ASSESSMENT OF HEAVY METAL CONTAMINATION OF STREET VENDED FOODSTUFFS IN MAKURDI

Supported by tetfund

John Omenka Ajegi [1], Benjamin Ishwah [2], Ekaete Johnson [1], Wallace Igori [1]
[1] Department of Chemistry College of Education Oju Benue State Nigeria
[2] Department: of Chemistry Benue State University Nigeria
*Corresponding Author's E-mail: omenkaajegi83@gmail.com

Received: May 11, 2023 Accepted: August 15, 2023

Abstract

There may exist some health concerns associated with the consumption of street vended foods due to contamination by heavy metals. Roadside dust and vehicular emissions have been reported to be the major sources of street vended foods contaminants in the urban areas. In the current research, six of such commonly vended and highly consumed foodstuffs within Makurdi metropolis; fried yam, roasted chicken, boiled eggs, pork, garri and akara were assessed for heavy metal contamination (Zn, Cd, Cu and Pb) using an atomic absorption spectrophotometer. From the result obtained, Lead was below detectable limit in all samples except in chicken meat where the concentration was 8.50±0.03 mg/kg and was above the recommended limit by W.H.O, EPA and FAO. Cadmium was detected above permissible limits in all the food samples, ranging from 1.30±0.03 mg/kg in roasted eggs along Wadata road to 6.90±0.00 mg/kg in garri vended along Akpehe road. Generally, the concentration of cadmium was higher in samples in from Akpehe road than in Wadata market road. Zinc had the highest concentration in all the metals, ranging from 12.50±0.02 mg/kg in roasted eggs samples from Akpehe road to 230.82±0.00 mg/kg in roasted chicken along the same road. Nickel and copper were also detected above permissible limits, ranging from 4.56±0.02 mg/kg to 15.80±0.02 mg/kg and 0.45±0.00 mg/kg to 7.50±0.03 mg/kg respectively. The variation in concentrations of these metals have been attributed to several factors, mainly vehicular traffic density and vendors' handling of the food items. It was therefore recommended that food sold along the roadside be handled with adequate compliance to standards of hygiene to prevent contamination by heavy metals and safeguard public health.

Keywords: Contaminants, Heavy metal, Permissible limit, Street vended food

Introduction

Food is usually a plant or animal product consumed for its nutritional support for growth and wellbeing (WHO/FAO, 1996; Opeolu *et al*., 2020). Food materials are known to contain essential nutrients such as carbohydrates, proteins, vitamins and minerals that are vital to the sustenance of life, hence they are consumed by humans on daily basis for the purposes of growth, energy, and good health.

Today, many people depend largely on vended foods to meet their daily nutritional needs. They resort to these streets vended fast foods due to the fact that they hardly find the time to prepare their own meals, and these foods are cheap and readily available. There is no doubt vended foodstuffs provides a large source of employment in many developing countries, Nigeria inclusive (Zenbaba *et al*., 2022; Katiyo *et al*., 2019). This perhaps contributes significantly to household income. Roadside vending of foodstuffs is hardly regulated in Nigeria, resulting in an all comers situation, with the vendors rarely observing best practices in the handling of the foodstuffs with respect to hygiene (Mohamed *et al*., 2018). Research has revealed that most handlers of street food in developing countries are ignorant of the basic food safety measures, consequently, street foods are commonly exposed to various contaminants at different stages of handling (Ogu *et al*., 2017; Aondoakaa *et al*., 2017)

Rapid industrial development has contributed to the elevation of the concentration of pollutants and contaminants in the environment. This has invariably resulted in the elevation of the concentration of heavy metals in urban environments of developing countries. The contamination of the environment by pollutants has negatively impacted the quality of the food and the purposes for which these foods are consumed are not successfully achieved (Kelvin *et al*., 2015)

One of the most likely contaminants of street vended foods are heavy metals. Heavy metals are elements having atomic weights between 63.5 and 200.6 u, and a specific gravity greater than 5.0 kg/m^3. Most of the heavy metals are dangerous to health or to the environment. Heavy metals in street vended foods include lead, chromium, mercury, uranium, selenium, zinc, arsenic, cadmium, silver, gold, and nickel, most of which are associated with vehicular emissions (Das *et al*., 2019). The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as the World Health Organization (WHO) and Food and Agricultural Organization (FAO). Acute heavy metal intoxications may damage central nervous function, the cardiovascular and gastrointestinal (GI) systems, lungs, kidneys, liver, endocrine glands, and bones (Wardhana *et al*., 2021). These heavy metals are present in road side vended foods as a result of so many factors including automobile emissions and other anthropogenic activities. Although heavy metals occur as natural constituents of the earth crust, they are mostly considered persistent environmental contaminants since they cannot be degraded or destroyed. Hence, they can enter the body system through food, air and water (Desye *et al*., 2023). It has been discovered that some illnesses can result from the consumption of roadside vended foodstuffs, a situation attributable to poor sanitary practices by the vendors. In developing countries, many are known to have suffered from the effects of contaminated street vended foodstuffs. People

consume these foods because they are cheaper, ironically, those who consume them are exposed to food-borne diseases (Rortana *et al*., 2021; Ezirigwe *et al*., 2018). Research has revealed that worldwide, about 2.5 billion people patronize street vended foods on a daily basis. With Nigeria having such a high population (over 280 million people), there is no doubt a huge number of the people are exposed to the risks associated with the consumption of these foods (Adebayo *et al*., 2010)

Roadside dust and vehicular emissions have been known to be significant sources of heavy metals such as Cu, Hg, As, Cr, Mn, Ni, Cd, Zn, Fe, Al and Pb. This is attributed mainly to deposition of metal particulates from motor vehicles (Alum *et al*., 2016; Abdulmajid *et al*., 2014). They may be contained in vehicular exhaust fumes or parts such as tires, catalytic converters and brake pads/disks that tend to wear and tear over time, resulting in the release of their constituent elements, which include these heavy metals, into surrounding environments. Therefore it is likely that with the exposure of these foodstuffs to the elements due to poor handling, the heavy metals may end up being deposited on them (Iwegbue *et al*., 2008)

In light of the foregoing, it has become imperative to assess the quality of these commonly vended foodstuffs such as *garri*, grilled eggs, *akara*, fried yam, pork and roasted chicken with respect to their concentration of heavy metals, especially in densely populated urban centers such Makurdi.

Materials and Methods

Study area

The research was conducted in Makurdi town, the Benue state capital. Makurdi is located at latitude 7º 38'N - 7º 50'N and longitude 8º 24'E - 8º38'N. It is situated in the Benue valley in North Central Nigeria. Both Akpehe and Wadata are densely populated areas within Makurdi, with high vehicular traffic, and with very significant street vending activities as shown in Fig. 1.

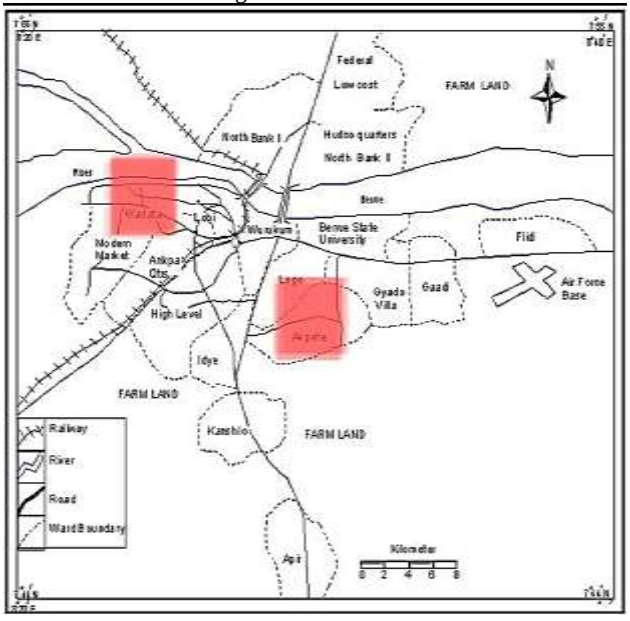

Fig. 1: The shaded portions shows the two major sampling location- Akpehe and Wadata.

Sampling

Six different varieties of commonly consumed street vended food samples namely yam, *akara*, *garri*, boiled eggs, pork, roasted chicken were purchased directly from vendors at two different locations in Makurdi – along Akpehe road (Wurukum) and Wadata market road. The food samples were collected in appropriately labelled zip-lock plastic bags. Each of the foodstuffs were collected from three different vendors in each of the two study locations. All three batches of each items from each location were blended together to obtain a composite sample of each food item. The three sampling points in each of the two locations were at least fifty meters apart. This implies that there was a total of eighteen samples for each sampling site (Akpehe road and Wadata).

For the collection of control samples, the sampling were done just as described above, but in this case, the samples were collected before the foodstuffs are put on display or exposed to the elements.

Chemicals and Reagents

Analytical grade reagents were used for all analyses and are products of Aldrich Chemical Company, England**.**

Concentrated trioxonitrate (v), (HNO_3), and hydrochloric acid was used for digestion while double distilled water was used to rinse the apparatus before and after every use, and deionized water to analyze the digested samples.

Sample preparation

With the exception of the garri samples, all other samples were diced into smaller sizes using a stainless steel knife. Sufficient portions were taken and dried in an oven at 105℃ for 24 hours. After drying, they were crushed into fine powder using a mixer grinder. Powdered samples (2g each) with three powdered replicates were taken from each food item and placed in a silica crucible, and a few drops of concentrated HNO_3 was added to aid ashing. Dry ashing was carried out in a muffle furnace by stepwise increase of the temperature up to 550℃ and the samples will be left to ash for 6 hrs. The ash was kept in desiccators and then rinsed with 3M hydrochloric acid. The ash suspension was filtered into a 50 mL volumetric flask through a Whatman No. 1 filter paper and the volume made up to the mark with 3N HCl.

Standards: Standard solutions of the heavy metals, namely, lead (Pb), cadmium (Cd), copper (Cu), nickel (Ni), and zinc (Zn), were purchased from Merck (Darmstadt, Germany). The standards were prepared from the individual 1000 mg/L standards (Merck) supplied in 0.1 N HNO_3. A series of working standards were prepared from these standard stock solutions.

Quality assurance

Appropriate quality assurance procedures and precautions were taken to ensure the reliability of the results. Samples were carefully handled to avoid cross-contamination. Glassware was properly cleaned, and reagents used were of analytical grades. De-ionized water was used throughout the study. Reagent blank determinations were used to apply corrections to the instrument readings.

Heavy metals Analysis

The metal elements (lead, cadmium, copper, nickel and zinc) were analyzed by using Atomic Absorption Spectrophotometer at wavelength of 248.3nm, 217.0nm,

228.8nm and 193.7nm respectively using acetylene gas, air and N_2 gas.

Data collection and statistical analyses

Two types of statistical analyses were be carried out on the replicated values of the quantitative results using the computer-based SPSS (statistical) software version 17.0. Firstly, one-way analysis of variance was conducted along with Duncan's multiple range tests (at $P<0.05$) to compare the means of each heavy metal across the six food items; and secondly, for each heavy metal, the mean for each food item will be compared with permissible levels as test value using a one-sample student t-test at 99% confidence interval of the difference.

Results and Discussion

The concentration of heavy metals in the selected food-stuffs obtained in this study are shown in Tables 1 and 2.

Table 1. Concentration of heavy metals in some Roadside vended Foods at Akpehe Road in mg/ kg (mean ± SD)

Heavy metals	Control samples	Pork meat	Fried yam	Boiled eggs	Roasted Chicken	Akara	Garri	FAO/WHO/EPA permissible limit (mg/kg) (2015)
Zn	10.00 ±0.00	280.30±0.00	75.22±0.01	12.50±0.02	230.82±0.00	108.40±0.01	45.03±0.01	50.00
Cd	0.01±0.00	4.30±0.00	2.80±0.03	6.50±0.02	1.60±0.01	2.93±0.03	6.90±0.00	0.05-0.20
Ni	0.01±0.00	4.56±0.02	6.41±0.01	7.01±0.00	8.20±0.03	5.52±0.01	8.42±0.00	0.50
Cu	0.02±0.00	1.60±0.01	7.50±0.03	0.45±0.00	4.20±0.00	2.50±0.02	BDL	0.05-0.50
Pb	BDL	BDL	BDL	BDL	8.50±0.03	BDL	BDL	0.50-0.20

Notes: BDL = below detectable limit, SD = standard deviation. Data represented in mean of three replicates

Table 2. Concentration of heavy metals in some Roadside vended Foods at Wadata in mg/ kg (mean ± SD)

Heavy metals	Control samples	Pork meat	Fried yam	Boiled eggs	Roasted Chicken	Akara	Garri	FAO/WHO//EPA permissible limit (mg/kg) (2015)
Zn	7.00 ±0.00	280.60± 0.00	82.03±0.01	160.52±0.00	142.05.±0.00	170.25.40± 0.00	50.20.03±0.03	50.00
Cd	0.02±0.00	3.10±0.00	2.01±0.00	1.30±0.03	3.50±0.00	3.20±0.00	2.50±0.00	0.05-0.20
Ni	0.03±0.00	6.09±0.02	5.80±0.00	6.20±0.00	6.70±0.00	15.80±0.02	6.30±0.00	0.50
Cu	0.02±0.00	3.30±0.02	6.50±0.01	3.00±0.00	3.01±0.00	7.02±0.00	BDL	0.05-0.50
Pb	BDL	BDL	BDL	BDL	8.50±0.03	BDL	BDL	0.50-0.20

Notes: BDL = below detectable limit, SD = standard deviation. Data represented in mean of three replicates

Generally, the contamination of food by metals in areas with high anthropogenic activities, vehicular emission and industrial activities is widespread and is a major determinant of food quality (Colak *et al*., 2005). Most of the heavy metals are dangerous to health and the environment. Heavy metals that contaminate street vended food stuff include, lead, cadmium, silver, gold, nickel, zinc, arsenic, mercury and uranium. These heavy metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as WHO, EPA, FAO and so on (Soepranianondo *et al*., 2019). Acute heavy metals intoxication may damage the central nervous system, the cardiovascular and gastrointestinal systems, lungs, kidney, liver endocrine glands and bones (Divikli *et al*., 2006; Divikli *et al*., 2003). Food contains mostly organic matter and heavy metals remains associated with it. Hence there is no possibility to affect the heavy metal content in food samples during frying, heating and drying and culinary processing of food affects their bioavailability (Abdulmijid *et al*., 2014; Khan *et al*., 2013)

Lead, when entering the body, has properties similar to calcium, that is, it accumulates in the bones and in the hair. Intake of lead can cause several severe malfunctions of the body including acute poisoning such as physical exhaustion, dizziness, vomiting and muscle spasms; headache and difficulty sleeping; chronic poisoning which anemia and slim body are accounted. Furthermore, lead has an ability to inhibit the activity of enzymes as well as the process of red blood cell formation causing anemia. It can, in addition, results in bone decay, and creates damages in the nerve cells causing the brain to swell and inhibiting the activity of chemicals in the brain leading to the risk of dementia and neurological symptoms (Obhanardakani 2017). Moreover, it could lead to kidney damage which then results in renal

failure as well as reproductive system malfunction; weak sperm, ovarian atrophy, irregular menstruation and risk of infirmity (Nurudeen *et al*., 2014).

The heavy metals concentration of Pb in this study were below the detectable limit set by FAO, WHO and EPA except for chicken meat with values ranging from 5.60 – 8.50 mg/kg which were higher than the permissible limit of 0.50 – 0,20 mg/kg by FAO, WHO and EPA (WHO/FAO 1996). The level of Pb observed in this study is comparable to those reported by Nurudeen *et al* (2014) for fried chicken 4.50 mg/kg and Oyelola *et al* (2013) for roasted chicken (7.20 mg/kg). This concentration of Pb could be attributed to the point of sale (open display of food along road-sides due to emissions from vehicular traffic.

Cadmium

Cadmium is a metallic element that occurs naturally at low levels in the environment**.** Cd exposure occurs through food, which a major route (Iweala *et al*., 2014). The data obtained in respect of Cd in this study revealed that the level of the metal in the vended food was higher than the previously reported concentration in food and above the limit set by FAO, EPA and WHO (0.05 – 0.20.mg/kg) with values ranging from 1.30 – 6. 90 mg/kg. This result is in agreement with that reported by Oyelola *et al* (2013). There was no significant difference in the Cd content of the vended food at $P<0.05$ on the two sampling locations. The presence of Cd in the analyzed samples is in agreement with the Cd content of street vended foods and volume of vehicular traffic as reported by Iwegbue *et al* (2013). High concentration of Cd in the body is detrimental to health and causes bone disorder, anemia, cancer of the lungs and renal damage, hence its concentration must be checked to ascertain tolerable limit set by regulatory bodies (Olalekan *et al*., 2014; Stopforth *et al*., 2012)

Copper

Copper is a metal that is essential to the body. To clarify, it is a part of the formation of hemoglobin and the function of some enzymes which are peroxidase and cytochrome oxidase such as amino acids, amines and alcohols. Copper also helps in delivering oxygen into cells. In addition, it is a component of many drugs; such as those that induce vomiting, burn wounds, anthelmintic drugs and fungicides (Tobias *et al*., 2013)

The presence of Cu in food samples is likely to be from the soil, especially for cereal products which is a rich source of the metal and also from the utensils used in processing the food and from the burning of fossil fuels (Sobukola *et al*., 2010). High Cu concentration was recorded in this study (0.45 – 7.50 mg/kg) when compared with the values by previous researchers which were 0.06, 0.05, 0.63 and 0.70 mg/kg. The concentration of Cu was below the detection limit for *garri* in the two sampling locations and no significant difference exist at $P<0.05$. The concentration of Cu obtained in this study is higher than recommended limit of 0 .05 – 0.5 mg/kg by WHO and FAO and this data is in consonance with previous research work on some food and drinks in Ota, Ogun State Nigeria and road side roasted corn and plantain from Alimosho Local Government Area of Lagos State Nigeria (Oyelola *et al*, 2013). The presence of Cu in the sample is an indication that it was contaminated by automobile emission. Excessive copper in the body is associated with nausea and diarrhea, including anemia, kidney damage and inhibition of urine production (Tegegne *et al*., 2015)

Zinc

Zinc is found existed in human body as a component of various enzymes. It helps to promote development in memory and learning in children, as well as the functioning of the reproductive system. Similarly, it helps a body to achieve fertility according to the appropriate age and stimulates the work of sex hormones. (Ezirigwe 2018). Additionally, it is used in plant growth accelerators or in fertilizers, used in the pharmaceutical industry, used to coat metal to prevent rust, and used as an octane booster in fuel industry (Laura *et al*., 2010)

Zinc is an essential nutrient for both plant and animals and its importance lies in the fact that many body functions are linked to zinc-containing enzymes. The side effects of consuming excess zinc in humans include focal neuronal deficits, epigastric pains, vomiting, and respiratory disorder after inhalation of zinc smoke and diarrhea (Lanre-Iyanda *et al*., 2012). The Zn concentration in the analyzed sample were in the range of 45.30 – 280.00 mg/kg. Similar values were obtained by Ojo *et al*., (2015) on Toxic and essential metals in staple foods commonly consumed by students in Ekiti State, South West, Nigeria. The higher concentration of Zn could be attributed to emission from automobiles arising from vehicle exhaust and wear arriving from some vehicular parts such as brake pads and disks. The concentration of zinc in pork meat, chicken meat, fried yam, grilled eggs were above the WHO/FAO permissible limit of 50.00 mg/kg. The values for the analyzed samples ranges from 12.50-280.30 mg/kg for samples harvested from Akpehe road and 50.20-280.60 mg/kg for those from Wadata market road. The values were above the allowable limit except for garri and boiled eggs (45.03 and 12.50 mg/kg) and were significantly different from the samples between the two sampling points.

Nickel

Nickel can occur in plants and animals based-foods and drinks. Ni plays an important role in the function of enzymes involved in the nitrogen fixation process (Salama *et al*., 2005) Nickel is an element that the body does not need. However, when it accumulates more higher and higher in the body, it can cause symptoms including: nausea, headache, vomiting and chest pain, weak and slim body, severe pneumonia, abnormally fast pulse, high blood pressure, risk of ruptured blood vessels in the brain which can lead to paralysis, and risk of cancer (Bamuwamye *et al*., 2015).

Contamination can occur at any state of the production, processing or packaging of foods. Ni can leach from contact materials to food or drinks before their consumption by human (Abedi *et al*., 2018). The values of Ni ranged from 4.56 – 15.80 mg/kg and slightly above those reported by Salama, *et al* (2005). Ni is also carcinogenic to humans causing lungs and nasal cancer on acute exposure. The concentration of Ni in the food samples across the two sampling locations were above the 0.05 mg/kg permissible limit set by WHO/FAO and EPA. This could be attributed to emission from the burning of liquid and solid fuels, as well as municipal and industrial waste from the point of sales (Ogunkunle *et al*., 2014; Olaoye *et al*., 2010).

Conclusion

Assessment of heavy metals content in street vended foods that are commonly consumed by people in the Makurdi metropolis has been carried out**.** The concentration of five heavy metals; Zn, Cd, Ni, Cu and Pb were determined in food samples procured from Akpehe road (Wurukum) and Wadata market in Benue State. The results of the analysis revealed food products exposed by road side are contaminated by heavy metals from automobile emissions. It was found that the concentration of Zn, Cd, Ni and Cu street vended foods were above the permissible limit by WHO/FAO and EPA. The concentration of Pb was below detection limit for all the samples except chicken meat obtained from the two sampling locations. Hence, necessary hygienic and sanitary measures should be employ during the various stages of production and supply of these foods to avoid contamination by heavy metals and microorganisms. Therefore health authorities to create evolve strategies to enlighten streets food vendors as to the health implications of improperly handling their products and ensure standards are strictly informed amongst street vendors in order to safeguard public health

Funding

This Research was funded by Tertiary Education Trust Fund Institution-Based Research projects (IBR) Intervention [TETFUND] of the College of Education Oju, Nigeria.

Acknowledgement

We acknowledged the contributions of College of Education Oju, Nigeria towards the success of this work

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Competing interest

Authors have declared that no competing interests exist.

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