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HEALTH RISK ASSESSMENT OF METALS CONTAMINATION IN CHOCOLATES AND CHEWING GUM SOLD IN KANO STATE, NIGERIA

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ABSTRACT

Confectionaries such as chocolates and chewing gums are consumed routinely in Nigeria due to their affordability and characteristic taste and flavor. However, the high demand may affect the quality of manufacture and production with possible contamination of heavy metals which have shown to cause serious illness or death in humans. In this research, a total of 20 representative chocolate and chewing gum samples were collected from local shops and markets in Kano metropolitan. All the samples were analyzed to determine the presence of some chemical constituents of health significance (sugar, phosphates, carbohydrates, fats and proteins) and to assess the levels of Lead (Pb), Nickel (Ni), Chromium (Cr) and Cadmium (Cd) using Atomic Absorption Spectrophotometry. The results showed the presence of sugar, phosphates, carbohydrates, fats and proteins in the sampled chocolates and chewing gums at varying concentrations. The results also indicated concentration of Ni, Cd, Cr and Pb in the range of 0.10 – 1.21 mg/g, 0.17 – 1.51 mg/g, 0.10 – 1.99 mg/g, and 0.45 – 3.55 mg/g in chocolate samples respectively, while the mean concentration of Ni, Cd, Cr and Pb in chewing gum samples ranged from 0.10 – 4.23 mg/g, 0.33 – 3.91 mg/g, 0.50 – 5.34 mg/g and 0.55 – 2.50 mg/g, respectively. Higher concentration of all the studied metals were found in chewing gum compared to chocolate samples. All the confectionaries studied indicated presence of the studied metals (Ni, Cr and Pb) at concentrations which exceeded the permissible limit recommended by WHO/FAO and China standard limits of 0.1 – 1.4 mg/g in both chocolate and chewing gum brands studied with exception of Cd in only one sample of chewing gum (3.91 mg/g). Therefore, consumption of these products may likely to pose health risk implication. Thus, there is need to exercise caution in consumption of these confectionary products. Also, the presence of chemical constituents in both chocolates and chewing gums contribute to the characteristic taste of the confectionaries which justifies their frequent consumption in the country.

Keywords: *Heavy metals, Contamination, Confectionaries, Chemical constituents.*

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INTRODUCTION

Foods and drinks are generally consumed for several purposes aimed at growth, development and maintenance of good health. The high consumption rate of confectionaries is attributed to the characteristic taste and flavor (Estruch, 2008). These characteristics are defined by the constituents present such as sugar which is responsible for its sweetness, flavouring agents to add flavour to the confectionaries (Kirk R.S, 1991). In addition to taste satisfaction, chocolates and chewing gums contain other constituents such as vitamins, phosphates, fluoride, calcium, antioxidants, etc. which are of nutritional and health benefits to the body (Emsley, 2004; Pofahl, 2005).

The contamination of foods and drinks by metals such as cadmium, manganese, copper, lead, chromium, mercury, zinc and nickel in areas with high anthropogenic pressure is widespread and is a major determinant of food quality (Ejazul Islam *et al.,* 2007). Some of these contaminants, especially the heavy metals, are cumulative poisons that pose potential hazards and toxicity (Jarup, 2003; Ellen *et al.,* 1990). Recent trends in food safety issues have generated concern over the presence and level of heavy metals in chocolate and chewing gums. For instance the American environmental safety institute took legal action in 2002 against chocolate manufacture for excessive levels of Pb and Cd found in chocolate (Anderson, 2002).

Some research found that chocolates, consumed in controlled quantity, can lower blood pressure. Despite the various health benefits and pleasure associated with the consumption of chocolates of cocoa origin, candies and chewing gum, the issue of heavy metal contamination in the products has become a global concern (Miller *et al.*, 2006). Heavy metals enter into human body by ingestion or inhalation and absorption through skin or mucous membrane, when they are not metabolized by the body, get accumulated in soft tissue and become toxic.

The consumption of chocolate and candy is common among Nigerian children especially those in the cities. Contamination of imported food products with heavy metals may cause a serious risk for human health because of the physiological effects of heavy metals. Consumption of even small quantity of metals can lead to considerable bio-toxic effects. Much illness like *gastrointestinal disorders, diarrhea, stomatitis, depression, pneumonia* and many more have been reported as general signs associated with **Cd, Pb, As, Hg, Zn, Cu and Al** 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 (Kocak *et al*., 2005).

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The increase in heavy metal contamination of foods in developing countries is due to the unregulated increase in urbanization and industrialization (Wong *et al.,* 2003). These contaminants are usually released into the environment as a result of activities of industries, most of which lack the capacity to handle and dispose them appropriately. The biodegradable and chemical nature of the contaminants especially cadmium, copper and lead makes them persistent and easily deposited on foods and drinks (Singh *et al.,* 2010; Sharma *et al.,* 2008;Haiyan and Stuanes, 2003). In Nigeria, the incidence of high thresholds of heavy metal contamination as a result of population growth, urbanization, dumping of wastes, agricultural and industrial activities have been reported in several cities (Ladigbolu and Balogun, 2011; Nubi *et al.,* 2011).

Heavy metals are metals that have shown to be harmful and toxic to the human body life and constitute a major public health concern (Bingol *et al.,* 2010; Cabrera *et al.,* 1995; Duffus, 2012). These metals have the potential of causing acute and chronic toxicity by various modes of action in both children and adults (Ibrahim *et al.,* 2006). Some heavy metals act as catalyst in oxidative reactions of biological macromolecules, therefore their intoxication may lead to oxidative tissue damage (Shaw *et al.,* 2004). Others have genotoxic/carcinogenic potential causing chromosomal aberrations and mutation as well as cancer (Rubio *et al.,* 2006). One of the major mechanisms by which heavy metals exert toxic effect is through impairment of cellular respiration by inhibition of various mitochondrial enzymes, and the uncoupling of oxidative phosphorylation (Lösch *et al.,* 2004; Sharma *et al.,* 2005; Sharma *et al.,* 2008). Some of the heavy metals of health importance include: cadmium, lead, mercury, etc.

Useful information on metals concentration in foods at the point of consumption is necessary in order to estimate health risk associated with heavy metals contamination in chocolates and other confectionaries. Chukwyjindu *et al.,* (2015) have documented the concentration of selected metals in some Ready- to – eat food consumed in southern Nigeria. However, generally in Nigeria, little is known about the effects of heavy metals contamination in chocolates, candies, chewing gums, etc. and potential health risk associated with long term consumption among children. Thus, the current study was conducted to evaluate some constituents of chocolates and chewing gums assessable in Kano metropolitan which may be characteristic of their taste and consumption and also to assess the level of selected heavy metals for possible contamination.

MATERIALS AND METHODS

Research Design

Descriptive-quantitative research design was used for the study. Samples were prepared through acid digestion and analyzed for the presence of lead, cadmium, chromium and nickel by the use of Atomic Absorption Spectroscopy (AAS).

The water used for sample preparation and cleaning of glass wares in this study was distilled, deionized water so as to avoid traces of metals contamination. All laboratory glassware and other apparatus used were thoroughly washed with a suitable detergent and sterilized. All chemicals and reagents used for the study were of analytical grade.

Subject of the Research Study

For this study, twenty (20) different confectionaries which include ten (10) brands each of chocolates and chewing gums were purchased from local grocery stores in the commercial city of Kano State, Northern Nigeria. The collected samples were analyzed qualitatively for the presence of sugar alcohols, phosphates, sucrose, proteins, citric- and fatty- acids according to the standard procedures described by AOAC (2005) and Marier and Boulet (1958), while the heavy metals concentration were assessed quantitatively using atomic absorption spectrophotometer (AAS 460 Model) analysis for possible contamination. The selected heavy metals for the study include: Chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni).

Sample Collection

Twenty (20) different confectionaries which include ten (10) brands each of chocolates and chewing gums were purchased from local grocery stores in the commercial city of Kano State, Northern Nigeria and stored in clean polythene bags. The soft chocolates were stored in a refrigerator before subjected to the digestion procedure and further experimental analysis.

Screening for Constituents in Chocolate and Chewing gum

Test for sugar

Benedict solution was used and tested for the presence of sugar. In this procedure, To 5 ml of Benedict's solution, 1ml of the test solution was added and shaken in each tube. Tube was placed in a boiling water bath and heated for 3 minutes. The tubes were removed from the heat and allowed to cool and the formation of reddish color confirms the presence of sugar in chocolate and chewing gum.

Test for phosphates

3 ml of sample for each brand of chocolates and chewing gums were taken into separate test tubes. 2 ml of ammonium molybdate followed by 2 ml of concentrated nitric acid (HNO_3) were added. The solution was heated in a water bath for 10 min and appearance of canary-yellow precipitate confirms the presence of phosphate ions in selected confectionaries (i.e. chocolate and chewing gum).

Test for Carbohydrates

Few drops of a-naphtol was added to each brand of chocolates and chewing gum dissolved in distilled water, this was then followed by addition of 1ml of concentrated H_2SO_4 by the side of the test tube. The mixture was then allowed to stand for 2minutes. Formation of red or dull violet color at the interface of the two layers indicates a positive test.

Test for fats

3 ml of sample for each brand of soft drinks was taken into separate test tubes and few drops of acetic anhydride were added. To this mixture, added few drops of conc. H_2SO_4 and mixed well. Red colour at first, followed by blue and finally, becomes green confirms the presence of fats.

Test for proteins

Xanthoproteic Test was carried out for the presence of proteins .To 3 ml of each test sample in a test tube, few drops of conc. Nitric acid (HNO_3) is added and the formation of yellow colour indicates the presence of proteins.

Determination of heavy metals concentration

Preparation and Digestion of Chocolate and Chewing gum samples

One (1g) gram each of chocolate and chewing gum samples were taken into 50 cm3 conical flask, and digested in 10 ml concentrated nitric acid (Conc. HNO3) and 2 ml H_2O_2 in an open glass container for 24 hours, at room temperature. In the next day, the pre-digested samples were then taken into microwave oven at 100 ^{o}C for 10 minutes until all the samples become solubilized. All samples were cool to room temperature, and the volume was adjusted to 50 ml using distilled ionized water, and then filtered via filter paper. The diluted samples were stored in polyethylene (PET) bottles and then analyzed using atomic absorption spectrophotometer (AAS460 Model). A blank was prepared using the same procedure without the sample tests. Calibration curves were plotted using the concentration of the standard working solutions (micro gram) against their absorbance (nm).

Preparation of Metal ions and SSA Analysis

Lead, Nickel, Cadmium and Chromium contents in both chocolates and chewing gum samples marketed in Kano Metropolitan, Kano State, Nigeria were analyzed using Atomic Absorption Spectrophotometer (AAS). A stock standard solution, 1000 ppm, of the metal ion was prepared by dividing the molar mass of the compound containing the element by the molar mass of the element (British Pharmacopoeia, 2005). The weight obtained was equivalent to 1.0 g of the metal ion. This weight was dissolved in 1000 ml to give 1000 ppm. Prepared working standard solutions with different concentrations (0.2, 0.4, 0.6, 0.8 and 1.0 mg/kg) of lead, nickel, cadmium and chromium were used to calibrate the spectrophotometer before analysis using distilled ionized water as the control.

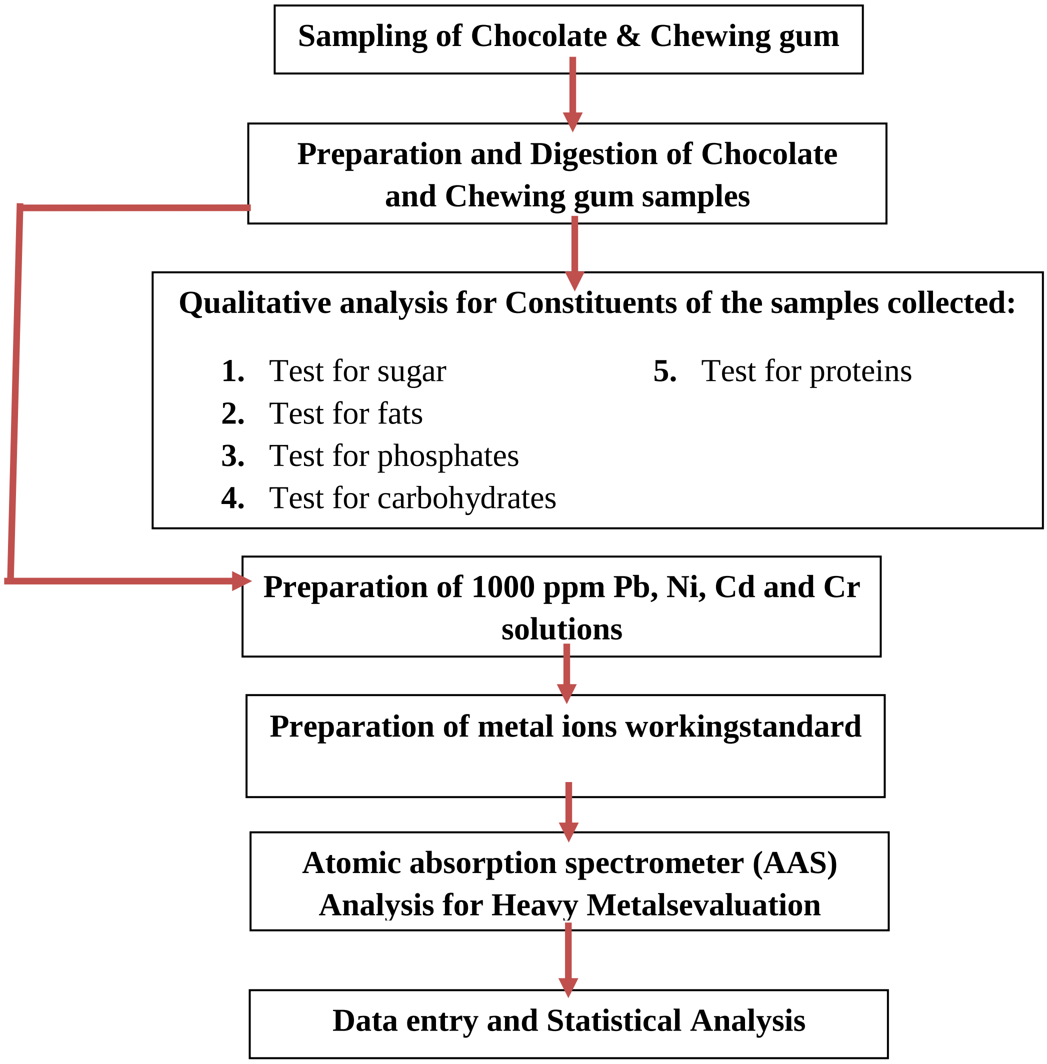

Figure 1: *Flow-chart of the research study*

RESULTS

Table 1 below summarizes the results for qualitative analysis of some brands of chocolates and chewing gums. The results showed the presence of sugar, phosphates, carbohydrates, fats and proteins in the sampled chocolates and chewing gums. Sugar and carbohydrates wereabundantly present in all the 20 samples in which, sugar appears to be more present compared with the carbohydrate constituents. Phosphates were present in 7samples as well as fats in 11 samples. Proteins were present in 15 samples and absent in 5.

Table 1: *Chemical constituents determined in selected brands of chocolates and chewing gums*

	Samples	Test for sugar	Test for phosphates	Test for carbohydrates	Test for fats	Test for proteins
Chocolate						
1.	Nuss-Nino	+++	-	++	+	+
2	Love	+++	-	++	-	+
3	Maxi-star	+++	+	++	+	+
4	Reflex fingers	++	-	++	-	+
5	Soft-kiss	++	+	++	+	+
6	Choco éclair	++	-	++	-	+
7	Coccos	+++	-	++	-	+
8	Cash	+++	+	+++	+	+
9	Parago	++	+	++	+	+
10	Roxy	+++	+	++	+	+
chewing gum						
1	Clorets	++	+	+	-	-
2	Big bum	++	-	+	-	-
3	Time bomb	++	-	+	+	-
4	Super-star	++	-	+	-	+
5	Center fresh	++	-	+	+	-
6	Center fruit	+++	-	++	-	-
7	Center filled	++	+	+	-	+
8	Crispy	++	-	+	+	-
9	Crips	++	-	+	+	+
10	Small	+++	-	++	+	+

Table 2 below illustrates the results of the mean concentration (in mg/ g) of Pb, Ni, Cd and Cr in chocolate samples. The concentrations of the heavy metals (Pb, Ni, Cd and Cr) in selected brands of chocolate sold in the markets of Kano metropolitan, Kano State, Nigeria were determined by Atomic absorption spectrophotometer. From the results obtained, Pb was detected all in the ten (10) brands of the chocolates investigated which was below the permissible limit recommended by *FAO/WHO and China Standards* except for Roxy (Rx) chocolate which was found higher above the standard limit. Thus, agrees with the findings of Garba and Madinatu 2018 in the reported that, Pb, Cr and Ni were detected at higher concentration in the studied chocolates and chewing gums sold in retail stores and by hawkers. The levels of Ni ranged between 0.10 – 1.21 mg/g with Maxi-star (MS) chocolate having the highest concentration of 1.21 mg/g and least concentration of 0.10 mg/g for Love (Lo) chocolate. The concentrations of Cd and Cr ranged between 0.17 – 1.51 mg/g and 0.10 –

1.99 mg/g, respectively. These concentrations were higher than those reported by Iwegbue (2011) and Ochu *et al.*, (2012). The results were also similar to what have been reported by Dias and Wickramasinghe (2016). All the found concentrations of the studied heavy metals in the different brands of chocolate are within the allowed permissible limits for consumption except for Roxy (3.55 mg/g) Coccos (1.99 mg/g) chocolates which were found above the recommended limit by *FAO/WHO and China Standards.*

Table 2*: Mean Concentration* (mg/g) *of Heavy Metals in Chocolate Samples Compared with FAO/WHO and China Standards*

S/N	Brand Name	Sample Code	Lead (Pb)	Nikel (Ni)	Cadmium (Cd)	Chromium (Cr)
1.	Nuss-Nino	NN	0.88	0.38	1.22	0.21
2.	Love	Lo	1.22	0.10	1.10	0.42
3.	Maxi-star	MS	1.42	1.21	0.66	0.17
4.	Reflex fingers	RF	1.33	0.44	0.17	0.58
5.	Soft-kiss	SK	1.23	0.24	0.40	0.10
6.	Choco éclair	CE	1.51	0.13	1.40	0.98
7.	Coccos	Cc	0.45	0.16	1.51	1.99
8.	Cash	Cs	0.98	1.20	0.99	0.70
9.	Parago	Pr	0.87	0.34	0.81	0.50
10.	Roxy	Rx	3.55	0.11	0.41	0.33
	WHO/FAO Limit			**0.4-1.4**		
	China Standard Limit			**0.1-0.5**		

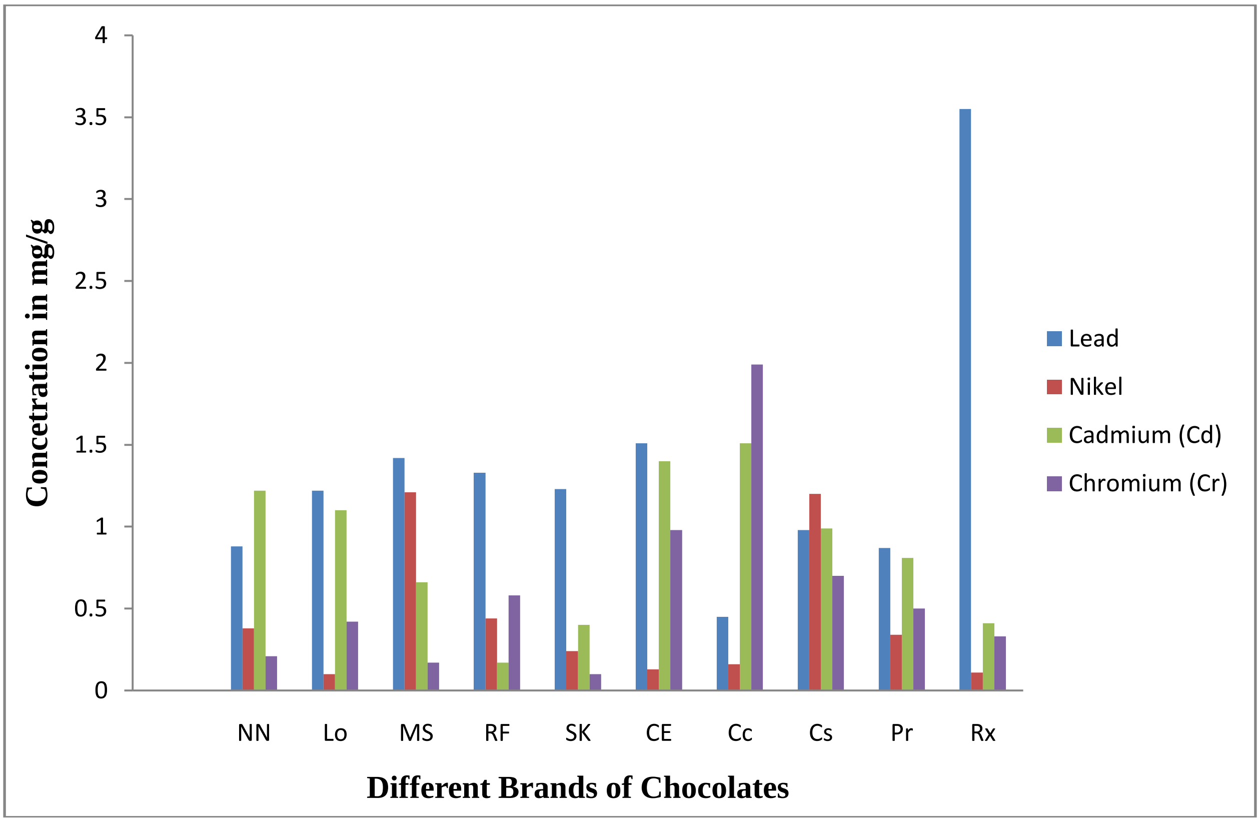

Figure 2: *Comparison of Heavy metals between different Brands of Chocolates*

Figure 2 indicated that different brand of chocolate samples contain various concentrations of the studied metals. Among the metals studied in the chocolate samples, the highest concentration of Pb was found in Rx chocolate sample followed by CE, MS, RF, Lo, SK, Cs, NN, Pr and Cc which gives the following sequential order Rx > CE > MS > RF > Lo > SK > Cs > NN > Pr > Cc. For Cr, the order of the mean concentration of Ni is MS > Cs > RF > NN > Pr > SK > Cc > CE > Lo > Rx. The order forCd is Cc > CE > NN > Lo > Cs > Pr > MS > Rx > SK > RF, while for Cr the order was observed to be Cc > CE > Cs > RF > Pr > Lo > Rx > NN > MS > SK.

Table 3: *Mean Concentration* (mg/g) *of Heavy Metals in Chewing gum Samples Compared with FAO/WHO and China Standards*

S/N	Brand Name	Sample Code	Lead (Pb)	Nikel (Ni)	Cadmium (Cd)	Chromium (Cr)
1.	Clorets	CR	1.89	3.33	0.96	4.12
2.	Big bum	BB	2.11	4.12	0.34	2.23
3.	Time bomb	TB	1.92	4.23	3.91	1.99
4.	Super-star	SS	2.50	1.55	0.66	1.79
5.	Center fresh	CF	1.88	0.46	0.56	5.17
6.	Center fruit	Cf	0.89	0.22	1.99	5.34
7.	Center filled	Cfd	2.30	0.67	1.44	4.10
8.	Crispy	Cp	0.77	1.10	0.33	2.13
9.	Clips	Cl	0.55	0.79	0.45	2.40
10.	Small	Sm	0.65	1.11	0.41	0.50
WHO/FAO Limit			**0.4-1.4**			
China Standard Limit			**0.1-0.5**			

Table 3 above shows the results of the mean concentration of Pb, Ni, Cd and Cr in chewing gum samples. The mean concentration of Pb in the analyzed chewing gum samples ranged from 0.55 -2.30 mg/g, where the highest concentration was observed in Center filled (Cfd) samples. The mean concentration of Ni in the chewing gum samples ranged from 0.022 – 4.23 mg/g. TB chewing gum sample was found to posses the highest concentration of Ni. Also Cd was observed to have the highest concentration in TB (3.91 mg/g) and lowest concentration in Cp chewing gum samples. Moreover, Cf chewing gum was found to possess the highest mean concentration of Cr (5.34 mg/g) and lowest concentration in Sm chewing gum samples.

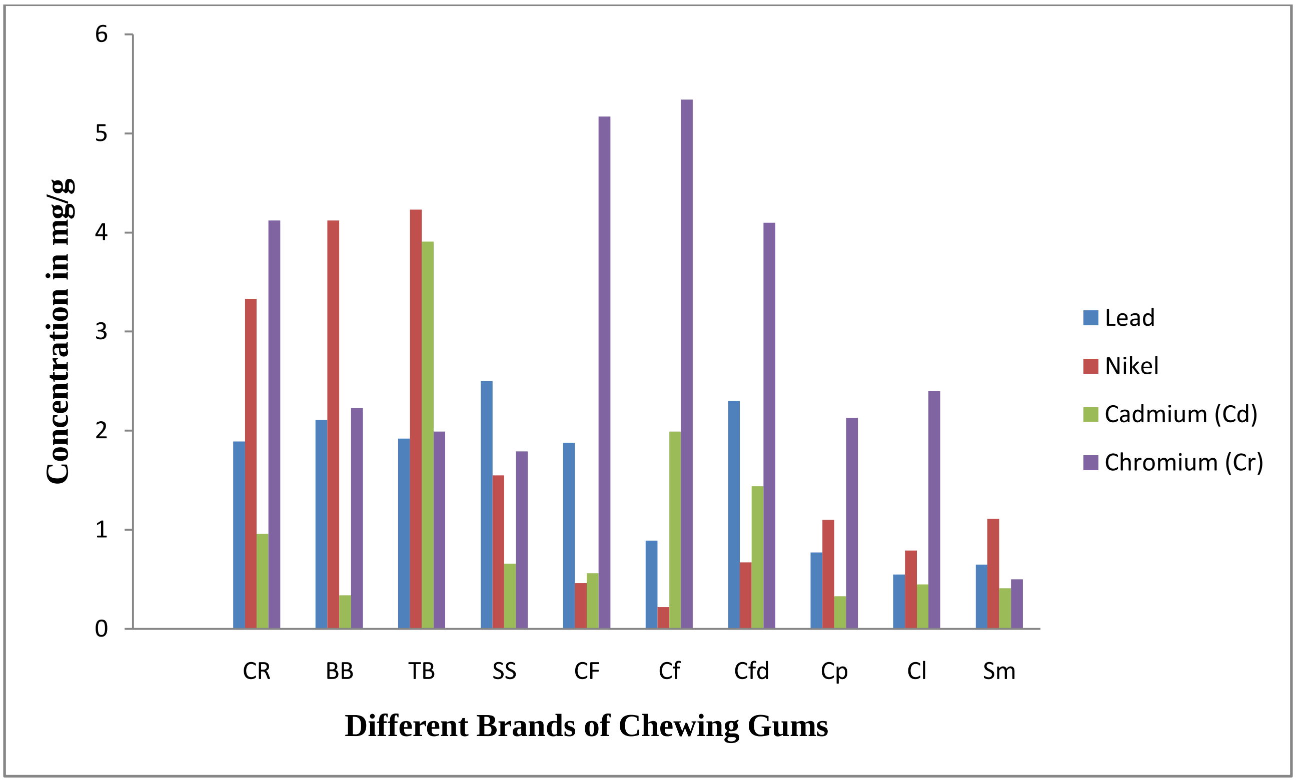

Figure 3: *Comparison of Heavy metals between different Brands of Chewing Gums*

Figure 3 revealed that different brands of chewing gum samples contain different concentration of the studied metals. Among the metals studied in the chewing gum samples, the highest concentration of Pb was found in SS sample following by Cfd, BB, CR, TB, CF, Cf, Cp, Sm and Cl. Which gives the following sequential order, SS > Cfd > BB > CR > TB > CF > Cf > CP > Sm > Cl. For Ni, the order of the mean concentration is TB > BB > CR > SS > Sm > Cp > Cl > Cfd > CF > Cf. Also, the order of the mean concentration in Cd is TB > Cf > Cfd > CR > SS > CF >Cl>Sm>BB>Cp, while for Cr the order was found to be Cf > CF > CR > Cfd > Cl > BB > Cp > TB > SS > Sm.

DISCUSION

The most liable reason for high consumption rate of confectionaries is attributed to the characteristic taste and flavor (Estruch, 2008). These characteristics are defined by the constituents present such as sugar which is responsible for its sweetness, flavoring agents to add flavour to the confectionaries (Kirk, 1991). In addition to taste satisfaction, chocolates and chewing gums contain other constituents such as vitamins, phosphates, fluoride, calcium, antioxidants, etc. which are of nutritional and health benefits to the body (Emsley, 2004; Pofahl, 2005). Phosphorous is an important element for the body. It forms a major constituent of the DNA, cell membrane layer and channels and is also vital for teeth and bone formation. Phosphorous naturally exist as phosphates which are acidic in nature and can be obtained from dietary sources. Phosphate was present in most of the chocolates and chewing gums thus, could be beneficial especially in children for the development of teeth and bones (Emsley, 2004).

Also based on the results obtained, the chewing gum samples contain higher concentration of all the 4 metals studied (Pb, Ni, Cd and Cr). The high risk of the heavy metals contamination is associated with chewing gum samples more than in chocolate samples. Also, the most of the results obtained from the analysis were below the permissible level recommended by WHO/FAO and China standard limits. Therefore, this indicates that the consumption of most of the studied brands of chocolates and chewing gums pose no health risk or hazard. Most heavy metals are usually toxic metals and are mostly carcinogenic in nature as tend to accumulate in visual and sensory organs of human beings leading to cancer (Salama, and Radwan, 2005). Thus, chocolates and chewing gums meant for consumption must be below WHO standard or China limit for their safety.

CONCLUSION

The presence of sugar, phosphates, carbohydrates, fats and proteins in chocolates and chewing gums in Nigeria gives it the characteristic taste which justifies its frequent consumption. However, this high consumption gives room for the risk of heavy metal contamination. For the current study, it can be concluded that **Pb, Ni and Cr** were detected at higher concentrations in the studied chocolates and chewing gums sold in retail stores and by hawkers in Kano metropolitan. Therefore, consumption of these products may likely to pose health risk implication. Thus, there is need to exercise caution in consumption of these confectionary products.

RECOMMENDATIONS

1. Laws should be enforced to regulate the consumption of these products due to higher concentration of studied metals above the recommended limit.
2. People should avoid consumption of such products, more especially children which are more susceptible to these metals contamination.
3. Public awareness is made to avoid the excess consumption of chewing gums and chocolates which nowadays become a passion without considering the health implications.
4. Quality control should be ensured during production and the quality of sugar and water used for chewing gums and chocolates manufacturing be evaluated for the presence of heavy metals at the level of purification and sterilization to minimize subsequent health effects of intoxication.

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AUTHOR CONTRIBUTIONS

All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the research work.

DISCLOSURE

We declared no conflicts of interest in this research study.

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