theproducts through food quality monitoring programs.

This research aimed to evaluate the levels of the toxic metals Cadmium, Lead, Copper, Chromium, Nickel and Zinc in the most consumed food in the city of Natal, RN, Brazil, (beans, rice, and solution of coffee) since these metals are bioaccumulative. The investigations were conducted through atomic absorption spectrophotometry and the results were compared to the maximum limits of tolerance (LMs) for inorganic contaminants stablished by law.

2METHODS

2.1 Sampling

The food items for analysis of toxic metals were selected based on the food consumption frequency factor of the POF 2008-2009, which is a household budget survey conducted by the IBGE (2011) that provides an analysis of the food intake of Brazil's population over 10 years old using a Personal Food Intake Diary, in which each resident records, in two non-consecutive days, all the food eaten in and out of the household, in the urban and rural areas of the entire country, during the 24 hours of the day. From this data, a triage table (Table 1) was created isolating the 10 (ten) most consumed food items of the Northeast of Brazil.

Table 1: Most consumed food items in the Northeast of Brazil

MOST CONSUMED FOOD ITEMS PER CAPITA (g/day)		
Ranking	**Food item**	**Northeast (g/day)**
1º	Coffee (solution)	230.4
2º	Beans	152.0
3º	Rice	142.6
4º	Juice/refreshments drinks/powdered soft drinks	134.7
5º	Soups and broths	60.1
6º	Sodas	59.4
7º	Bovine meat	57.1
8º	*Pão de sal*(a popular roll in Brazil)	56.1
9º	Corn and corndishes	50.9
10º	Poultry	41.7

Source: POF 2008-2009 (IBGE, 2011).

Based on the Table 1, the three most consumed food items in the Northeast were listed as: solution of coffee, beans and rice. The Table 2 presents the description and the codes for the three samples (popular brands in the market) for each item selected.

The items were acquired in an establishment of a popular supermarket chain in Natal, RN, Brazil, and transported to the Laboratory of Technology of Surfactants of UFRN, where the samples were kept in the same conditions as when acquired. For the analysis, only the items that had intact packaging and that were within the expiration date were acquired.

Table 2: Description and codes of the analyzedsamples

DESCRIPTION OF THE SAMPLES		
Food item	**Description**	**Code**
Coffee	Darkroasted and ground.	Coffee A
	Traditional; roasted and ground.	Coffee B
	Family; roasted and ground.	**Coffee C**
Beans	Black, Type 1; Regular beans.	Bean A
	Pinto beans (*carioca*), Type 1; Regular beans.	Bean B
	White beans/Cowpea; Type 2.	**Bean C**
Rice	Parboiled; Type 1; Long grain rice.	Rice A
	Parboiled; Type 1; Long grain rice.	Rice B
	Parboiled; Type 1; Long grain rice.	Rice C

Source: Elaborated by the author (2015).

2.2 Sample preparation

The beans and rice were ground in the Food Technology and Dietetics of UNI-RN using a high rotation speed blender,model TA-02, Skymsen®. The samples of coffee did not require processing once they were already in a powder form. After the processing, polyester mesh sieves with polypropylene structure were acquired, washed with detergent, rinsed, and used to sift the samples. The granules that did not transpose the sieve of finest mesh were discarded.

The powdered samples were kept in nontoxic plastic recipients of which the material was 100% virgin. The recipients were acquired exclusively for this purpose, and before used for storing the sample, they were washed with detergent and rinsed with distilled water.

All the samples were digested/solubilized following the wet digestion method recommended by the Adolfo Lutz Institute (2008; 1985): a Becker is heated to 70ºC in a hot plate for 1 hour. One gram of the sample is weighted, adding 25 mLof HNO_3 P.A. and 50 mL of deionized H_2O. The solutions are transferred to 100 mL volumetric flasks, reaching the final volumes. Paper filter is used while transferring the solutions to the volumetric flasks for ensuring the absence of insolubilized parts.

All the samples prepared were entirely digested. The coffee, rice and bean samples were weighted in an analytical scale *Precisa®* 240A.

2.3 Heavy metal analysis in food

The analysis of metals in the selected samples were conducted through Atomic Absorption Spectrophotometry (AAS), utilizing an Atomic Absorption Spectrophotometer (VARIAN – SPECTRAA – 10PLUS). In this analysis the sample is aspirated to a flame and then atomized. The solution of the metal in study is vaporized in the flame and is uniformly distributed in small droplets, forming what is called aerosol (MELO, 2008; APHA, 1995; GONÇALVES, 1990).

The standard operational conditions for the analysis are determined according to the equipment specifications. The calibration curves for each metal analyzed were prepared from 1.000 mg/L standard solutions forCd, Pb, Cu, Cr, Zn analytical solutions, and a 2.000 mg/L standard solution was used to prepare the Ni analytical solution. The points of the calibration curves were chosen according to the detection limits specified by the equipment manual (VARIAN – SPECTRAA – 10PLUS).The calibration curves of absorbance by the concentration of the standard solutions presented the following correction coefficients R^2: 0.9941 (Cd), 0.9866 (Pb), 0.9589 (Cu); 0.9993 (Cr); 0.9923 (Ni), and 0.9987 (Zn).

The results of the analysis were compared to the maximum limits of tolerance (LMs) for heavy metals in food, stablished by the legislation in Brazil(BRASIL, 2013; BRASIL,1965). The LMsare shown in the Table 3. The software Microsoft Excel 2013 was used for the descriptive statistics of the results.

Table 3 – Maximum Limits of Tolerance (LMs)for heavy metals in the selected samples

MAXIMUM LIMITS OF TOLERANCE (LMs) FOR INORGANIC CONTAMINANTS						
	Metal concentration (ppm)					
Food item	**Cadmium***	**Lead***	**Copper****	**Chromium****	**Nickel****	**Zinc****
Coffee	0.10	0.50	30	0.10	5.0	50
Beans	0.10	0.20	30	0.10	5.0	50
Rice	0.40	0.20	30	0.10	5.0	50

Source: *BRASIL (2013); **BRASIL (1965).

3 RESULTS AND DISCUSSION

The levels of Cadmium, Lead, Copper, Chromium, Nickel and Zinc were determined in samples of Coffee (solution), beans and rice (Table 4). The results showed conformity of the levels found with the maximum limits of tolerance (LMs) stablished by law (Tables 3 and 4), except for the concentrations of Zinc found in the samples of coffee and beans which were twice the LMs for this metal.

Among the metals analyzed, cupper presented the lowest percentage in the samples, with 0.003 ppm which corresponds to 0.01% of its LM. Although the levels of Nickel and Lead were similar, around 0.01 ppm, their percentages in relation to their LMs were different: 0.2% of the LM for Nickel and 2% of the LM for Lead. In the investigation of Cadmium was found a concentration of 0.02 ppm which corresponds to 20% of its LM.

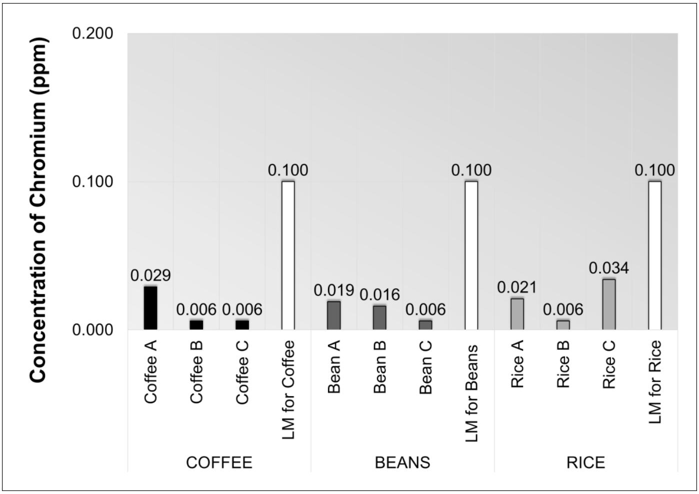
Higher concentrations of Chromium and Zinc were found. The Figures 1 and 2 present the comparative graphs of the metal levels (in ppm) found in the food samples and their LMs. While Chromium reached maximum concentration of 0.029 ppm (29% of the LM) in the sample of coffee, 0.016 ppm (16% of the LM) in the samples of beans and 0.021 ppm (21% of the LM) in the samples of rice, Zincsurpass all the LMs, with 102.0 ppm (204% of the LM) in the samples of coffee café, 51.4 ppm (102% of the LM) in the samples of beans and 100.5 ppm (201% of the LM) in the samples of rice.

Table 4 – Analysis results and maximum limits of tolerance

ITEM	CODE	CONCENTRATION IN PPM (mg/L)					
		Cadmium	Lead	Copper	Chromium	Nickel	Zinc
Coffee	Coffee A	<0.02	<0.01	<0.003	0.029	<0.01	74.9
	Coffee B	<0.02	<0.01	<0.003	0.006	<0.01	102.0
	Coffee C	<0.02	<0.01	<0.003	0.006	<0.01	99.9
	LMs	**0.1**	**0.5**	**30**	**0.100**	**5**	**50.0**
Beans	Bean A	<0.02	<0.01	<0.003	0.019	<0.01	51.4
	Bean B	<0.02	<0.01	<0.003	0.016	<0.01	46.2
	Bean C	<0.02	<0.01	0.003	0.006	<0.01	43.8
	LMs	**0.1**	**0.2**	**30**	**0.100**	**5**	**50.0**
Rice	Rice A	<0.02	<0.01	0.003	0.021	<0.01	68.0
	Rice B	<0.02	<0.01	0.003	0.006	<0.01	100.5
	Rice C	<0.02	<0.01	0.003	0.034	<0.01	68.6
	LMs	**0.4**	**0.2**	**30**	**0.100**	**5**	**50.0**

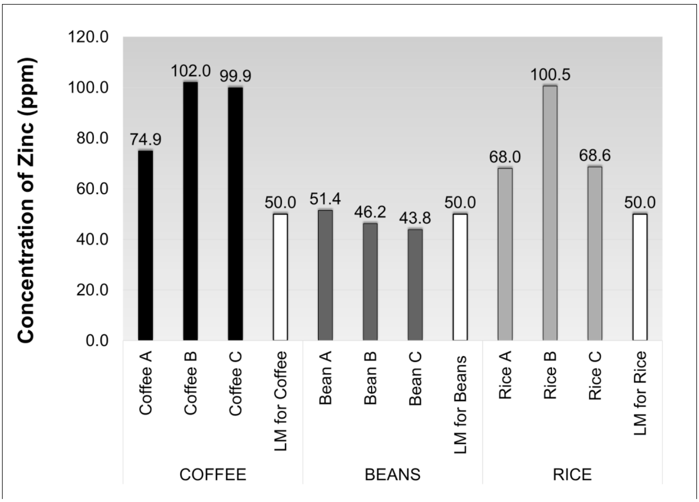
Source: Elaborated by the author (2015).

Figure 1: Levels of Chromium versus maximum limits of tolerance (LMs) per food item analyzed



Source: Elaborated by the author (2015).

Figure2: Levels of Zinc versus maximum limits of tolerance (LMs) per food item analyzed



Source: Elaborated by the author (2015).

It is important to keep in mind that Zinc is a micronutrient necessary on various biological functions and that it is found in a wide variety of food, such as oysters, bovine meat, chicken liver, turkey's dark meat, beans, wheat germ and yeast (CAMBIAGHI, CASTELLOTTI, 2004). However, a higher concentration o Zinc in the organism may lead to undesirable symptoms that can even be threatening to health, such as high sensitivity to sweet tastes, throat irritation, coughing, weakness, generalized pain, chills, fever, nausea and vomit(MELO, 2008).

Although the metals Cd, Pb, Cu, Cr e Ni were found in concentrations below the LMs, it is necessary to consider that these levels may be easily reached and surpassed depending on the food frequency consumption of the population, due to the fact that these elements are bioaccumulative.

4 CONCLUSIONS

It was verified from the comparison of the analysis results of the metals with the maximum limits of tolerance (LMs) stablished by law that only the levels of Zinc were above the LMs regulated by ANVISA— The National Health Surveillance Agency in Brazil. These finding should be interpreted considering that Zinc is an essential metal available in various food sources, becoming potentially toxic when its ingestion it higher than its Tolerable Upper Intake Level (UL), which means the ingestion has exceeded the average consumption considered as safe.

The findings of this study show an important degree of accordance regarding the levels of toxic metals in samples of the most consumed food in Natal, RN, Brazil, but also points to the relevance of food frequency consumption as a factor to be taken into consideration towards intoxication by food ingestion.

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