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Analysis of Heavy Metal Content and Human Health Risk in Selected Noodles Sold in Major Markets in Makurdi, Benue State, Nigeria

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Abstract

Five instant noodles samples were analyzed for proximate and heavy metals using established analytical procedures. The proximate analysis revealed the presence of moisture (3.65% - 7.80%), ash (1.11% - 5.50%), fat (13.64% - 18.69%), crude protein (0.167% - 0.202%), crude fiber (1.00% - 9.25%), and carbohydrate (63.68% - 79.72%). All essential elements (Fe and Zn) investigated in the noodle samples occurred within the WHO, (2003) standard threshold limit (10.00 - 50.00 mg/kg and 5.000 - 22.000 mg/kg), whereas heavy metals (Cd, Cr, Mn, Ni, and Pd) in some samples occurred at levels relatively above the WHO, (2003) minimum tolerable limit. A diet high in Pb, As, and Cd can cause permanent health conditions and death, as these metals are highly toxic even in small amounts and cannot be metabolized by the body. As a result, vigilance should be exercised in the subsequent intake of these noodles in order to avoid disorders connected with the accumulation of toxins over time.

Keywords: Noodles, heavy metals, health risk

Introduction

Noodles made of wheat flour are a common meal in many Asian nations. Historically, traders, migrants, and seafarers from Northern China brought noodles to various Asian and West African countries, including Nigeria. Today, more people consume noodles on a regular basis, and the development of dried noodles has made storage easier [1].

Additionally, technological innovation has been used to improve the taste of boiling noodles as well as the quality of noodles and responsiveness to client expectations. Also, the use of technology in the industries has significantly increased the use of Iron (Fe), a substance that is crucial for human health [2].

Instant noodles, which are a staple cuisine in Malaysia, lack certain nutritional components including enough dietary fiber consumption; as a result, adding lentils to the noodles increases their fiber level and indirectly raises their protein and mineral contents [3].

In the pasta market, noodles are a rapidly growing segment, being the second most popular item consumed globally after bread. This is because instant noodles have a somewhat long shelf life, are affordable, easy to make, and useful.

Instant noodles are typically made using wheat flour, which is low in protein and fiber and deficient in vital amino acids like lysine [4]. Adding alkaline salts can assist strengthen the structure and increase the final product's stiffness. Hard wheat flour is the key ingredient. Heavy metal contamination of food products is becoming an inevitable issue, though. According to Jaishankar *et al.*, (2014) [5], dangerous metals like cadmium (Cd), lead (Pb), mercury (Hg), and arsenic (As) are present in food items such instant noodles due to air, land, and water pollution.

Heavy metals have been found to enhance ecosystem components, mostly due to anthropogenic activities, rapid industrial growth, and advancements in the usage of chemicals for agricultural purposes [5]. These substances have caused metals to disperse throughout the environment, which has impacted people's health by causing them to consume food tainted with dangerous substances.

Heavy metals are regarded as toxic to living organism because of their tendency to accumulate in selected tissues. Heavy metals are toxic since they are not metabolized by the body and accumulate in the soft tissues. Over time, these buildups can cause a number of illnesses, including cirrhosis and mucosa in the mouth or nose due to arsenic, lead, cadmium, and chromium; impaired neuropsychological function and inhibition of heme biosynthesis due to elevated levels of lead in the central nervous system and blood system, respectively; tubular nephritis dysfunction and mild anemia due to cadmium in the renal system and blood system, respectively [6].

In light of the aforementioned threat and others, it is important to support initiatives like this one that aim to identify the dietary consumption and heavy metal content of consumer foods like instant noodles in order to identify possible harmful agents. In order to determine the daily intake rate of metals and the possible health hazards linked to the consumption of hazardous pollutants from Makurdi noodles, this study was conducted.

Evaluation of the Potential Health Risks for People due to Noodle Consumption

Intake of Nutrient by Human

According to Australian Critical Care (2022), adequate intake is "the average daily nutrient intake level based on the observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate."

The food and drug administration and health, respectively, use Reference Diet Intake (RDI) to calculate the daily value (DV) of food, which is printed on the information label (as% DV) in the US and Canada. If a food has 20% or more of the RDI, the terms "high", "rich in", or "excellent source of" may be used to describe it. If a food contains between 10% and 20% of the RDI, the terms "good source," "contains," or "provides" may be used on it [7] (Food and Drug Administration, April 1, 2017).

The factors used to determine the health risk of consumers after the consumption of contaminated noodles with heavy metals such as Cd, Cr, Pb, As, Ni, and Cu include daily dietary intake (DDI), daily metal intake (DMI), health risk index (HRI), hazard index (HI), and health quotient (HQ). The use of some standard thresholds to compare with the concentration of the metals determined.

Daily Metal Intake (DMI)

Estimated daily metal intakes (EDMIs) for heavy metals were calculated using the respective average concentration in food samples by the weight of food item consumed by an individual (body weight 60 kg for adult in Bangladesh), which was obtained from the household income and expenditure survey, and calculated by using the following formula:

$$DIM = \frac{C_{metal}\, x\, C_{factor}\, x\, D_{metalfood\ intake}}{BW_{average}} \quad (1)$$

Where; C_{metal} =The heavy metal concentration in noodles(mg/kg)

C_{factor} =Conversion factor = 0.012

$D_{food\ intake}$=The average

$BW_{average}$ is the body weight assuming 60 kg for adult residents [8].

Daily Dietary Intake

A Recommended Dietary Intake (RDI), sometimes referred to as recommended daily intake, is the average daily intake level of a particular nutrient that is likely to meet the nutrient requirements of 97-98% of healthy individuals in a particular life stage or gender group.

The daily dietary intake of metal was determined using the formula below:

$$DDI = X \times Y \times Z/B. \quad (2)$$

Where X= Metal in indomie

Y= dry weight of indomie

Z= approximate daily intake

B= average body weight (kg)

Health Risk Index

The health risk for the locals through the consumption of contaminated foods is defined as a quotient between the estimated exposures to the daily metal intake from soil through food chain and reference dose. It is estimated by;

$$HRI = \frac{DMI}{RfDo} \quad (3)$$

Where DMI= Daily Metal Intake

RfD= reference oral dose for metals (mg/kg bw/day)

$RfDo$ value for Cr, Cd, Ni, Zn, and Pb is 0.001, 0.04, 0.020, and 0.004 (mg/kgbw/day) respectively, [9].

Target Health Quotients

Target Health Quotients (THQ) is defined as the ratio of the body intake dose. The THQ can be calculated using the formula below;

$$THQ = Dfoodintake \times Cmetal / RfDo \times BWaverage \quad (4)$$

Where; Dfoodintake = Daily intake of indomie (kg/day)

Cmetal= Heavy metal concentration

BWaverage is the body weight 60 kg.

Permissible Guidelines for Heavy Metals in Instant Noodle

The below table gives the permissible limit of some heavy metals in instant noodles by food regulatory bodies.

Table 2: Permissible value of some heavy metals

Metals	WHO/FAO/European Standard (µg/g)	Indian standard (mg/kg)
Fe	10.0-50.0	NA
Cd	0.003	1.5
Mn	NA	ND
Pb	0.025	2.5
Zn	5.00-22.00	50.0
Cr	0.05	20
As	NA	ND

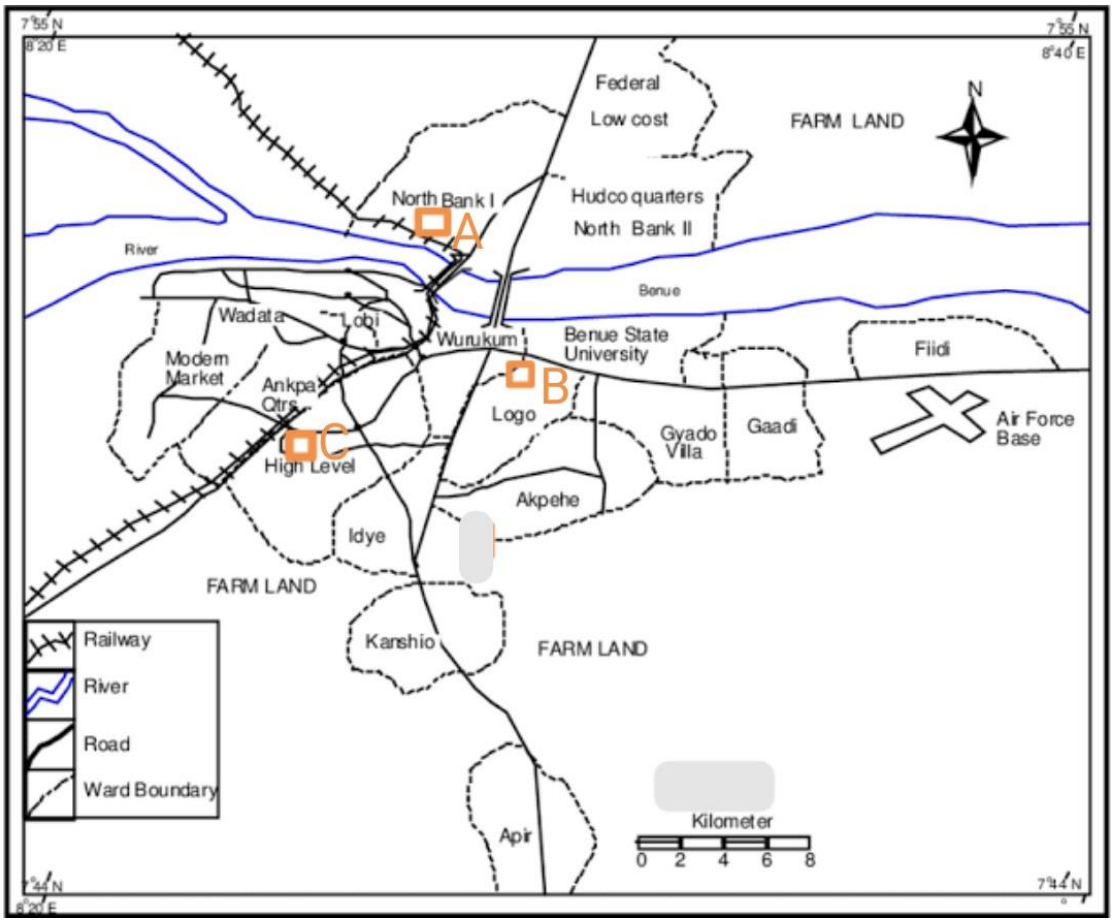
WHO (2003) World Health Organization Provisional Tolerable Weekly Intake of Toxic Heavy Metals

ND= not detected, NA= not available

Methods

Study Area

The study was carried out in Makurdi, which is a rapid growing city located at the coordinates 7.73 ◦N, 8.52 ◦E in the lower basin, the rain fall is 1200-165 mm and is distributed between March/April and October and November followed by a 4 months dry season. The daily maximum and minimum temperature during the rainy season are 30-34◦C and 22-24◦ respectively and 33-37◦C and 18-24◦C respectively in the dry season. It is situated at elevation of 104 meter above the sea level and it has a population of 292, 645. Sample A was obtained from North-Bank market, Sample B was obtained from Wurukum market, sample C was obtained from High level market.



Sample Collection

Five different brands of noodles were collected from five major markets in Makurdi. The packet noodles were labelled according to the site collected.

Sample Preparation

The sample collected were removed from sachet and pounded to powdered form using mortar and pestle and transferred into sample bottles.

Sample Digestion

All glass tubes were washed with 1 mol/L of HNO_3 solution for at least 24 hours and thoroughly rinsed 8 times with distilled water.

1 g of each sample was weighed into a digestion flask, 25 cm^3 of Nitric acid in the ratio of 1:3 respectively was mixed into separate beaker, the acid mixtures was added to the sample in the flask and was allowed to boil for 2 minutes and was then allowed to cool for 10 minutes. 5 cm^3 of the distilled water was added and then allowed to boil for 5 minutes and then let to cool. The solution was filtered into a 50 cm^3 volumetric flask and was then made up to the mark of the volumetric flask to move the sample solution [10] with water. For accuracy, each sample was digested and stored for atomic absorption spectrophotometer analysis.

Determination of Heavy Metals by AAS

In atomic absorption spectroscopy, the sample was aspirated into flame where it became atomized. a hollow cathode lamp made of metal element provide intense narrow beam of radiation into a monochromatic that separate the light into its component wavelength. A detector which measures the intensity of the light absorbed as each metal is employed which make the method relatively free of spectral or radiation interference. The amount of light intensity absorbed in the flame is proportional to the concentration of the element in the sample. This concentration concord as it appears on the digital display or readout device.

Results and Discussion

Results

Levels of potentially toxic heavy metals in five different brands of noodles sold in Makurdi. The samples were analyzed using AAS for Cr, Ni, Cd, Zn, and Pb. The results are shown in the table below.

Table 1: Concentration in ppm of heavy metals in five different brands of noodles sold in Makurdi, Benue State, Nigeria

Samples	**Heavy Metals**				
	Cr	**Ni**	**Cd**	**Zn**	**Pb**
Sample A	1.286	0.182	0.049	0.0480	0.99
Sample B	0.184	0.661	0.029	0.0502	2.48
Sample C	0.289	0.885	0.29	0.0440	1.91
Sample D	0.850	0.709	0.30	0.0369	0.07
Sample E	0.256	0.820	0.038	0.0444	1.16
WHO STANDARD	0.050	ND	0.003	5.000-22.000	0.025

ND: means not detected.

Table 1 displays the different levels of heavy metals found in the six brands of instant noodles that were evaluated for heavy metal content. The concentrations of Cr in five brands of noodles ranges from 0.184-1.286 mg/kg which is above the permissible limits (0.050) set by WHO. With the highest concentration been in Sample A and the lowest in sample B. The concentration of Cr in all the samples, exceeds the limit set by the WHO (0.050 mg/kg), therefore caution should be taken in the regular daily intake of these noodles to prevent health problems related with Cr contamination and bioaccumulation. The values obtained in this study is higher than the values (0.184-1.286 mg/kg) reported by Odidika *et al.*, (2020) [11]

Although chromium (as $Cr^{3+)}$ is a necessary dietary component and can be found naturally in a variety of fruits, vegetables, meats, and grains, high concentrations of Cr^{6+} can result in intestinal

bleeding, hemolysis, acute renal failure, decreased sperm count, pulmonary fibrosis, and lung cancer [12] [13].

The concentrations of Nickel were found to range from 0.182 to 0.885 with the highest concentration in sample C and the lowest in sample A. The WHO set permissible limit for Ni could not be accessed in the course of this research. Therefore, no further discussion could be rightly made in this regard. Nickel is a transition element extensively distributed in the environment, air, water, and soil. It may derive from natural sources and anthropogenic activity. Nickel contact can cause a variety of side effects on human health, such as allergy, cardiovascular and kidney diseases, lung fibrosis, lung and nasal cancer. Although the molecular mechanisms of nickel-induced toxicity are not yet clear, mitochondrial dysfunctions and oxidative stress are thought to have a primary and crucial role in the toxicity of this metal [14].

The concentration of Cadmium ranges from 0.049 to 0.29 with the highest been in sample C and the lowest been in sample A. Also, when compared with the WHO permissible limits (0.003), it was found that the concentration is slightly above limit. Which pose risk to consumers. Hence such noodles could be considered as being harmful to humans if taken over a long period of time due to bioaccumulation. Cadmium and its compounds have several health effects in humans. The health effects of cadmium exposure are exacerbated due to the inability of the human body to excrete cadmium. Cadmium can cause both acute and chronic intoxications [15]. Cadmium is extremely toxic to the kidney and it accumulates in the proximal tubular cells in higher concentrations. Bone mineralization may result from cadmium-induced renal failure or bone injury. Due to its regular occurrence, food, drink, and breath can all contain measurable amounts of cadmium [16].

The concentration of Zinc ranges from 0.369 to 0.502 with the highest been in sample B and the lowest been in sample D. The concentration of Zn was found to be within the WHO permissible limit in all five samples, therefore samples A-E all be rich in the essential Zn metal without any detrimental health effect. Zinc is naturally found in soil, but Zn levels are rising unnaturally due to man-made activities, especially mining, coal, and waste combustion, industrial activities, and steel processing. Numerous foodstuffs contain certain concentrations of Zn. Plants often have a Zn uptake that their systems cannot handle due to the buildup of this element in soils [17].

The concentration of Lead ranges from 0.07 to 2.48 with the highest been in sample B and the lowest been in sample D. The concentration levels of Pb in all the samples are above the World Health Organization (WHO, 2011) permissible limits (0.025 mg/kg) and thus could have adverse effects on health especially the central nervous system, the cardiovascular system, the kidneys, and the immune system [18] [19]; It is possible that unprocessed ingredients like wheat flour used to

make noodles caused the contamination. According to Ali and Al-Qahtani's (2012) [20] research, there may be a correlation between high levels of heavy metals in food and the air pollution caused by industrial activity. Additionally, Pb contamination may result from industrial emissions, fertilizer and metal-based pesticide applications, transportation, harvesting, and storage practices, and irrigation of wheat fields with polluted water. Satsananan, (2017) [21] conducted similar research on instant noodles and found that Pb was within WHO guidelines.

Evaluation of potential human risk from noodle consumption

Human exposure to heavy metals can occur from a variety of sources, including food, soil, water, and air. The last of these is a significant exposure pathway. Characterization of potential toxic effects caused by the extreme presence of heavy metals, such as Cr, Ni, Pb, Cd and Zn, all throughout the food chain, is measured by human health risk assessment. However, it's not possible to estimate the risks without prior determination of metal concentration in food. In this study, only the exposure route of noodle consumption was considered for the results of human health risk calculations (Tables 2-8).

However, the estimated health risk based on various factors was found to be acceptable even for a single exposure route The average daily intake of heavy metals in pasta obtained in this study ranges from 0.0122-0.0851 $\mu g \cdot kg^{-1} \cdot day^{-1}$ for chromium, 0.0016-0.8050 $\mu g \cdot kg^{-1} \cdot day^{-1}$ for Nickel, 0.002-0.0191 $\mu g \cdot kg^{-1} \cdot day^{-1}$ for cadmium, 0.0024-0.033 for Zinc and 0.046-0.164 for Lead. All obtained values were lower than the RfD for those elements, which means that they are not likely to be associated with adverse health risks.

As shown in Table 7, the DDI (mg/person/ day) daily dietary intake of Ni metal recorded the highest-level concentration in noodles 7.6×10^2 and 66.486 (mg /kg/person/day) respectively while Cadmium recorded the lowest level of concentration in noodles 9.7×10^{-2} -10.047 (mg /kg/person/day) respectively.

The result in Table 8 shows the target hazard quotient (THQ) of heavy metal in noodles in the study area. The result shows that the THQ values for the heavy metals which were detected in the noodles were less than 1. This implies that the heavy metals concentration in the noodle is not posing any risk and there is no potential health risk associated with the consumption of the noodles at the moment. According to IRIS, it is only THQ values greater than 1 designates there is potential health risk associated with the consumption of food contaminated with a certain pollutant or heavy metal (IRIS (2003). Based on this, THQ agrees with the fact that the mean concentrations of these heavy metals in the noodle are still low and are within the permissible limits of FAO/WHO.

Table 2: Average daily intake of heavy metals (Cr), average body weight and average weight of noodles

Sample	Average daily intake of Cr (kg/person/day	Average body weight (kg)	Average weight of package noodles (kg)
Sample A	0.0851	63.45	85
Sample B	0.0122	63.45	85
Sample C	0.0191	63.45	85
Sample D	0.0563	63.45	85
Sample E	0.0169	63.45	85

Table 3: Average daily intake of Ni, average body weight and average weight of noodles

Sample	Average daily intake of Ni (kg/person/day)	Average body weight (kg)	Average weight of package noodles (kg)
Sample A	0.0120	63.45	85
Sample B	0.8050	63.45	85
Sample C	0.0586	63.45	85
Sample D	0.0469	63.45	85
Sample E	0.0016	63.45	85

Table 4: Average daily intake of Cd, average body weight and average weight of noodles

Sample	Average daily intake of Cd (kg/person/day)	Average body weight (kg)	Average weight of package noodles (kg)
Sample A	0.0032	63.45	85
Sample B	0.002	63.45	85
Sample C	0.0191	63.45	85
Sample C	0.365	63.45	85
Sample D	0.003	63.45	85
Sample E	0.003	63.45	85

Table 5: Average daily intake of Zn, average body weight and average weight of noodles

Sample noodles	Average daily intake of Zn (kg/person/day)	Average body weight (kg)	Average weight of package (kg)
Sample A	0.0032	63.45	85
Sample B	0.0033	63.45	85
Sample C	0.0029	63.45	85
Sample D	0.0024	63.45	85
Sample E	0.0029	63.45	85

Table 6: Average daily intake of Pb, average body weight and average weight of noodles

Sample noodles	Average daily intake of Pb (kg/person/day)	Average body weight (kg)	Average weight of package (kg)
Sample A	0.066	63.45	85
Sample B	0.164	63.45	85
Sample C	0.126	63.45	85
Sample D	0.046	63.45	85
Sample E	0.077	63.45	85

Table 7: DDI for heavy metals

Samples	**Heavy Metals**				
	Cr	**Ni**	**Cd**	**Zn**	**Pb**
Sample A	60.297	17.067	1.641	7.0×10^{2}	4.735
Sample B	8.62×10^{2}	15.576	9.7×10^{-2}	46.937	11.861
Sample C	13.55×10^{3}	8.2×10^{3}	9.712	41.14	9.135
Sample D	39.854×10^{2}	66.486	10.047	5.4×10^{-2}	3.3×10^{-2}
Sample E	12.0×10^{2}	7.6×10^{2}	1.273	6.5×10^{-2}	5.548

Table 8: THQ for heavy metals in noodles

Samples	Heavy Metals				
	Cr	**Ni**	**Cd**	**Zn**	**Pb**
Sample A	6×10-4	3×10-4	5×10-3	3×10-2	4.91*
Sample B	4×10-6	3×10-4	5×10-3	2×10-3	1.59*
Sample C	1×10-4	3×10-4	5×10-3	4×10-3	6.7×10-3
Sample D	39×10-3	3×10-3	5×10-3	4×10-3	42.9×10-2
Sample E	4×10-6	21×10-3	5x10-3	3×10-3	2×10-3

Conclusion

This study assessed the human health risk from heavy metals in five instant noodles sold in Makurdi, Benue, Nigeria. The levels of heavy metals (exception of Zn and Ni) in all brands of the noodles (Sample A to Sample E) were above the maximum permissible limits established by WHO. The continuous consumption of these noodles may lead to heavy metal toxicity which could result in impaired neuronal and renal functions. Although some of the heavy metals are within the permissible limit (Zn), their consumption could still be unsafe because of the cumulative potential of these contaminants.

From the health point of view, the average daily intake for the individual metals showed the estimated health risk values obtained were all lower than the recommended permissible limit set by WHO/FAO. While the calculated THQ values on humans due to the combined effect of all the metals considered in the study area were found to be less than 1, which indicate that potential health risk for consumption of noodles is insignificant.

To guarantee that only healthy noodles are given to customers, it is highly advised that government regulatory bodies like the Consumer Protection Council, Standards Organization of Nigeria, and the National Agency for Food, Drug Administration and Control closely monitor the activities of these noodle manufacturers.

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