Journal of the Nigerian Association of Mathematical Physics
***Volume 52* (*July & Sept., 2019 Issue*), pp247 – 252**

EVALUATION OF TOXIC ELEMENTS CONTENTS IN INFANT FOODS COMMERCIALLY AVAILABLE IN GOMBE TOWN, NIGERIA

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Abstract

Heavy metal contamination is a critical phenomenon of environmental concern nowadays. The tremendous human activities are subjecting the environment to changes susceptible of causing health hazards to human in general and infant in particular. This study was aimed at analyzing heavy metals in some selected infant food formula in Gombe Town. The infant samples were five different infant food formulas obtained from Gombe market. The sample were digested using hydrochloric (HCl) acid and nitric (HNO_3) in the ratio of 5:1 and analyzed using Atomic absorption spectrophotometer (ASS) for determination of heavy metals concentrations. The mean concentrations obtained were compared with the maximum tolerable values reported by WHO. Lead was not detected in all the samples. The heavy metal concentration levels was found to be within safe limit except for copper (0.100 to 0.400 mg/kg), nickel (0.100 to 4.500 mg/kg) and Magnesium (18.600 to 31.700 mg/kg).Sample B and D give values above WHO for Cu. Sample A, B, D and E give values above WHO for Ni. Samples, A, B, C, D and E give values above WHO for Mg. The higher concentration may be due to the environmental mismanagement such as improper disposal of electronic waste and application of agricultural chemicals such as fertilizers, pesticides and herbicides. All samples showed lower intake values when compared with the WHO values with exception of Cd which gave values ranging from 0.01 to 0.09 mg/day while the recommended value is zero.

***Keywords**:* Atomic Absorption Spectroscopy, Heavy metals, Infant Food Formula, Daily Intake and Gombe Town, Nigeria.

1. Introduction

Heavy metals are persistent as contaminants in the environment and come to the fore front of dangerous substances causing health hazards in human (infant) [1, 2.The infant formula sometimes lead to nutrient imbalance poor bioavailability and hypersensitivity [3].They enter into infant through food(infant formula), water and air. Chronic heavy metals toxicity has been the result of many chronic diseases. The critical issues mentioned above should be avoided by making sure that the infant food is safe for consumption and does not contain toxic heavy metals that will lead to infant intoxication.

This work is aimed at studying the level of toxicity of heavy metals in some selected infant food. This was achieved through the following objectives:

(a) Determination of the concentration of heavy metals in different infant food using atomic absorption spectrophotometer.
(b) Determination of intake of heavy metals through different infant food and comparison with other works
(c) Comparison of the obtained concentration of heavy metal with the standard values as reported by WHO.

The presence of contaminants, such as heavy metal, in infant formula may pose health risks to children. It has been reported that children are more susceptible to exposure because of their greater intestinal absorption than adults and a lower threshold for adverse effect [4]. Cumulative exposure from such formula should not exceed the provisional tolerable weekly intake (PTWI) for toxic metal as set by the joint (JECFA) and where the recommended daily allowance (RDA) cannot be determined, adequate intake can be used as a recommended intake values [5].

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The study can help in creating awareness to both consumers and manufacturers about the dangerous effect of the heavy metals. This can also serve as a base line data which can be used by standard organization such as World Health Organization (WHO) and United Children's Fund (UNICEF).

There are many heavy metals but this study considered only eight metals Cu, Co, Cr, Mn, Mg, Pb, Ni and Cd which may be prevalent in infant food in Gombe metropolis. The study also was based on some selected infant food such as Peak Milk 0-12 month, Frico Cream, Cerelac, My boy (Eldarin) and Tina Cowbell, available in Gombe metropolis.

2. Principle of Atomic Absorption Spectroscopy

Atomic absorption is a process involving the absorption by free atoms of an element of light at a wavelength specific to that element, or put more simply, it is a means by which the concentration of metals can be measured.

In Atomic Spectrometry, emission, absorption and fluorescence, energy is put into the atom population by thermal, electromagnetic, chemical and electrical forms of energy and is converted to light energy by various atomic and electronic processes before measurement. Atomic Absorption Spectrometry is useful not only for the identification but also the quantitative determination of many elements present in samples. The technique is specific, in that individual elements in each sample can be reliably identified and it is sensitive, enabling small amounts of an element to be detected down to around 1ppm using straightforward flame procedures. Lower levels can be determined down to 0.001ppm using more sophisticated procedures

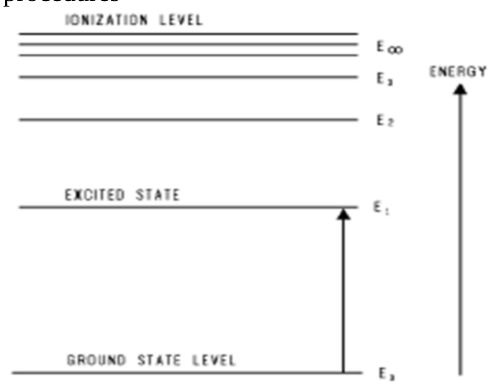

Figure 1: Energy level diagrams [6]

When a sample or sample solution is burned in a flame or heated in a tube, the individual atoms of the sample are released to form a cloud inside the flame or tube. Each atom consists of a positively charged nucleus surrounded by a number of electrons in rapid motion around the nucleus. For each electron in each atom there is a discrete set of energy levels that the electron can occupy. The spacing of the energy levels is different for each electron in the atom, but for similar atoms corresponding electrons have identical spacing. The energy levels are usually labeled E_0, the ground state, through E_1, E_2 etc. to E_∞ as shown on Figure1 for an unexcited atom, each electron is in the ground state. To excite the atom, one or more electrons can be raised to the first or higher energy levels by the absorption of energy by the atom. This energy can be supplied by photons or by collisions due to heat. Those electrons furthest from the nucleus require least energy to go from the ground state E_0 to the first energy level E_1. The energy E corresponds to the energy gap between the ground state and the first energy level

$$E = E_1 - E_0 \qquad (1)$$

The energy required for this transition can be supplied by a photon of light with an energy given by:

$$E = h\nu \qquad (2)$$

Where h = Planck's constant and ν the frequency.

This corresponds to a wavelength (λ) of:

$$E = \frac{hc}{\lambda} \qquad (3)$$

where c is the speed of light in vacuum.

3. Materials and Method

Materials

The materials used in this study include:

Measuring cylinder (100ml), funnel, beaker (30ml), filter paper, masking tape, electro- thermal heater, sampling bottles (50ml), electrical weighing machine and atomic absorption spectrometer.

Sample collection

The samples were obtained from five different infant foods within Gombe metropolis which are namely: peak milk 0-12 month, frico cream, cerelac, my boy (eldarin) and tina cowbell, these were labeled sample A, B, C, D, and E.

Sample treatment and analysis

Sample digestion was achieved by using the wet digestion method 5g of the samples (infant formula) were weighed each and dissolved in 30ml of mixed acid (Hcl:HNO_3 in the ratio 5:1) for 24 hr. The mixture was heated on a hot plate until the brown fumes changed to white. It was allowed to cool and 10 ml of distilled water was added. The mixture was again heated until complete white fumes were generated. After cooling it was filtered into 50 ml volumetric flask. The final volume was made up to 50 ml exactly with demineralized water and it was transferred into the sampling bottles which were taken for analysis using atomic absorption spectrometer. A blank sample was also prepared and analyzed along with the sample. The obtained results in mg/l were converted to mg/kg with the help of the following equation reported by [7]

$$C_s = \frac{C \times V}{W} \quad (4)$$

where V is volume of sample (ml), C is concentration of sample (mg/l), W is mass of the sample (g) and C_S is concentration (mg/kg)

Determination of estimated Daily Intake (EDI)

Daily intake depends on metal contamination and daily consumption of foods and is determined by the following equation.

$$EDI = C \times Cons \quad (5)$$

where, C is the concentration of heavy metals and *Cons* is the daily average consumption

4. Result and Discussion

The concentrations of the heavy metals under studies were determined using AAS and the results are compared with the WHO referral value. The results obtained are presented in mg/l and mg/kg in Table 1 and Table 2 respectively in order to diversify the comparison.

Table 1: concentration of elements detected from some selective infant sample within Gombe metropolis, in (mg/l)

Sample I. D	Sample code	Element							
		Cu	Mn	Pb	Cr	Co	Ni	Cd	Mg
Peak milk	Sample A	0.010	0.060	N.D	0.002	0.017	0.450	0.007	2.540
Frico cream	Sample B	0.025	0.395	N.D	0.002	0.016	0.090	0.001	1.860
Ceralac	Sample C	N.D	0.325	N.D	N.D	0.033	0.010	0.001	1.930
My boy (eldarin)	Sample D	0.040	0.055	N.D	0.001	0.022	0.050	0.009	2.760
Tina cowbell	Sample E	N.D	0.011	N.D	0.003	0.019	0.045	0.002	3.170
*WHO Values		1.200	0.020	0.01	0.050			0.003	

ND = Not Detected

* WHO [8,9]

Table2: concentration of all the trace element detected from some selective infant samples within Gombe metropolis, in (mg/kg).

Sample I. D	Sample code	Element							
		Cu	Mn	Pb	Cr	Co	Ni	Cd	Mg
Peak milk	Sample A	0.10	0.60	N.D	0.02	0.170	4.50	0.07	25.40
Frico cream	Sample B	0.25	3.95	N.D	0.02	0.160	0.90	0.01	18.60
Ceralac	Sample C	N.D	3.25	N.D	N.D	0.330	0.10	0.01	19.30
My boy (eldarin)	Sample D	0.40	0.55	N.D	0.01	0.220	0.50	0.09	27.60
Tina cowbell	Sample E	N.D	0.11	N.D	0.03	0.190	0.45	0.02	31.70

Manganese (Mn) as essential trace element was detected and measured in all samples. The deficiency of Mn has been related to bone deformation, impairment of reproductive organs and reddening of hair amongst others, while excess Mn may inhibit Fe assimilation [4, 10]. In this work, the concentration of Mn detected is in the range of 0.110 to 3.950 mg/kg. The contents of manganese in some baby formulas were found within the range of 0.29-10.5 mg/kg in Turkey [11], this range of manganese concentration is consistent with results obtained in this work. The maximum level of Mn by the food standards code (standard 2.9.1.) as reported by WHO [12] is 24 mg/kg which shows that theses work values are below the maximum level.

Copper (Cu) is an essential element for human and adverse health effect are related to deficiency as well as excess copper. Deficiency is associated with anaemia, neutropenia (decreased number of neutrophilic lymphocytes in the blood) and bone abnormalities [4]. The concentration of Cu in the samples ranges from 0.010 to 0.0400mg/l. The maximum limit which according to WHO and joint expert committee on food and agriculture is 0.01 mg/l as shown in Table1. Concentration of copper is above the recommended value for samples B and D.

Lead (Pb) is among the main metals present in the environment which have major toxic effects; its increased level has been associated with learning deficiencies in children [3]. This finding showed that Pb is highly toxic. The maximum level of Pb as reported by Codex Standard 108-1981 is 0.02 mg/kg [5]. It was not detected in all the five infant formula considered in this work.

Cadmium (Cd) has estrogenic properties and causes an increased incidence of cancer in mice [3] infant, particularly those born prematurely have reduced renal function and their developing kidneys are more susceptible to damage caused by excessive Cd in their diet. In this work the concentrations of cadmium range from 0.010 to 0.090 mg/kg. The maximum level limit prescribed by WHO is 0.3 mg/kg, which shows that these work values are below maximum limit (Table 2) [9].

Nickel (Ni) was reported to be the cause of immediate and delayed hypersensitivity noticed in occupationally exposed people in industries and in the general population respectively. The metal is not only an allergen but also a potential immune modulator and immunotoxic agent in humans. The main source of nickel in infant foods may possibly be due to cocoa additive which is known to contain elevated concentration of nickel. In addition to this, contamination of raw materials and leaching of a nickel-chromium plated container during processing could be another possible source [4]. In this work the concentrations of nickel range from 0.100 to 4.500 mg/kg. The maximum residual limit according to joint expert committee on food and agriculture, and world health organization is 0.01mg/l. It can be seen in Table1 that this work value for nickel are above the maximum level given by WHO for sample A, B, D and E.

The major factors governing the toxicity of chromium compound are oxidation state and solubility. Dermal exposure to chromium has been demonstrated to produce irritant and allergic contact dermatitis, in this work the concentration of chromium ranges from 0.010 to 0.7 mg/kg. The mean level of chromium of some milk based powder formula in Nigeria, UK and USA have been reported as 0.006, 0.005, 0.007µg/l respectively [1]. The National Standards of People's Republic of China, GB 2762-2012 reported a value of 2.0 mg/kg [5], this work value varies between 0.2 to 0.3mg/kg showing that Cr level is low when compared with the above given limit value.

Cobalt (Co) is an essential component of vitamin B12. The concentration in the tested infant formula ranges from 0.160 to 0.330 mg/kg.

Magnesium is a part of bone and teeth that helps to maintain normal function of muscles and nerves. It has been used in treatment of asthma and persistent pulmonary hypertension (pphn) in newborn babies. Deficiency of magnesium leads to spasm of the muscles (tetany). Deficiency can occur as a result of malnutrition, diabetes, chronic kidney disease and in patients with pancreatic problem. Magnesium deficiency can be diagnosed by measuring the magnesium level in the blood. In this work the concentration of magnesium ranges from 18.600 to 31.700 mg/kg. The maximum level by food standards code as reported by WHO is 4.0 mg/kg, this shown that this work values for Mn are above the maximum level.

Table 3: Determining estimated daily intake (EDI) of infant sample, values in mg/d

Sample I. D	Sample code	Element							
		Cu	Mn	Pb	Cr	Co	.Ni	Cd	Mg
Peak milk	Sample A	0.100	0.600	N.D	0.020	0.170	4.500	0.070	25.400
Frico cream	Sample B	0.250	3.950	N.D	0.020	0.160	0.900	0.010	18.600
Ceralac	Sample C	N.D	3.250	N.D	N.D	0.330	0.100	0.010	19.300
My boy (eldarin)	Sample D	0.400	0.550	N.D	0.010	0.220	0.500	0.090	27.600
Tina cowbell	Sample E	N.D	0.110	N.D	0.033	0.190	0.450	0.020	31.700
*RDI		0.900		0.000	-	-	0.500	0.000	-
*ULDI		10.00		0.240	-	-	1.00	0.064	-

* **Recommended daily intake** (RDI) and upper tolerable daily intake
* (ULDI) levels of heavy metals in foodstuffs [13, 14]

Cupper and Nickel give values below RDI values. While all samples showed high intake of Cd but values are below the ULDI [13, 14].

The institute of medicine recommends that intake of manganese from food, water and dietary supplement should not exceed the tolerable daily upper limit of 11mg per day given by National Research Council (NRC) [15].The intake values of Mn obtained in this work are below the limit.

5. Conclusion

The application of atomic absorption spectrometer (AAS) in this work has been successful in determination of toxic elements' concentrations. The concentration ranges of the detected elements in mg/kg are, Cu (0.100 - 0.400), Mn(0.110 - 3.950), Cr(0.010 -0.033) , Co(0.160- 0.330) , Ni (0.100- 4.500) , Cd (0.010 - 0.090) and Mg (18.600 -31.700).

The concentrations of elements detected are within the maximum level when compared with the mean WHO values with exception of copper, nickel and magnesium which showed high values in some samples.

6. Recommendation

The use of other techniques such as, Energy Dispersive X-ray Fluorescence Techniques, Neutron Activation Analysis is recommended in order to fill up the missing gaps in heavy metals analysis is recommended. It is also recommended that heavy metals' contamination should be routinely monitored in foods for baby in order to reduce food born hazards in infants and young children

7. Acknowledgement

Gombe State University is hereby acknowledged for providing the means and facilities for the conduction of this work.

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