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Determination of Cadmium Concentration in Eight Nigerian Food Samples from Some Selected Markets using Atomic Absorption Spectrophotometric Method

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ABSTRACT

This study investigates the presence of cadmium in eight Nigerian food samples from Oja Oba, Ojuwoye and Kuto markets in Kwara, Lagos and Ogun State respectively. The food samples were analyzed using atomic absorption spectrometer. The results obtained revealed that cadmium was present in all the food samples that were analyzed at different concentration ranging from 0.001 ppm to 0.007 ppm. The results showed a permissive concentration of cadmium in the food samples as compared to FAO/WHO Expert Committee on food additives (EFSA, 2012) weekly limit of 2.5 µg/kg body weight. Since trace amount of cadmium is expected in almost all food samples due to natural conditions, it is necessary to pay close attention to cadmium contamination in food samples as continuous intake of food containing cadmium is dangerous to health.

1. Introduction

Cadmium is a metallic element best known for its high toxicity and carcinogenicity. Like all heavy metals, it accumulates in the bodies of most organisms (including humans). Although the kidneys and liver can convert most cadmium that enters the body into a form that is not harmful, too much overload may cause toxicity even at very low concentration [1]. Several cases of human disease, disorders, malfunction and deformity of organs due to metal toxicity have been reported [2]. Environmental pollution of heavy metals commonly arises from the purification of the metals such as smelting of copper, preparation of nuclear fuels and electroplating. Unlike organic pollutants, they do not decay and thus pose a different kind of challenge for remediation [3]. Cadmium is present in the environment in form of either an elemental substance (metal) or salts (e.g., cadmium sulfate, chloride, and oxides) even in areas remote from cadmium emission and it can also build up through atmospheric deposition and the use of Cadmium-containing fertilizers [4]. Large concentration of heavy metals such as lead, zinc and cadmium in soil has adverse effect on human due to their toxic effects on plants resulting to the uptake of the metals by garden and yard plants grown on contaminated soil which are then consumed by humans. Breathing of contaminated soil, dust particles and direct contact on the skin pose potential harmful effects particularly on children [5]. The level of cadmium contamination in soil varies in different regions/area and food is the major source of cadmium exposure in human [6]. The level of cadmium in diet varies depending on both the concentration of cadmium in the soils and the category of agricultural/aquatic products. Cadmium can be taken up through a process called bioaccumulation by crops and aquatic plants such as rice, vegetables, seaweed and so on, or be absorbed by livestock/poultry/aquatic animals and accumulated in the gastrointestinal systems. Thus, the level of cadmium in crops, in the organs of livestock/poultry, and in aquatic animals and plants is equal to the concentration of cadmiun in the environment [7].

Cadmium is one of the most mobile elements among all toxic heavy metals. Because of its high mobility in soil, the bioaccumulation of cadmium in plant-based food is usually high compared to the other trace elements. In contrast to cadmium, lead has low transfer coefficients and is strongly bound to soil colloids. Studies have reported that the accumulation of lead in plants occurs only when a high concentration of lead is found in the soil. Historically, cadmium caused the infamous itai-itai disease in the 20th century in Japan, which caused softening of the bones, severe pain, and kidney failure [8]. Though new typical cases of this disease have not been reported for decades, a few studies suggest that the dietary exposure to cadmium through food is currently high enough to pose a potential hazard to human health in many areas [9]. Recent data on risk assessment of cadmium exposure in human populations indicates increased risk of cancer in relation to cadmium exposure even at low levels [10-12], with females being more susceptible [13]. Toxicological studies on cadmium indicate that its exposure may cause increased gene mutation [14] and other epigenetic effects in humans, endpoints commonly recognized as mechanisms of carcinogenesis [15]. Evidence shows that exposure to cadmium is positively associated with cancer in the kidneys and prostate [16]. Cadmium and its compounds have been classified by the International Agency for Research on Cancer as group 1 (human) carcinogens, based on sufficient evidence for their carcinogenicity in animals and induction of cancers in humans [12]. When cadmium replaces zinc and other metals in the vital genetic functions in the body, it often leads to defective genetic expression related to birth defects. Cadmium hardens and toughens the tissues and ages the body, it is also associated with low sperm counts, impotence in men and reduce fertility in women [17].

According to the Integrated Risk Information System provided by the U.S. Environmental Protection Agency in 2015, chronic oral exposure of humans to cadmium results in a build-up of cadmium in the kidneys that can cause kidney diseases [18]. Cadmium-associated kidney disorders include kidney stone formation and proteinuria [19]. In the liver, cadmium may bind to metallothionine, and the bound form of cadmium may spread through the blood flow to various organs/tissues; in particular, it may be selectively accumulated in the kidneys [20]. Renal tubular damage was observed at lower cadmium exposure than anticipated in previous studies [21], and it is now acknowledged that renal dysfunction is the most

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sensitive toxicological endpoint arising from cadmium exposure [22]. Although medical literature states that cadmium toxicity is largely irreversible, excellent success in reversing cadmium-induced pathology using mineral balancing approach is possible [23]. Dietary cadmium absorption can be reduced by administration of iron, zinc, copper and calcium which are cellular antagonist to cadmium. The aim of this study is determine the cadmium concentrations in eight staple food samples obtained from three different markets in Nigeria. Various instrumental method of analysis may be employed to measure the concentration level of heavy metals in various samples. The most predominant techniques are atomic absorption spectrometry (AAS); atomic emission/ fluorescence spectrometry (AES/AFS); inductively coupled plasma mass spectrometry (ICP-MS); inductively coupled plasma optical emission spectrometry (ICP-OES); neutron activation analysis (NAA), X-ray fluorescence (XRF); and anodic striping voltammetry (AVS). Atomic absorption spectrometry (AAS) was used in the research.

2. Experimental Methods

2.1 Sample Collection

The food samples were collected from three different markets in different states as mentioned in Tables 1-4. The fruits were washed and the seeds were grounded before sample preparation.

2.2 Sample Preparation

The method of digestion of samples involved the use of concentrated sulfuric and concentrated nitric acids to destroy the organic matters present in the food samples and bring their ions into solution. In this procedure, 5 g of each grinded sample was weighed into a 250 mL conical flask and 5 mL conc. nitric acid was added. The resulting mixture was heated gently after the initial vigorous reaction subsided and the cooled. 8 mL conc. sulfuric acid was gradually added at such a rate that excessive heating was prevented and then heated until the mixture darkened appreciably in color. Concentrated nitric acid was added again gently in small portions (1 to 2 mL), heating after each addition whilst avoiding strong heating to prevent excessive charring. The gradual addition of small portions of conc. nitric acid was continued until the solution failed to darken on prong heating and a colorless or pale yellow solution was obtained. The solution was allowed to cool and made up to 100 mL with distilled water. The digested samples were analyzed with the aid of atomic absorption spectrophotometer for quantitative determination of cadmium in the samples.

2.3 Preparation of Blank Solution

Blank solution was prepared by adding other reagents used with the exception of food samples and made up to 100 mL with distilled water [24, 25].

2.4 Instrumentation

The spectroscopy characterization have been employed with PerkinElmer Analyst 200 AA Spectrometer throughout this work.

3. Results and Discussion

Tables 1-3 show the data obtained for the analysis of cadmium in eight food samples from Oja oba market Ilorin in Kwara State, Ojuwoye market Mushin in Lagos State and Kuto market Abeokuta on Ogun State respectively while Table 4 and Fig. 1 give the comparison of the results from the three market samples.

Table 1 Cadmium concentration of food samples bought from Oja oba market Ilorin in Kwara State

Food sample	Cadmium concentration (ppm)		
	1st Run	2nd Run	Average
Orange	0.0011	0.0010	0.001 ± 0.001
Onion	0.0020	0,0021	0.002 ± 0.001
Beans	0.0050	0,0050	0.005 ± 0.002
Yam Flour	0.0061	0.0061	0.006 ± 0.001
Guinea corn	0.0029	0.0031	0.003 ± 0.001
Tomato	0.0040	0.0040	0.004 ± 0.001
Banana	0.0020	0.0020	0.002 ± 0.001
Tapa (local) rice	0.0060	0.0060	0.006 ± 0.002

Table 2 Cadmium concentration of food samples bought from Ojuwoye market Mushin in Lagos State

Food sample	Cadmium concentration (ppm)		
	1st Run	2nd Run	Average
Orange	0.0021	0.0030	0.002 ± 0.001
Onion	0.0020	0.0020	0.002 ± 0.001
Beans	0.0051	0.0050	0.005 ± 0.002
Yam Flour	0.0049	0.0051	0.005 ± 0.001
Guinea corn	0.0030	0.0030	0.003 ± 0.001
Tomato	0.0032	0.0028	0.003 ± 0.001
Banana	0.0020	0.0020	0.002 ± 0.001
Ofada (local) rice	0.0070	0.0070	0.007 ± 0.002

Table 3 Cadmium concentration in food samples bought from Kuto market Abeokuta in Ogun State

Food sample	Cadmium concentration (ppm)		
	1st Run	2nd Run	Average
Orange	0.0010	0.0010	0.001 ± 0.001
Onion	0.0020	0.0020	0.002 ± 0.001
Beans	0.0060	0.0060	0.006 ± 0.002
Yam Flour	0.0020	0.0020	0.002 ± 0.001
Guinea corn	0.0040	0.0040	0.004 ± 0.001
Tomato	0.0020	0.0020	0.002 ± 0.001
Banana	0.0030	0.0030	0.003 ± 0.001
Ofada (local) rice	0.0050	0.0050	0.005 ± 0.002

Table 4 Comparison of results from the three different markets

Food sample	Oja oba Market (Kwara State)	Ojuwoye Market (Lagos State)	Kuto Market (Ogun State)
Orange	0.001 ppm	0.002 ppm	0.002 ppm
Onion	0.002 ppm	0.002 ppm	0.002 ppm
Beans	0.005 ppm	0.005 ppm	0.006 ppm
Yam Flour	0.006 ppm	0.005 ppm	0.002 ppm
Guinea corn	0.003 ppm	0.003 ppm	0.004 ppm
Tomato	0.004 ppm	0.003 ppm	0.002 ppm
Banana	0.002 ppm	0.002 ppm	0.003 ppm
Ofada (local) rice	0.006 ppm	0.007 ppm	0.005 ppm

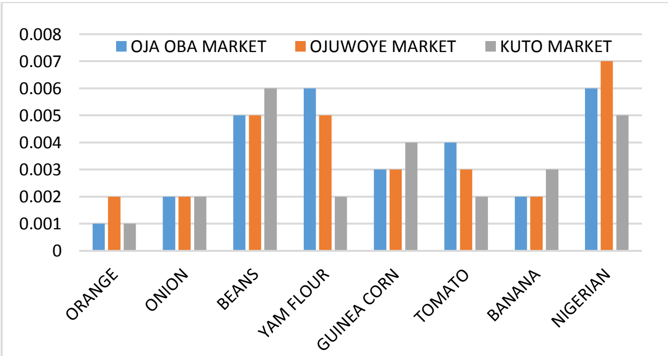

Fig. 1 Chart showing concentration of cadmium in eight food samples from three different markets

Generally, according to the Joint FAO/WHO Expert committee on food additives [22], the permissible level of cadmium is 25 μg/kg body weight or weekly intake if 2.5 μg/kg. As can be seen from the Tables 1-4, the cadmium content in the most food samples varied from 0.001 to 0.007 ppm and since trace amount of cadmium is expected in almost all samples due to natural conditions, it is therefore necessary to pay greater attention to the samples containing high amount of cadmium. It is important to note that the critical thing is not the total intake of toxic materials from food but the balance of intake and elimination, and if man can eliminate the toxic substance fast enough to keep its internal concentration low, he may free from ill effect.

4. Conclusion

Special attention should be given as regards to Yam flour, Onion and local rice samples for their high cadmium content as these are among the most staple foods in Nigerian. This high amount coupled with other sources of cadmium exposure could lead to excessive accumulation of the cadmium in the body.

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