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Flame atomic absorption spectrophotometric determination of heavy metals in selected infant formula in the Nigerian Market

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ABSTRACT

Eight(8) selected Infant formula from the Nigerian market were analyzed by Flame Atomic Absorption Spectrophotometry to assess the level of some heavy metals (Pb, Cd, Ni, Cu, Zn, Cr, Co, and Mn) in them. The pH of the samples range from pH 6.4 -6.8. The quality assurance for the digestion method was verified by recovery studies which result range is: 91-98. The concentrations of heavy metals in the samples ranged from 0.08-0.23 μgg^{-1}, 0.05-0.40 μgg^{-1}, 0.09-0.48μgg^{-1}, 0.85-10.21 μgg^{-1}, 6.82-17.19 μgg^{-1}, 0.36-1.00 μgg^{-1},0.04-0.28 μgg^{-1}, and 0.14-3.09 μgg^{-1}, for Pb, Cd, Ni, Cu, Zn, Cr, Co and Mn respectively. The result of elemental analysis indicates that the order of abundance of metals in the infant food as follow Zn > Cu > Mn > Cr > Ni > Cd > Co > Pb. The levels of the metals in the samples were less than acceptable limits in foods as specified in international guidelines.

Keywords: Spectrophotometry, digestion, concentrations, elemental and abundance.

INTRODUCTION

Human milk is considered to be the best source of nutrition for the infant [1]. While nursing using milk-based formula and/or milk substitutes is generally recommended in developed and developing countries when it is difficult to bring up an infant on mother's milk. Infant milk formula serve as substitutes for human milk and play particular role in the diets of infants, because in the absence of breast milk, they are the major source of nutrients [2].

The infant formula are derived mostly from animals or plants and as a result are mostly milk-based or soy-based formulations. The infant formula based on soybean, are anticipated as one of the most fascinating substitutes for children who are allergic to animal proteins [3]. Nutrient levels in formula for infants are usually modeled on the composition of human milk and one goal of the improvement of infant formula is to make them even more similar to human milk [4].

Despite the benefits of infant formula as a major source of food for infants, the presence of contaminants, such as heavy metals, pesticides and polychlorinated biphenyls (PCBs) in infant formula may pose health risks to children. It has been reported that children are more susceptible to exposure [5] because of their greater intestinal absorption than adults, and a lower threshold for adverse effects [6]. These pollutants may arise from the raw materials used in production, poor quality production processes, adulteration of infant foods and bad practices by mothers as regards infant formulation preparation and handling [7].

Infants are an especially sensitive population to expose to environmental contaminants. Their small mass and developing systems, including brain development may show adverse health effects from even low levels of contamination on a chronic or single dose case.

This study is to ascertain the levels of some selected heavy metals (lead, cadmium, chromium, nickel, zinc, copper, cobalt and manganese) in some selected samples of infant formula in the Nigerian market, comparing their results with standards and understanding the use and potential risk involved through contamination.

MATERIALS AND METHOD

Sampling

A total of eight (8) different brand of infant formula (milk and cereal based) were randomly selected from products available in shopping centers from Kwali and Gwagwalada, Abuja in Nigeria. These brands show a fair representative of infant formula product commonly consumed. The samples (CG, FS, SG, PK, NN, CC, ND and GM) were stored in their original container and taken to the laboratory where they were processed for analysis.

Sample Preparation

20g from each Infant formula samples were weighed into different crucible and heat in a muffle furnace at 150^{o}C till the fume ceased, the temperature was further increased to 650^{o}C and heated for 6hrs to ash. The crucible was cooled to room temperature in desiccator, the content were homogenized and then dissolved in 5ml of Analar grade concentrated nitric acid. The solution was heated at 95^{0}C, with subsequent addition of 2.5ml while evaporating until a clear solution was observed. The sample was removed and allowed to cool. After cooling, the solution was diluted with distilled deionized water and filtered through a Whatman 41 filter paper to remove the insoluble particles and brought to a final volume of 25ml. All metallic determinations from the samples were based on the ash obtained. The final processed samples were quantitatively analyzed using Young Lin 8010 Flame Atomic Absorption Spectrophotometer in Chemistry department Laboratory, Faculty of Applied Science, Kaduna state University, Kaduna State.

Determination Of pH

The pH of the infant Formulas were measured with formula to water ratio 1:10 (w/v) using Jenway model 430 pH/conductivity meter, as follows: 1g of samples were weighed into 100ml beakers and 10cm^{3} of distilled-deionized water was added. The mixture was stirred several times for 30 minutes. Then the Formula suspensions were allowed to stand for 30 minutes undisturbed. The electrode of the pH meter was inserted into the settled suspension and the pH of the samples measured [8]. Before use, the pH meter was calibrated with standard buffer solutions of pH 4, 7 and 9.

Quality assurance

Quality control test was conducted on digested samples in order to evaluate the experimental procedures. This was done by spiking the pre-digested samples with multi element metal standard solution (0.5mgL^{-1} of Cd, Pb, Cr, Zn, Cu, Co, Mn and Ni) [9]. 20ml of the multi element standard solution (MESS) was drawn with graduated pipette and used to spike one of the processed sample. These were then digested in triplicate. The digestions were done in triplicates with blank digestion. The digest were run on AAS. Concentrations of metals in spiked and unspiked samples were used to calculate percentage recovery in order to validate the method.

RESULTS AND DISCUSSIONS

Percentage Recovery .

Tables 1 shows the percentage(%) recovery of metals using the dry digestion method.

The percentage recovery for all metals ranged from 91 – 98% with a mean of 95±2%. This clearly shows that the digestion method used in the preparation of the samples for trace metal determination was good.

Table 1; Percentage recovery of metals.

Metals	% Recovery
Pb	93
Cd	92
Ni	95
Cu	97
Cr	98
Co	97
Mn	96
Zn	91

pH Result

The pH result in Table 2; shows that the infant formula are all almost neutral. The pH ranges from 6.4 to 6.8. Most metals become ionic in environmental matrix at low pH(pH<7) and immobile at a high pH(pH>7) [10].

Table 2: pH of samples

Samples	pH
SG	6.7 ±0.3
FS	6.8 ±0.2
CC	6.6 ±0.1
PK	6.5 ±0.2
GM	6.4 ±0.2
NN	6.5 ±0.2
CG	6.4 ±0.3
ND	6.5 ±0.3

Heavy Metals concentrations in infant formula

The mean and range results of heavy metal concentration in the infant formula are presented in Table 3. All the infant formula samples analyzed were found to contain lead, nickel, copper, zinc, cobalt, cadmium, chromium and manganese in varying concentrations.

Table 3: Summary of metal in all samples types.

Metals	Mean ug/g (this survey)	Range ug/g
Pb	0.15±0.02	0.08-0.23
Cd	0.20±0.03	0.050.40
Ni	0.23±0.04	0.09-0.48
Cu	5.62±0.44	0.85-10.21
Cr	0.73±0.10	0.36-1.00
Co	0.17±0.02	0.04-3.09
Mn	1.19±0.04	0.14-3.09
Zn	10.99±0.87	6.82-17.19

The mean concentrations of Zinc in the various brands of infant formula ranged from 6.82 to 14.86ugg^{-1}. Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction[11].

Manganese**,** Mn an essential trace element were detected and measured in all the samples in the range of 0.14 to 3.09ug/g. 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 [12].

The mean concentrations of copper in these infant formula ranged from 0.85 -10.21 µgg^{-1}. Copper is an essential element for human and adverse health effects 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[13].

Chromium, Cr concentration range from 0.36-1.00 µgg^{-1}. The major factors governing the toxicity of chromium compounds are oxidation state and solubility. Dermal exposure to chromium has been demonstrated to produce irritant and allergic contact dermatitis [14].

The mean levels of Nickel in the different brands spanned from 0.09 to 0.48ugg^{-1}. Nickel is the most observed cause of immediate and delayed hypersensitivity noticed in occupationally exposed as well in the general population. The metal is not only an allergen but also a potential immunomodulatory and immunotoxic agent in humans [15]. The main source of nickel in infant foods may possibly be due to cocoa additive which is known to contain elevated concentrations of nickel . In addition, the contamination of raw materials and leaching of a nickel-chromium plated container during processing could be a source.

The concentration of Cadmium ranged from 0.05ugg^{-1} to 0.40ug$g^{-1.}$ implications of cadmium exposure are exacerbated by the relative inability of human beings to excrete cadmium. (It is excreted but then re-absorbed by the kidney.) Acute high-dose exposures can cause severe respiratory irritation. [16].

The concentrations of Lead range from 0.08 to 0.23ug/g . These shows that the level of lead in the samples are within the permissible limits. The presence of Lead in food may possibly be due to contamination during industrial food production, food handling or leakage of metals from packing materials. A number of factors can modify the impact of lead exposures. For example, water with a lower pH (such as drinking water stemming from the collection of untreated "acid rain") will leach more lead out of plumbing connected by lead solder than more alkaline water [17].

The average Cobalt concentrations in the tested infant formula ranged from 0.04 and 0.28 µgg^{-1} . Cobalt is an essential component of vitamin B12.

Table 3 shows the total mean concentrations of the metals and their range. The results ranged from 0.08-0.23 µgg^{-1}, 0.05-0.40 µgg^{-1}, 0.09-0.48µgg^{-1}, 0.85-10.21 µgg^{-1}, 6.82-17.19 µgg^{-1}, 0.36-1.00 µgg^{-1}, 0.04-0.28 µgg^{-1}, and 0.14-3.09 µgg^{-1}, for Pb, Cd, Ni, Cu, Zn, Cr, Co and Mn respectively. The result of elemental analysis indicates that the order of abundance of metals in the infant food follow Zn > Cu > Mn > Cr > Ni > Cd > Co > Pb.

Therefore, the concentrations of metal in infant milk formula and infant cereal formula marketed in Nigerian market analysed in these survey were all found to contain the metals Zn, Cu, Mn, Cr, Ni, Cd, Co and Pd in varying concentrations . The mean of the concentrations were also found to be within the permissible limits and thereby suitable for consumption.

CONCLUSION

The results of this work shows that infant milk and cereal formula tested are adequate in both essential and non essential trace elements; the concentrations of the metal compared well within the limits specified in international guidelines.

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