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Determination of Heavy Metals in Different Brand of Chocolates, Marketed in Anyigba, Kogi State

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Abstract

This study reviews the concentration of heavy metals in four imported chocolate candies (Samples 1, 2, 3 and 4) marketed and sold in Anyigba, Kogi state. In order to evaluate the quality of the products, the levels of some heavy metals (Cu, Pb, Cd, Ni, Zn, and Cr) were evaluated in the samples using Atomic Absorption Spectrometry (AAS). Concentrations of metals in the studied samples ranged 0.50 – 0.80 mg/100g for Cu, 1.94 – 3.82 mg/100g for Pb, 0 – 1.40 mg/100g for Cd, 0.59–7.75 mg/100g for Zn, 0.08 – 0.53 mg/100g for Cr. Nickel was generally below detection level in the four samples. The data showed that these metals are at lower levels in the studied samples compared to other studies in chocolate candies in Nigeria. Thus, frequent intake of these selected products is likely not to induce health effects arising largely from Cu, Cd, Cr, Pb, Ni and Zn.

1. Introduction

In recent times, there is an increasing concern about the quality of imported foods and food related products in several parts of the world [1]. This observation was due to the large size of shipments, the many different routes of entry, the variety of foods imported, and the large numbers of potential contaminants make effective interdiction of contaminated foods difficult [2]. Chocolate is a typical example of food related products sold in several parts of the world and hence, the need for serious concern. Chocolate is a brownish sweet food, prepared from *Theobroma* cacao seeds. It usually comes in form of a liquid paste or in block. Chocolate is a vastly nutritious energy source, with a fast metabolism and good digestibility. The presence of cocoa, milk and sugar in its composition can be the warranty of proper ingestion of proteins, carbohydrates, fats, minerals and vitamins [3]. It is of paramount necessity therefore, to monitor human exposure to heavy metals present in the food chain [4]. These heavy metals could have a potency of migrating into the food through

packaging materials, which may contain non-food grade substances, printing inks which might contain heavy metals. Regular consumption of contaminated chocolates results in accumulation of heavy metals in human organs and may results in serious health problems [3].
The biotoxic effects of heavy metals to the body when consumed above the bio-recommended limits. The nature of effects could be acute, chronic or sub-chronic, neurotoxin, carcinogenic, mutagenic or teratogenic [5]. Though individual metal exhibit specific signs of toxicity, many illness like gastrointestinal disorders, diarrhea, stomatitis, depression, pneumonia and many other have been reported as general signs associated with Cd, Pb, Cr, Zn, Cu and Ni consumption. In addition, young children are considered to be at greatest risk due to their ability to effectively absorb metals and thereby suffer physiological development retardation [3, 6, 7].
Therefore, this research is aimed at the determination of the concentration of Cd, Pb, Cr, Zn, Cu, and Ni in some selected foreign chocolates available in different brands in Anyigba, Kogi State.

2. Methodology

2.1 Sample collection

Four most popularly consumed chocolate samples of different brands were purchased from selected supermarkets within Anyigba metropolis. The selected chocolates were labeled sample 1 (CH), sample 2 (CR), sample 3 (SK) and sample 4 (SS). Anyigba is a town under Dekina Local Government Area of Kogi State, Nigeria. Before the choice of the sampling, a market survey was carried out to ensure that these products were sold across the length and breadth of Anyigba.

2.2 Sample preparation

About 0.2 gram of each samples were taken separately in pyrex flasks, the contents of flasks were treated with 2 mL mixture of acid and oxidant (65 % HNO_3 and 30 % H_2O_2) in the ratio of (1:1, v/v) for decomposition of organic matter. The contents of flasks were heated on electric hotplate at 80 ^oC, for 2–3 hours, till a clear solution is obtained. The resulting solutions were evaporated to semidried mass and the final solutions were made up to 25 mL with 0.2 M HNO_3, for the determination of Cd, Ni, Cr, Cu, Zn and Pb by AAS.

2.3 Analysis of metals ions using AAS

In atomic absorption spectrometry (AAS) the sample is vaporized and the element of interest atomized at high temperatures. The concentration of Cd, Ni, Cr, Cu, Zn and Pb were determined using Atomic Absorption Spectrometry [8]. The principle is based on nebulising sample solution into an air-acetylene flame where it vapourizes. Elemental ions are atomized and the atoms formed absorb radiation of characteristic wavelength from a hollow-cathode lamp. The absorbance measured is proportional to the amount of analyte in the sample.
The AAS machine (Alpha 4 Model) was set up in accordance with the manufacturer's instruction for each element to be analyzed. These include fuel (acetylene) and oxidant (air) selection, burner type, an optimum wavelength and slit-width settings. The standards, blanks and the sample were aspirated into the flame and their concentrations in ppm were recorded automatically. The concentration of each analyte (Z) in the sample was calculated using Equation (1).

$$Z\left(\frac{mg}{100g}\right) = \frac{Zppm\ x\ vol.of\ sample}{weightof\ sample\ x\ 10} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

2.4 Estimated daily intake of metals (DIMs)

To appraise the health risk associated with heavy metal contamination of the studied products, estimated daily intake of metal (DIM) was calculated as shown in equation (2) below according to [9].

$$DIM = \frac{C_{metal}\ x\ W_{food}}{B_w} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (2)$$

C_{metal} / (mg/g) is the concentration of heavy metals in the samples.
W_{food} represents the daily average weight of sample consumed (assumed 20 g of each sample is taken by an individual).
B_w is the body weight assuming the samples are consumed by adult of average weight of 65 kg.

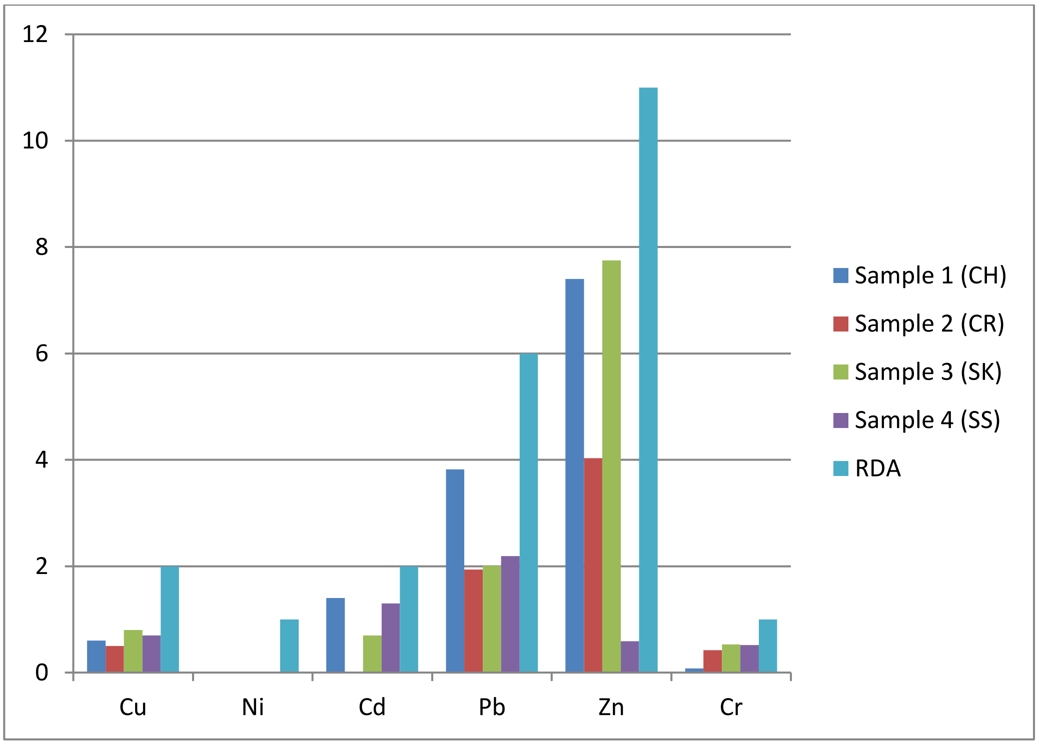
1. Result and Discussion

Cocoa is the main ingredient in chocolate, besides milk and sugar. The analytical results showing the mean and standard deviation of the heavy metals concentration in different chocolate samples are given in Table 1.

Table 1: Concentration of Heavy Metals in Selected Chocolate Candies

Chocolate samples	Cu (mg/100g)	Ni (mg/100g)	Cd (mg/100g)	Pb (mg/100g)	Zn (mg/100g)	Cr (mg/100g)
Sample 1 (CH)	0.60 ±0.001	ND	1.40 ± 0.35	3.82 ± 0.056	7.40 ± 0.15	0.08 ±0.006
Sample 2 (CR)	0.50 ± 0.03	ND	ND	1.94 ± 0.023	4.03±0.001	0.42 ± 0.022
Sample 3 (SK)	0.80 ± 0.07	ND	0.70±0.053	2.01 ± 0.039	7.75 ± 0.002	0.53 ± 0.007
Sample 4 (SS)	0.70 ± 0.001	ND	1.30±0.056	2.19 ± 0.016	0.59 ± 0.001	0.52 ± 0.007
RDA	2.00	1.00	2.00	6.00	11.00	1.00
Mean	0.65	ND	0.85	2.49	4.81	0.39

KEY: ND = not detected



RDA = Recommended Daily Allowance

Figure 1: Heavy Metal Concentration in the Chocolate Samples

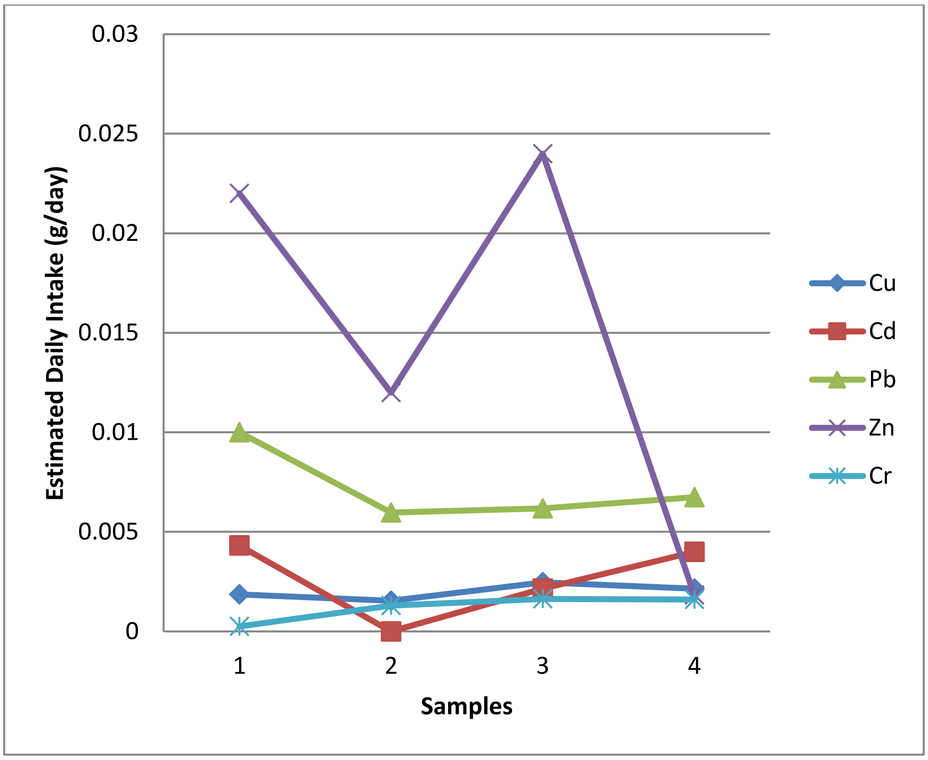


Figure 2: Estimated Daily Intake of Heavy Metals in the Chocolate Samples

3.1 Discussion

3.1.1 Heavy metals in chocolate samples

Literatures have revealed that heavy metals such as Cu, Zn, Cr, Mn, and Ni are essential in human nutrition. However, the concentration in food products is paramount, because at high concentrations they threaten human health.

In this study, the concentration of lead (Pb) in the chocolate samples is ranged between 1.94 and 3.82 mg/100g with a mean value of 2.49 mg/100g. This value is low, when compared with the recommended daily allowance of 6.00 mg/100g for solid food substance [10]. The value is higher than 0.009 – 0.92 mg/100g reported by [11] for Pb in some kinds of candy imported from Turkey and China. Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children. Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage [12].

The Concentration of copper (Cu) in the four brands of chocolates examined ranged between 0.50 and 0.80 mg/100g with an average value of 0.65 mg/100g. The value is low when compared with the recommended dietary allowance of 2 mg/100g [10]. The low value resulted from the fact that, copper is retained when the bean from the cacao tree is processed into cocoa or chocolate. Copper at trace level is an essential metal and serves as anti-oxidant which helps the body to remove free radicals and prevent cell structure damage [13]. Generally, cocoa solid is a major source of copper intake. In a study carried out by [14], copper concentration in cocoa and its products ranged from 3.47 - 31.60 mg/100g. In USA, chocolate drinks and chocolate cakes were found to range among the 20 top foods for copper [14]. The total dietary copper intake by males and females was positively associated with the consumption of chocolate foods, which is the main source of Cu intake [14].

The concentration of zinc (Zn) in the four brands of chocolate ranged between 0.59 and 7.75 mg/100g with a mean value of 4.81 mg/100g. The value is low when compared with the Joint Expert Committee on Food Additive (JECFA) and Provisional Maximal tolerable daily Intake (PMTDI)

for Zn (10.00mg/100gbw day^{-1}) [15]. The value is also low when compared with recommended daily allowance for an adult male (11 mg/100g) [16]. The dietary requirement for zinc is necessary for growth, tissue repair, and obligatory excretion. However, its deficiency leads to growth failure, sexual infantilism in teenage individuals and impaired wound healing [17].
The concentration of cadmium (Cd) in the studied samples ranged from 0.70 to 1.40 with a mean value of 0.85 mg/100g. This value is low, when compared with the recommended daily allowance (2.00 mg/100g) for food substances [10]. The concentration of Cd in the studied chocolates was higher than the range (0.01- 0.19 mg/100 g) of Cd reported by [18] in ready to eat food in Ilorin, Nigeria. Cadmium is a metallic element that occurs naturally at low levels in the environment. High level of cadmium in the body is very dangerous, causing bone disorder, cancer of the lungs, anemia and renal damage.
The concentration range of chromium (Cr) in the study (0.08 – 0.53 mg/100g) was lower than the range (0.8 – 21.4 mg/100g) reported by [19] in selected ready-to-eat foods from Southern Nigeria. The main form of Cr found in food is the trivalent form [20]. In order to prevent deficiency of Cr in human, the committee on medical aspect of food policy (COMA) recommended that Cr should be within the dietary limit of 1 mg/100gbwd^{-1} for adolescent [21].
The concentration of nickel (Ni) in the chocolate samples is below the detection level. Nickel is found in small quantities in many foodstuffs (0.001-0.01mg/100g) and in higher concentrations in grains, nuts, cocoa products and seeds (up to 0.8mg/100g) [22]. Nickel is found as complex bond Ni^{2+} ions in diets [23]. Despite the possibility of cocoa solid being a source of nickel in chocolate, the major source of nickel contamination in chocolate results from the manufacturing process when hardening is done by hydrogenation of unsaturated fats using nickel as catalyst [24]. Nickel at trace amount may be beneficial as an activator of some enzyme systems. At higher levels, it accumulates in the lungs and may cause bronchial hemorrhage. Other symptoms of nickel toxicity include nausea, weakness and dizziness [24].

3.1.2 Estimated daily intake of metals (DIMs)

It should be noted that the estimated daily intake of metals estimation is a risk assessment designed to avoid underestimation of the risk. Thus, it incorporated several assumptions such as ingested quantities of metal ions with respect to the quantities that are absorbed (United States Environmental Protection Agency [25]. The estimated daily intake of metals value for the four products studied as shown in Tables 2 – 6 (Figure 2) varied from 0.00185 - 0.00215 g/day for Cu, 0.0000 – 0.00431 g/day for Cd, 0.00597 – 0.011 g/day, 0.00182 – 0.024 g/day for Zn and 0.00025 – 0.00163 for Cr. The trends of daily intake of heavy metals in the samples were in the order: Zn > Pb > Cd > Cu > Cr.

4.0 Conclusion

The study revealed that, the concentration of heavy metals in the selected chocolates was within the acceptable limit. Thus, frequent intake of these selected products is likely not to induce health effects arising largely from Cu, Cd, Cr, Pb, Ni and Zn.

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