HER Vol. 25, No. 2, December, 2018, pp. 115 - 126

Heavy Metal Quantification of Noodle Products Commonly Consumed in Nigeria

Otitoju, O., Otitoju, G.T.O., Boyi R.N., Baiyeri S.O., and Ezenwa, C. P.
Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University, Wukari, Taraba State, Nigeria.
Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu State, Nigeria.

Abstract

Technological advancement in the food industry in the last five decades has resulted in the production of ready meals and convenience food. Instant noodles are some of the most common convenience foods in Nigeria. Noodles' production in Nigeria is estimated to be the 12th biggest convenience food in the world. However, with the rate of its demand there is the need to know the safety of its consumption by consumers. This study investigated the levels of some heavy metals [arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg)] in eleven brands of noodles sold in Nigerian markets. The results shows that the levels of As, Cd, Cr and Pb in the noodles ranged from (0.13±0.04 to 0.34±0.05), (0.55±0.12 to 0.77±0.04), (0.18±0.05 to 0.46±0.21) and (0.55±0.08 to 1.46±0.17) respectively and they were relatively higher than the tolerable limit set by WHO. Although these noodles are above the tolerable limit, awareness among the consumers, industries and regulatory agencies will go a long way to reduce possible risk associated with its consumption. Noodles contamination with heavy metals is of public health importance because consumers are at higher risk of heavy metal toxicity which predisposes them to diseases such as nervous, cardiovascular, circulatory system disorders, liver and kidney damage as well as cancer. Therefore, regulatory bodies like NAFDAC, SON should monitor the processes involved in the production of these noodles to ensure that only wholesome products are given to consumers.

Introduction

Food is one of the basic needs of man and nature has provided abundant resources for man's exploitation and use (Iniobong, Atieme, & Inimfon, 2017). Interestingly, technological advancement in the food industry in the last five decades has resulted in the production of ready meals and convenience food, thus ensuring the availability of food for immediate consumption (Iniobong *et al.,* 2017). Instant noodles are one of the most common convenience foods in Nigeria, with a high category penetration of about 60% and market size of about

250,000 t in 2012. With just four (4) brands in 2006, the Nigeria instant noodles market now boasts of up to 16 competing brands (Marketing Edge, 2017).

Instant noodle is consumed on a global scale and is second only to bread (World Instant Noodles Association, 2016). It is a fast-growing sector of the pasta industry. This is because instant noodles are convenient, easy to cook, low cost and have relatively long shelf-life. As the consumption of instant noodles continues to grow globally, the processes involved in the production and packaging of these noodles become a global concern (Iniobong *et al.,* 2017).

Lack of food safety is a major problem in most developing nations including Africa. Many of our food items are laden with lots of pollutants ranging from fertilizer, pesticides to heavy metals (Otitoju, Otitoju G, Iyeghe, & Onwurah, 2014). Consumption of contaminated foods has serious implication on health and economic status of the populace (Cao et al., 2010). The occurrence of foreign materials in food has always elicited strong response from governments, and unravelling the possible occurrence of toxic substances in food continues to draw the attention of researchers. The use of contaminated raw materials has been identified as a major source of food contamination (Sousa, 2008). Heavy metals are generally defined as metals with relatively high densities, atomic weights, or atomic numbers (Paul, Clement, Anita, & Dwayne, 2012). They are chemical elements with a specific gravity that is at least five times the specific gravity of water. In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Also, human exposure has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications (Bradl, 2002).

Dietary exposure to heavy metals, namely cadmium (Cd), lead (Pb), mercury (Hg), arsenic (As) and chromium (cr), has been identified as a risk to human health through the consumption of contaminated food (Otitoju, Akpanabiatu, Otitoju G, Ndem, & Uwah, 2012). These occur as natural constituents of the earth crust and are also distributed by human activities. They contaminate food source and accumulate in both agricultural products and sea food through water, air and soil pollution (Galadima & Garba, 2012). Apart from contamination from environmental contamination of food, food can also be contaminated during processing.

Most heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts (Otitoju *et al*., 2014). However, these heavy metals become toxic when they do not get metabolized by the body and end up accumulating in the soft tissue (Otitoju, Otitoju, & Igwe, 2014). Even low concentrations of heavy metals have damaging effects to man and animals because there is no good mechanism for their elimination from the body (Chen, Wang, & Wang, 2005). They enter the body system through food, air and water (Duruibe, Ogwiegbu, & Egwurugwu, 2007). If the metals are ingested beyond the permitted concentration, they can cause serious health disorders which can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behaviour, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al.,* 2008).

Toxic heavy metals like lead has no known beneficial function in human metabolism and has been implicated with several acute and chronic effects to living organisms including humans (Iniobong *et al.,* 2017). According to the Agency for Toxic Substances and Disease Registry (2014), some of the organ systems affected by lead, arsenic, and mercury include cardiovascular, gastrointestinal, neurological, renal, reproductive, and respiratory. In similar vein, cadmium is known to bio accumulate in the kidney for a relatively long time, ranging from two to three decades, and at high doses, is also known to produce health effects on the respiratory system and induce the renal and hepatic toxicity and has been associated with bone disease, poor reproductive capacity, hypertensions, tumours, and hepatic dysfunction (Waalkes, 2000). Although, beneficial to plants and animals in minute quantity, chromium and nickel become toxic in high concentration and can cause gastrointestinal haemorrhage, haemolysis, acute renal failure, chest pain, encephalopathy, reduced sperm count, pulmonary fibrosis, and lung cancer (Suzuki, *et al*., 2017).

Exposure of consumers to heavy metals and related health risk are usually expressed as percentage intake of Provisional Tolerable Weekly Intake (PTWI), a reference value established by WHO (1992) and WHO (1995). Despite the tolerable limit set by FAO/WHO most studies conducted on heavy metals in food indicated the presence of heavy metals in food. According to a study conducted by Otitoju *et al.,* (2014) on the presence of heavy metal in imported rice, it revealed that all the rice samples had levels of lead higher than the WHO permissible limit which therefore exposes all the consumers to lead toxicity.

As the consumption of instant noodles is growing at an astronomical rate in Nigeria and indeed the world as evidenced in the consumption of over 100 billion packs of noodles worldwide in 2012, with China constituting 44% of global demand (IMARC Group, 2017), there is need for intensive monitoring of ready meals and convenience food for consumer safety.

Materials and methods

Study Design**:** The study design is experimental

Samples**:** Eleven (11) brands of Instant noodles

Equipment and Chemical Reagents Used in the Study**:** Several Laboratory equipment will be used and they include: volumetric flask, pipettes, funnels, filter papers, desiccator, sensitive balance, lamp, wash bottle, round bottom flask, crucible, Atomic absorption spectrophotometer (UNICAM 939). The chemical reagents that will be used include: Hydrochloric acid (HCl), Nitric acid (HNO_3)

***Collection of Samples*:** A total number of 11 different samples from the 11 different noodle brands sold in Nigeria will be collected from major market in Enugu state. The samples will be put in a sealed polythene bag and transported to the laboratory.

***Determination of Heavy Metals*:** The samples were grinded and sieved using a mesh of 0.5m. One (1) of the sample was weighed into a round bottom flask, three (3) spatula of anti-bump granules was added. 50mls of 2molar HNO_3 was added, it was then put into an electro-thermal heater and allowed to concentrate for 1 hour**.** The samples were then poured into 100ml volumetric flask and distilled water was added up to the mark, the samples was then taken to the UNICAM 939 Atomic Absorption Spectrophotometer for heavy metal determination. **T**he method involved direct aspiration of the samples into an acetylene flame ignited by a hollow cathode lamp at specific wavelength. Arsenic ASTM D 3972**,** Cadmium ASTM D 3557**,** Chromium ASTM D 1667**,** Lead ASTM D 3559**,** Mercury ASTM D 3223.

Human health risk assessment: In evaluating the level of human exposure to heavy metals in contaminated noodles, the recommendations of the US EPA (2011) was adopted and the estimated average daily intake (ADI_e) (mg/kg/day) for adults was determined by the following equation:

$$ADI_e = C_m \times IR_n \times EFh \times EDf \div B_{aw} \times ATd$$

- Where C_m = the metal concentration in noodle samples (mg/kg)
- IR_n = the noodles ingestion per day. According to US EPA (2005), food intake for an adult is considered to 0.310kg/person/day.
- EFh = the exposure frequency (365 days/year).
- EDf = the exposure duration (70 years).
- B_{aw} = the average body weight of exposed individual considered to be 60kg for an African adult (FAO/WHO, 2011).
- ATd = the 70-year lifetime for carcinogenic effects (US EPA, 2005).

Target hazard quotient of heavy metals in the noodles: The non-carcinogenic health risks from consumption of the noodle samples were assessed based on the target hazard quotient (THQ). The method of estimating risk (US EPA, 2011) using THQ is stated below:

$$THQ = ADI_e \div RfD_{ing}$$

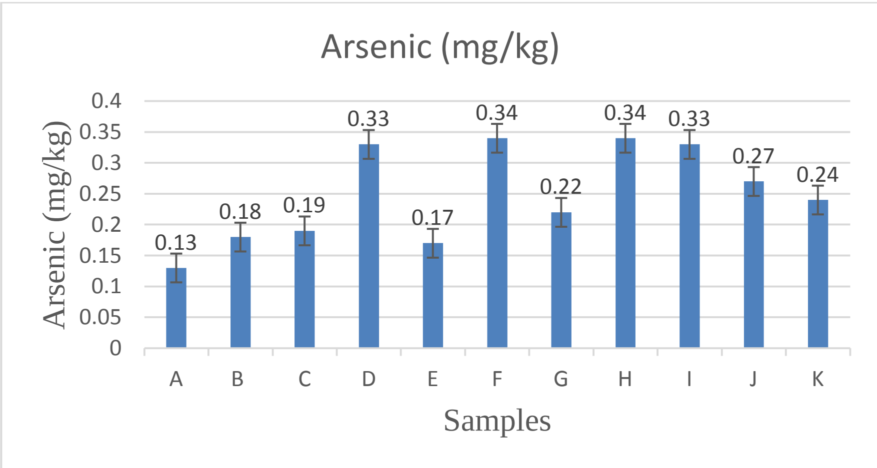
- Where THQ = target hazard quotient
- ADI_e = estimated average daily intake (mg/kg/day)
- RfD_{ing} = Oral reference dose (mg/kg/day)

Statistical Analysis: SPSS version 22 will be used to analyse the data obtained from the study. Descriptive analysis (mean and standard deviation) will be used to present the data obtained. Analysis of Variance (ANOVA) will be used to compare the means while Fishers Least Significant Difference (FLSD) test will be used for Post-Hoc analysis. A p value < 0.05 will be considered statistically significant.

Results

Concentration of Arsenic (As) in noodles: The concentrations of arsenic in the eleven brands of noodle samples are presented in figure 4.1 below. The result shows that the range of the heavy metal concentration is from 0.13 ± 0.04 to 0.34 ± 0.05mg/kg with highest average (mean ± SD) concentrations observed in samples F (0.34 ± 0.05) and H (0.34 ± 0.05) which were significantly higher ($P < 0.05$) than those in sample A (0.13 ± 0.04) but not statistically significant in other samples.

Figure 1: levels of arsenic concentration in different brands of noodles

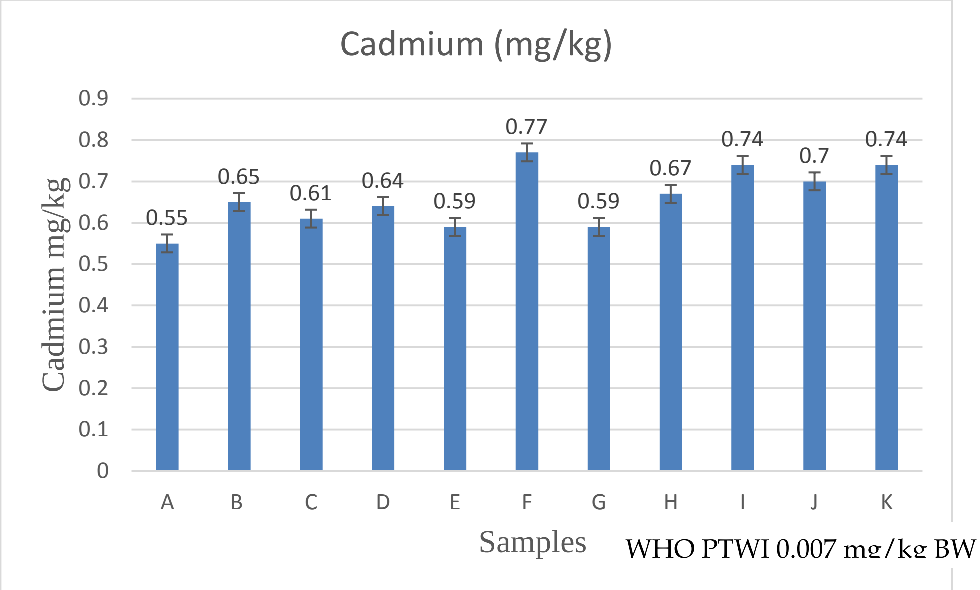


WHO PTWI 0.015 mg/kg BW

Concentration of Cadmium (Cd) in noodles

The concentrations of cadmium in the eleven brands of noodle samples are presented in figure 4.2. They ranged from 0.55 ± 0.12 to 0.77 ± 0.02mg/kg with highest and lowest average (mean ± SD) concentrations observed in sample F (0.77 ± 0.02) and A (0.55 ± 0.12) respectively. The concentration of cadmium in sample F is significantly higher ($P< 0.05$) than sample A (0.55 ± 0.12) but not statistically significant in other samples.

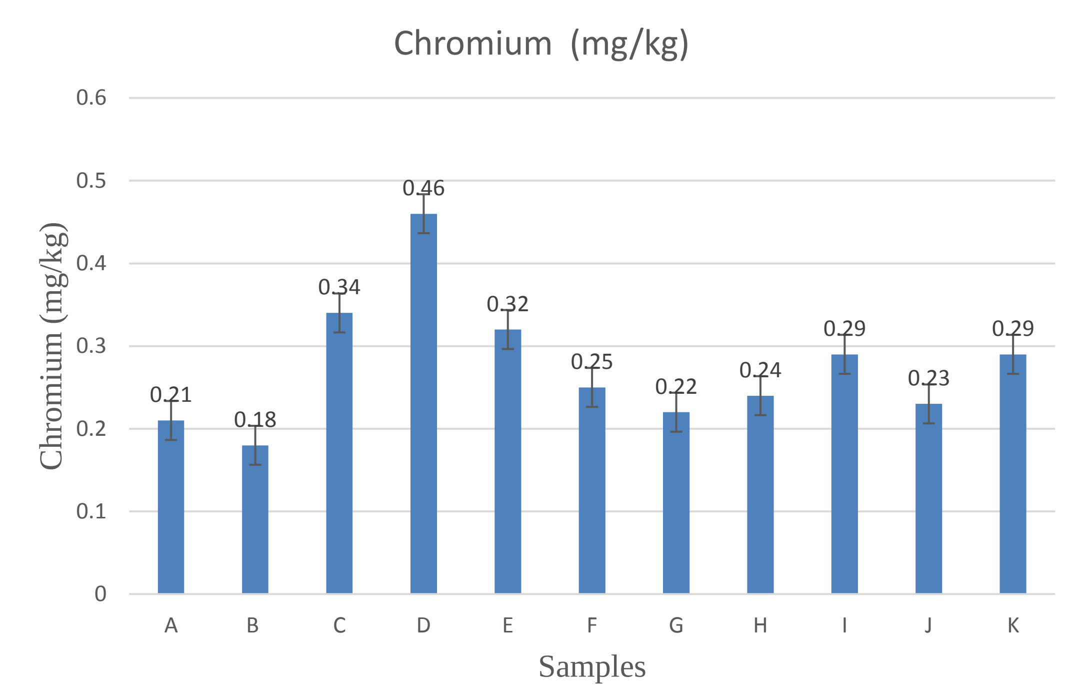
Figure 2: levels of cadmium concentration in different brands of noodles



Concentration of Chromium (Cr) in noodles

The concentrations of chromium in the eleven brands of noodle samples analysed are presented in figure 4.3 below. They ranged from 0.18 ± 0.05 to 0.46 ± 0.21 mg/kg with samples D (0.46 ± 0.21 mg/kg) and B (0.18 ± 0.05 mg/kg) recording the highest and lowest average (mean ± SD) concentrations respectively. The concentration of chromium in sample D is significantly higher ($P < 0.05$) than those in samples B (0.18 ± 0.05 mg/kg), F(0.25 ± 0.02 mg/kg), G(0.22 ± 0.99 mg/kg), H(0.24 ± 0.11 mg/kg), I(0.29 ± 0.06 mg/kg), J(0.23 ± 0.04 mg/kg) and K(0.39 ± 0.10 mg/kg) but not statistically significant in samples A(0.21 ± 0.03 mg/kg), C(0.34 ± 0.16 mg/kg) and E(0.32 ± 0.09 mg/kg).

Figure 3: levels of chromium concentration in different brands of noodles

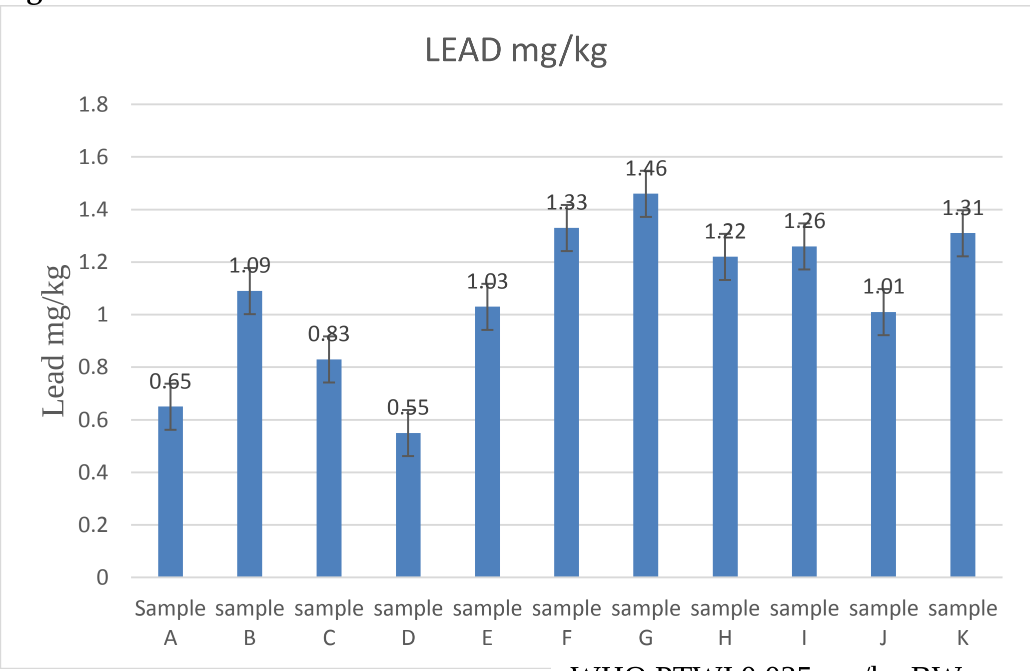


WHO PTWI 0.050 mg/kg BW

Concentration of Lead (Pb) in noodles

The concentrations of lead (Pb) in the eleven brands of noodle samples analysed are presented in figure 4.4 below. They ranged from 0.55 ± 0.08 to 1.46 ± 0.17 mg/kg with highest and lowest average (mean ± SD) concentration observed in samples G (1.46 ± 0.17mg/kg) and D (0.55 ± 0.08mg/kg) respectively. The concentration of lead in sample G is significantly higher ($P < 0.05$) than those in samples A (0.65 ± 0.12 mg/kg), C (0.83 ± 0.11mg/kg) and D (0.55 ± 0.08mg/kg) but not significant in other samples.

Figure 4: levels of lead concentration in different brands of noodles



WHO PTWI 0.025 mg/kg BW

Potential health risk assessment

The potential health risk associated with consumption of heavy metal contaminated food is presented in table 4. For a target hazard quotient less than one it is expected that no adverse health effect occurs but the hazard quotient greater than one, then adverse health effects are possible.

Table 4: Estimated average daily intake and target hazard quotient of heavy metals through consumption of noodles sold in Nigeria

Samples		Arsenic	Cadmium	Chromium	Lead
A	ADI_e	6.71E-4	2.84E-3	1.09E-3	3.36E-3
	THQ	2.24	2.84	7.23E-4	0.95
B	ADI_e	9.3E-4	3.36E-3	9.3E-4	5.63E-3
	THQ	3.27	3.36	6.2E-4	1.61
C	ADI_e	9.82E-4	3.15E-3	1.76E-3	4.29E-3
	THQ	3.27	3.15	1.17E-3	1.23
D	ADI_e	1.71E-3	3.31E-3	2.37E-3	2.82E-3
	THQ	5.68	3.31	1.58E-3	0.81
E	ADI_e	8.78E-4	3.05E-3	1.65E-3	5.32E-3
	THQ	2.93	3.05	1.10E-3	1.52

F	ADI$_e$	1.76E-3	3.98E-3	1.29E-3	6.87E-3
	THQ	5.85	3.98	8.61E-4	1.96
G	ADI$_e$	1.14E-3	3.05E-3	1.13E-3	7.54E-3
	THQ	3.78	3.05	7.5E-4	2.15
H	ADI$_e$	1.76E-3	3.46E-3	1.24E-3	6.30E-3
	THQ	5.85	3.46	8.27E-4	1.80
I	ADI$_e$	1.71E-3	3.82E-3	1.49E-3	6.51E-3
	THQ	5.68	3.82	9.99E-4	1.86
J	ADI$_e$	1.39E-3	3.62E-3	1.18E-3	5.21E-3
	THQ	4.65	3.62	7.92E-4	1.49
K	ADI$_e$	1.24E-3	3.82E-3	1.49E-3	6.77E-3
	THQ	4.13	3.82	9.99E4	1.93

Potential health risk (THQ ≥ 1)

Discussion

Instant noodle is a common household food usually consumed by children and young adults (especially students) in Nigeria. Its consumption rate is very high and this is because of its convenient method of preparation (Iniobong, Atieme, & Inimfon, 2017). Due to its high consumption rate there is need to determine the safety of its consumption. Heavy metals are the most common food contaminant this is because they can contaminate food through the raw materials or the equipment used in the production process (Li, Ma, Vander, Yuan, & Huang, 2014). This study demonstrates that heavy metals are present in varying concentrations in noodles sold in Nigerian market.

The assessment of heavy metals in the samples indicated the presence of Pb, Cr, Cd and As. The levels of As in all the samples are above the World Health Organization (WHO, 2011) tolerable limit (0.015mg/kg) and this can have adverse health effect on human health. Comparing the results of the analysis of arsenic carried out in this work to that of Jakia & Burhan (2014) on heavy metals in commercial brand of noodles, it showed that the mean arsenic content of their study was 0.36mg/kg and is higher than the mean arsenic content of this study. Surprisingly, As was not detected in the study conducted by Iniobong *et al.*, (2017) on health risk assessment of instant noodles commonly consumed in Port Harcourt, Nigeria. This may be due to the difference in samples used, raw materials, concentration of heavy metal in the soil and the equipment used in processing the noodles.

Also, the levels of Cd in all noodle samples are all above the WHO tolerable limit (0.007mg/kg) (WHO, 2011). According to Jakia & Burhan (2014), cadmium is present as a pollutant in phosphate fertilizers that are used in cereals or grains like wheat which is a major raw material for noodles. This study agrees to that of Chukwuebuka, Uche, Augustina, Odinma, & Chinweotito (2014), on quality assessment of noodles sold in Nigerian markets. It shows that there is presence of Cd in noodles but their mean Cd level (0.004mg/kg) is lower than the mean Cd level (0.65mg/kg) in this study. Cd was also not detected in the study conducted by Iniobong *et al.*, (2017).

The levels of Cr in all the samples are all above the tolerable limit (0.050mg/kg) set by WHO (WHO, 2011), Chromium (as Cr^{3+}) is an essential dietary element and occurs naturally in many vegetables, fruits, meats, and grain fruits; thus, it is of great benefit to health in that form; however, Cr^{6+} at high concentrations can cause gastrointestinal haemorrhage, haemolysis, acute renal failure, reduced sperm count, pulmonary fibrosis and lung cancer (Inoue 2013; Suzuki *et al.*, 2017). Although as Cr^{3+} is beneficial to health, in vitro studies indicated that high concentrations of it can lead to DNA damage (Eastmond, MacGregor, & RS, 2008 in Iniobong *et al.*, 2017). Cr contamination in the noodles can be as a result of unsafe agricultural practices and industrial processes (Iniobong *et al.*, 2017). Similar to a study carried out by Iniobong *et al.*, (2017), indicated the presence of chromium in noodles in varying concentrations though their mean Cr content (0.78mg/kg) is slightly higher than the mean Cr content (0.27mg/kg) in this study. Also, a study carried out by Chukwuebuka *et al.*, (2014), indicated the presence of chromium in noodles though their mean Cr content (0.08mg/kg) is lower than those in this study though all are above the tolerable limit set by WHO.

The levels of Pb in all the samples are above the WHO permissible limit (0.025mg/kg) and thus could have adverse health effects on health especially the central nervous system, the cardiovascular system, the kidney and the immune system (Bergeson, 2008 in Iniobong *et al.*, 2017). The contamination may be from raw materials such as wheat flour used in noodle production (Iniobong *et al.*, 2017). Maleki & Zarasvand (2008), opined that industrial activities could be a major source of lead in the environment. Also, Pb contamination could arise from irrigation of wheat farmland with contaminated water, application of fertilizer and metal based pesticides, industrial emmissions and transportation as well as the method of harvesting and storage. Similar work on instant noodles by Iniobong *et al.*, (2017), Jakia & Burhan (2014) and Chukwuebuka *et al.*, (2014) indicates the presence of lead in noodles in varying concentrations. Their mean lead content are 1.13mg/kg, 1.40mg/kg, 0.05mg/kg respectively. The mean lead content of Iniobong *et al.*, (2017) (1.13mg/kg), Jakia & Burhan (2014) (1.40mg/kg) is higher than the mean lead content of this study (1.06mg/kg) while that of Chukwuebuka *et al.*, (2014) (0.05mg/kg) is lower though all are above the limit set by WHO.

Mercury was not detected in any of the samples that is to say there is absence of mercury in noodle samples and this agreed to the study by Iniobong *et al.*, (2017). Heavy metal contamination of foods and their corresponding intake through the contaminated food is a major concern to Nutritionists and other health researchers. Consumption of such foods over a long period of time can lead to serious health implications such as cardiovascular diseases and cancers. They also contribute to other diseases such as Alzheimier's disease, Arthritis, Diabetes, Fatique and memory loss (Otitoju O, Otitoju GTO, Iyeghe, & Onwurah, 2014).

Conclusion

Heavy metals are environmental hazards and many developed and developing countries have continued to monitor its level of concentration in foods nevertheless they are still abundant in foods because various studies have shown varying concentration of heavy metals in foods. This study has shown that there are varying concentrations of heavy metals in noodles and suprisingly they are all above the tolerable limit set by WHO. Consumption of these heavy metal contaminated noodles will lead to bioaccumulation of heavy metals in the human body and further lead to health effects. It is essential for agricultural activities and other human activities that increase heavy metal contamination of food stuffs should be controlled (Otitoju O, Otitoju GTO, Iyeghe, & Onwurah, 2014).

Recommendation

It is strongly recommended that manufacturers of these noodles should review the sources of these heavy metals and regulatory agencies such as the National Agency for Food, Drug Administration and Control, Standards Organization of Nigeria, and Consumer Protection Council should strictly monitor the activities of food manufacturers to ensure only wholesome noodles are supplied to consumers. Similarly, nutrition awareness program should be organised in order to inform the consumers of possible health implications of these metals.

References

Arora, M., Bala, K., Shweta, R., Anchal, R., Barinder, K., & Neeraj, M. (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. *Food Chemistry, 111*, 811-815.

Bergeson, L. (2008). The proposed Lead NAAQS: is consideration of cost in the clean air act's future? . *Journal of Environmental Quality and Management, 18*, 79-84.

Bradl, H. (2002). *Heavy Metals in the Environment: Origin, interaction and remediation* (Vol. 6). London: Academic Press.

Chen, Y., Wang, C., & Wang, Z. (2005). Residues and source identification of persistent organic pollutants in farmland soils irrigated by effluents from biological treatment plants.

Chukwuebuka, O., Uche, E., Augustina, E., Odinma, S., & Chinweotito, S. (2014). Quality Assessment of Common Instant Noodles Sold in Nigerian Markets. *American Journal of Analytical Chemistry, 5*, 1174-1177.

Eastmond, D., MacGregor, J., & RS, S. (2008). Tvalent Chromium: assessing the genotoxic risk of an essential trace element and widely used human and animal nutritional supplement. *Journal of Critical Review and Toxicology, 38*(3), 173-190.

Iniobong, C., Atieme, O., & Inimfon, A. (2017). Health risk assessment of instant noodles commonly consumed in Port Harcourt, Nigeria. *Journal of Environmental Science and Pollution Research, 25*, 2580-2587.

Jakia, S. J., & Burhan, U. (2014). Detection of heavy metals in some commercial brands of noodles. *European Academic Journal, 2*(8), 10667-10679.

Li, Z., Ma, Z., Vander, K. T., Yuan, Z., & Huang, L. (2014). A review of soil heavy metal pollution from mines in china: pollution and health risk assessment. *Journal of Science and Total Environment*, 843-853.

Marketing Edge. (2017, January 01). *battle of noodle brands over market share.* Retrieved January 06, 2018, from www.marketingedge.com.ng: http://www.marketingedge.com.ng

Maleki, & Zarasvand. (2008). Heavy metals in selected edible vegetables and estimation of their daily intake in Sanandaj, Iran.

Otitoju, O., Akpanabiatu, M. I., Otitoju GTO, O., Ndem, J. I., & Uwah, A. F. (2012). Heavy Metal Contamination of Green Leafy Vegetable Gardens in Itam Road Construction Site in Uyo, Nigeria. *Research Journal of Environment and Earth Sciences, 4(4)*, 371-374.

Otitoju, G. T., Otitoju, O., & Igwe, C. J. (2014). Quantification of Heavy Metal Levels in Imported Rice Consumed in the Northern Parts of Nigeria. *Journal of Biodiversity and Environmental Sciences, 4*, 202-207.

Otitoju, O., Otitoju GTO, Iyeghe, L., & Onwurah, I. (2014). Quantification of Heavy Metals in some Locally Produced Rice from the Northern Region of Nigeria. *Journal of Environmental and Earth Science, 4*, 1-5.

Paul, B. T., Clement, G. Y., Anita, K. P., & Dwayne, J. S. (2012). Heavy metals Toxicity and the environment. *Journal of National Institute of Health, 101*, 133-164.

Sousa, C. P. (2008). The impact of food manufacturing practices on food borne diseases. *Braz Arch Biol Technol, 51(4)*, 615-629.

Suzuki, M., Takeda, S., Teraoka-Nishitani, N., Yamagata, A., Tanaka, T., Sasaki, M., et al. (2017). Cadmium-induced malignant transformation of rat liver cells: potential key role and regulatory mechanism of altered apolipoprotein E expression in enhanced invasiveness. *Journal of Toxicology*, 16-23.

Waalkes, M. P. (2000). Cadmium carcinogenesis in review. *Journal of Inorganic biochemistry*, 241-244.

WHO/FAO/IAEA. (1996). *Trace Elements in Human Nutrition and Health.* Switzerland : Geneva.