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Research Article

Levels Of Heavy Metals Concentrations in Chocolates From Bwari Market Abuja Fct, Nigeria

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A B S T R A C T

The concentration of some heavy metals in chocolates consumed in Bwari Area Council Abuja F.C.T, Nigeria were determined and the metal concentrations were compared with regulatory standards. Two brands of chocolate were purchased from Bwari market. The concentrations of Ni, Fe, Cu, Cr, and Pb were determined using Atomic Absorption Spectrophotometry (AAS). The mean concentrations of Ni, Fe, Cu, Cr, and Pb were found to be 0.98 ± 0.05, 6.48 ± 0.37, 5.01 ± 0.03, 4.08± 0.41, and 0.24 ± 0.12 mg/kg respectively and were compared to world health organisation standard (WHO). Estimated daily intake for each metal in the respective samples were also determined, showing that the trends of daily intake of heavy metals in the samples were in the order: Fe>Cu>Cr>Ni>Pb. The findings of the study indicates that the concentrations of the studied brands of chocolate from Bwari market are within the allowable limits hence pose no potential health risk or hazard upon consumption.

Keywords: Chocolate, Concentrations, Spectrometry, Acid digestion, heavy metals

Introduction

Concern over the quality of imported foods and food-related items has grown recently in a number of global locations.[1] This remark was made because it is challenging to effectively interdict contaminated goods because of the bulk of shipments, the variety of foods imported, the numerous entry points, and the numerous possible contaminants.[1]

There is a need for severe worry because chocolate is a common example of a food-related product that is sold all over the world. Chocolate is a delicacy made from the seeds of the Theobroma cacao plant. The negative consequences of heavy metals cannot be overstated. They accumulate in marine organisms and are absorbed by plants, including the Theobroma cacao plant, because they are prevalent in waterbodies. When humans take them through chocolate, they can cause a range of toxicological symptoms.[2] It is among the common foods consumed by people of all ages. For satisfaction, chocolate is frequently consumed.[3]

The phrase "heavy metal" refers to all chemical elements with an atomic density more than 4 g/cm^3.[4] Food products containing heavy metal contamination can pose major health hazards. This is due to the fact that consuming foods containing even trace amounts of heavy metals can produce significant concentrations in the body, which can have harmful effects.[5]

Monitoring human exposure to heavy metals found in the food chain is therefore absolutely necessary.[1] These heavy metals may have the ability to migrate into food through

printing inks that contain heavy metals and packaging materials that include compounds that are not fit for human consumption.[6] Frequent ingestion of tainted chocolates causes heavy metals to build up in human organs and can lead to major health issues.[1]

Effects may be neurotoxic, carcinogenic, mutagenic, teratogenic, acute, chronic, or sub-chronic.[1] Even if each metal has its own unique symptoms of toxicity, drinking Cd, Pb, Cr, Zn, Cu, and Ni has been linked to a number of common symptoms, including gastrointestinal disorders, diarrhoea, stomatitis, depression, pneumonia, and many more. Furthermore, young children are thought to be most vulnerable because of their capacity to absorb metals efficiently, which might lead to physiological development retardation.[7] Therefore, this research is aimed at determining the concentration of Ni, Fe, Cu, Cr, and Pb in some selected chocolates available in different brands in Bwari, FCT Abuja.

Materials And Methods

Sampling

2 brands of chocolate were purchased from the market in Bwari. Area Council Abuja, stored in a polythene bag and conveyed directly to the chemistry research laboratory for further analyses.

Microwave acid digestion

A microwave-assisted acid digestion procedure was carried out in order to achieve a shorter digestion time. About 0.2 g of each sample chocolates was taken in digestion flasks, added 2 mL of mixture of HNO_3: H_2O_2 (1:1, v/v), and kept for 10 minutes at room temperature. This was then heated for 3 - 5 minutes. After cooling the digestion flask, the resulting solutions were evaporated to semidried mass to remove excess acid, and then diluted to 10.0 mL in volumetric flasks with 0.2 M HNO_3, for the determination of Ni, Fe, Cu, Cr, and Pb by AAS.

Sample Analysis

All digested samples were analysed using Atomic Absorption Spectrometer to determine Ni, Fe, Cr, Cu and Pb concentrations at Sheda Science and Technology Complex, Abuja (SHESTCO). High temperatures are used to evaporate the sample and atomize the element of interest in atomic absorption spectrometry (AAS). Atomic Absorption Spectrometry was used to determine the concentrations of Ni, Fe, Cu, Cr, and Pb by AAS [8]. Nebulizing a sample solution into an air-acetylene flame, where it vapourizes, is the basis of the principle. A hollow-cathode lamp emits radiation with a certain wavelength that is absorbed by the atomized elemental ions. The amount of analyte in the sample is directly correlated with the measured absorbance. For every element to be examined, the AAS machine (Alpha 4 Model) was configured in compliance with the manufacturer's instructions. These consist of the choice of fuel (acetylene) and oxidant (air), kind of burner, ideal wavelength, and slit-width parameters. The concentrations of the standards, blanks, and sample in parts per million (ppm) were automatically recorded as they were inhaled into the flame. Each analyte's (Z) concentration in the sample was determined.

Statistical Analysis

The results of this study were analysed using ANOVA to get the mean concentrations. An ANOVA is a statistical method used to test differences between two or more means. It is called analysis of variance.

Estimation of Daily Dietary Intake (DIM)

To assess the risk associated with consumption of the studied products, estimated daily intake of each metal (DIM) was calculated by using the relation:

Where = concentration of heavy metals in the samples in mg/kg, = daily average weight of the sample consumed, assumed 0.02 kg and 0.1 kg of each sample is taken by children and adults, respectively, and = body weight, assuming that samples are consumed by children and adults with an average body weight of 20 kg and 70 kg, respectively.[1]

Result

Table 1.Concentrations of heavy metals mg/kg in chocolate samples

Samples	Heavy Metals				
	Ni	Fe	Cu	Cr	Pb
A	1.05	7.01	5.00	3.50	0.20
B	0.91	5.95	5.02	4.66	0.29
Mean conc.	0.98 ± 0.05	6.48 ± 0.37	5.01 ± 0.03	4.08 ± 0.41	0.24 ± 0.12

Table 2.Estimated daily Intake of Heavy metals (DIM) from Chocolate for Children and Adults in mg/kg

Sample	Heavy Metals in Children					Heavy Metals in Adults				
	Ni	Fe	Cu	Cr	Pb	Ni	Fe	Cu	Cr	Pb
A	0.00105	0.00701	0.005	0.0035	0.0002	0.0015	0.010014	0.007143	0.005	0.000286

B	0.00091	0.00595	0.00502	0.00466	0.00029	0.0013	0.0085	0.007171	0.006657	0.000414
Mean	0.000653	0.00432	0.00334	0.00272	0.000163	0.000933	0.006171	0.004771	0.003886	0.000233

Table 3.Comparison of Results with WHO Standards Limit and Similar Findings

Authors/Standard	Heavy Metals (mg/kg)				
	Ni	Fe	Cu	Cr	Pb
WHO	5.00	50.00	5.00	0.11	1.00
Present Study	0.98 0.05	6.48 ± 0.37	5.01 ± 0.03	4.08 ± 0.41	0.24 ± 0.12
Ibrahim & Madinatu (2018)	15.78	-	-	6.43	7.39
Mohammed et al. (2021)	-	-	-	0.13	Not Detected

Source WHO (2001)

Discussion

A glance at figure 1 it can be seen said generally that the concentration of Ni, Fe, Cu, Cr and Pb for samples A and B can be arranged in reducing order such that Fe>Cu>Cr>Ni>Pb for the two samples.

Analyses of the levels of the respective heavy metals in samples A and B

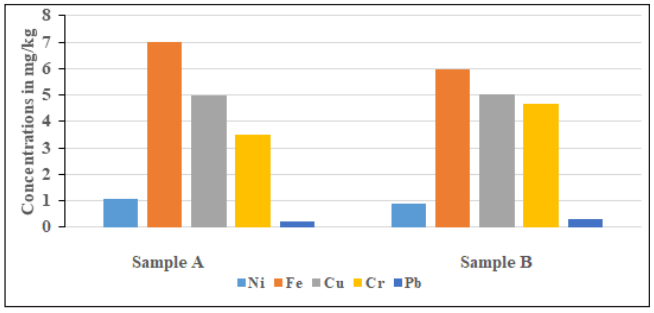

Figure 1.Concentration of heavy metals in chocolates (mg/kg)

Nickel (Ni)

As can be seen in Figure 1 above, nickel is present in samples A and B. The presence of nickel in the chocolates (A and B) may be due to the course of the production process, because nickel is used as a catalyst to hydrogenate unsaturated lipids during hardening.[9]

Iron (Fe)

At a glance, figure 1 shows that Fe is the most prevalent metal among those taken into consideration in samples A and B, with concentrations ranging from 5.95 to 7.01 mg/kg, with an average of 6.48 mg/kg. The increased amount of iron indicates that iron originated from the cacao beans rather than during the manufacturing processes of chocolate, and other studies have also shown similar associations.[6,9,10] For the human body to grow and develop properly, iron is necessary in that it contributes to the synthesis of blood cells and haemoglobin and aids in the metabolism of proteins.[9] Anaemia, chronic anaemia, coughing, and pre-dialysis anaemia are among the disorders that can result from an iron shortage. Eliminating various causes of weariness is one of the health benefits of iron. Additionally, iron helps to fortify the immune system, enabling it to fend off diseases. Fe controls body temperature and cures sleeplessness.[9]

Copper (Cu)

Table 1 and figure 1 show that copper concentrations for samples A and B are 5.05 and 5.02 mg/kg, respectively, lower than Fe and higher than the remaining metals in both cases. In comparison to the recommended dietary limit of 2 mg/100g, the value is low.[11] When the bean from the cacao tree is processed into cocoa or chocolate, copper is kept, which is why the value was low. At trace levels, copper is a necessary element that acts as an antioxidant to help the body eliminate free radicals and stop damage to cell structures.[12] In general, a significant source of copper intake is cocoa solids. According to a study by,[13] the content of copper in cocoa and its byproducts varied between 3.47 and 31.60 mg/100g.

Chromium (Cr)

The concentration of chromium (Cr) in samples A and B is lower than those of iron and copper, as presented in table 1 and figure 1, and was lower than the range (0.8 – 21.4 mg/100g) reported by[14] in selected ready-to-eat foods from Southern Nigeria. All samples from both sites contained chromium at concentrations of 3.50 and 4.66 mg/kg, which was greater than the 0.50–12.79 µg/g value published by Dauda et al.[6]

Lead (Pb)

With concentrations of 0.20 and 0.29 mg/kg, lead was found in all of the samples, which was less than the WHO standard of 1 mg/kg for lead in chocolate. The distribution of lead metal in the examined chocolates made it clear that the amount of lead present in the commodity is not solely

determined by the percentage of cocoa solids but also by manufacturing and other ingredients that make up milk chocolate. Other authors had previously proposed potential sources of lead contamination in chocolates and candies, including the introduction of lead into the product during processing, such as drying, storing, and grinding.[6] Pb transfer in chocolate may also result from product processing or storage in Pb-contaminated containers. Children who eat a lot of chocolate may be at danger of heavy metal poisoning, particularly from lead, according to several research, if they consume more than the recommended daily amount.

Estimated daily Intake of Heavy metals (DIM) from Chocolate for Children and Adults in mg/kg

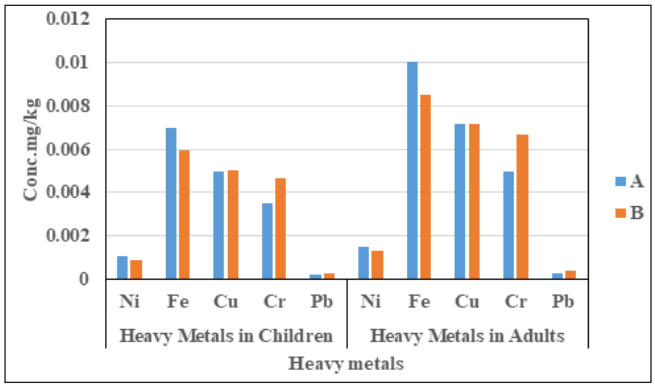

Figure 2.Daily Intake of Heavy metals (DIM) from Chocolate for Children and Adults in mg/kg

Figure 2 reflects the estimated daily intake of heavy metals under investigation from chocolate for children and adults obtained from Bwar Market in Bwari Area Council, FCT, Abuja, Nigeria. It should be noted that the estimated daily intake of metals estimation is a risk assessment designed to avoid underestimation of the risk [6]. 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 [16]. The estimated daily intake of metals values for A and B samples studied is shown in Table 2 as well. varied from 0.000653 to 0.000933 g/day for Ni, 0.00432 to 0.006171 for Fe, 0.00334 to 0.004771 for Cu, 0.00272 to 0.003886 for Cr and 0.000163 to 0.000233 for Pb. The trends of daily intake of heavy metals in the samples were in the order Fe>Cu>Cr>Ni>Pb (Table 3).

Conclusion

An assessment of metals (Ni, Fe, Cu, Cr and Pb) in chocolates from Bwari market, Abuja, was carried out in comparison with the WHO standard. The result reveals that the metals (Ni, Fe, Cu, Cr, and Pb) were present in the chocolates with concentrations lower than the permissible level recommended by WHO; this indicates that the consumption of the studied brands of chocolate poses no health risk or hazard. More regulatory actions should be taken to restrict consumption of contaminated chocolates, as the future of any nation depends on the health, prosperity and progress of the forthcoming generation.

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