EVALUATION OF HEAVY METAL CONTAMINATION IN APPLE, ORANGE, AND WATERMELON RETAILED ALONG ROADSIDES IN OKINNI, EGBEDORE LOCAL GOVERNMENT, OSUN STATE, NIGERIA

ABSTRACT

The escalating concern of heavy metal contamination in fruits underscores the need to evaluate associated health risks linked to their consumption. This study undertook assessment of heavy metal levels in commonly consumed fruits (orange, watermelon, and apple) retailed by roadside vendors in Okinni, Egbedore Local Government Area, Osun State. Data collection encompassed a meticulously designed questionnaire while 27 fruit samples (nine fruit each) were randomly procured from diverse market for laboratory analysis. Descriptive statistics, including frequency distribution, mean, and standard deviation, were computed for each heavy metal. The study discerned that majority of vendors predominantly procured their fruits from local farms, implemented the use of fertilizers or pesticides, employed baskets for storage and transportation, and generally held positive perspectives regarding the safety of fruits dispensed by roadside vendors. The results of heavy metal concentration averages in the sampled fruits fell within the permissible limits established by the World Health Organization (WHO) guidelines for safe levels in food. However, noteworthy concentrations of certain heavy metals, particularly As and Cr, were identified, signaling potential health risks for consumers. These findings underscore the ongoing necessity for rigorous monitoring and regulation of heavy metals in food, coupled with adherence to recommended dietary guidelines and safety standards to safeguard public health.

Key words: Heavy metal contamination, Fruit consumption, Health risks, Roadside vendors, Food safety

Introduction

Heavy metals, characterized by their relatively high atomic weight and density compared to water, are naturally occurring elements with diverse applications that have led to their widespread distribution in the environment. This ubiquity has raised significant concerns regarding their potential impacts on both human health and the environment. The global phenomenon of heavy metal contamination poses serious risks to ecosystems and human well-being, particularly in the face of increased urbanization, property transitions, and industrial development, especially in densely populated and emerging nations (Zhang,, 2020).

Originating from both anthropogenic and natural sources, certain heavy metals, such as chromium (Cr), vanadium, and nickel (Ni), play essential roles in cellular activity and are vital for human health in trace amounts (Afonne, and Ifediba, 2020). However, the dual nature of heavy metals means that some of them, including arsenic (As), cadmium (Cd), chromium, and lead (Pb), have detrimental effects on the environment and living organisms, including humans (El-Kady, and Abdel-Wahhab, 2018).

Human exposure to heavy metals occurs through inhalation, oral ingestion, and skin contact (Sanaei, Sanaei, Amin, Alavijeh, … Rezakazemi, 2021). The concentration of metal ions in living cells must be carefully regulated to maintain a balance between positive and negative effects. While essential metals like cobalt (Co), copper (Cu), nickel, lead (Pb), manganese (Mn), zinc (Zn), molybdenum (Mo), and selenium (Se) are crucial for living organisms, their consumption above safe limits can result in severe health complications. On the other hand, non-essential metals like arsenic, cadmium, chromium, and lead can cause health issues even at low concentrations (Munir, Jahangeer, Bouyahya,… Ali, 2022).

The mobility and bioavailability of heavy metals determine their contamination, with ecosystem risk assessment being a primary concern for environmental food scientists. The accumulation of heavy metals in fruits, vegetables, and other crops raises significant alarm due to the potential health risks associated with their consumption (Tufuor, Bentum, Essumang, Koranteng, 2011). Various sources contribute to metal contamination in food crops, including discharges onto agricultural lands, industrial and sewage wastewater, pesticide applications, and atmospheric deposition from vehicle emissions and other sources. These trace metals can be translocated from the soil to different parts of the plant, posing risks to human health depending on the specific metal (Tufuor et.al, 2011).

Lead, arsenic, zinc, and other metals have been found in food crops at levels exceeding recommended dietary allowances, highlighting the potential dangers of heavy metal contamination in the food supply (Okoronko, as cited in Tufuor et.al, 2011). The consequences of this contamination include kidney damage associated with cadmium, neurological damage from mercury and lead, and various cancers, particularly skin cancer, from arsenic (Jarup, 2003).

Reports indicate that approximately half of human lead intake comes from food, with fruits being a significant contributor. This poses severe consequences for both human and ecological health, as the surfaces of fruits can become contaminated during production, transportation, preservation, and marketing. Contaminants from vehicles, industrial environments, and pollutants like PAHs and PAEs may adhere to fruit surfaces. Additionally, fertilizers and pesticides can introduce heavy metals into the air, water, and surrounding environments, further contributing to contamination (Fathabad et al., 2018).

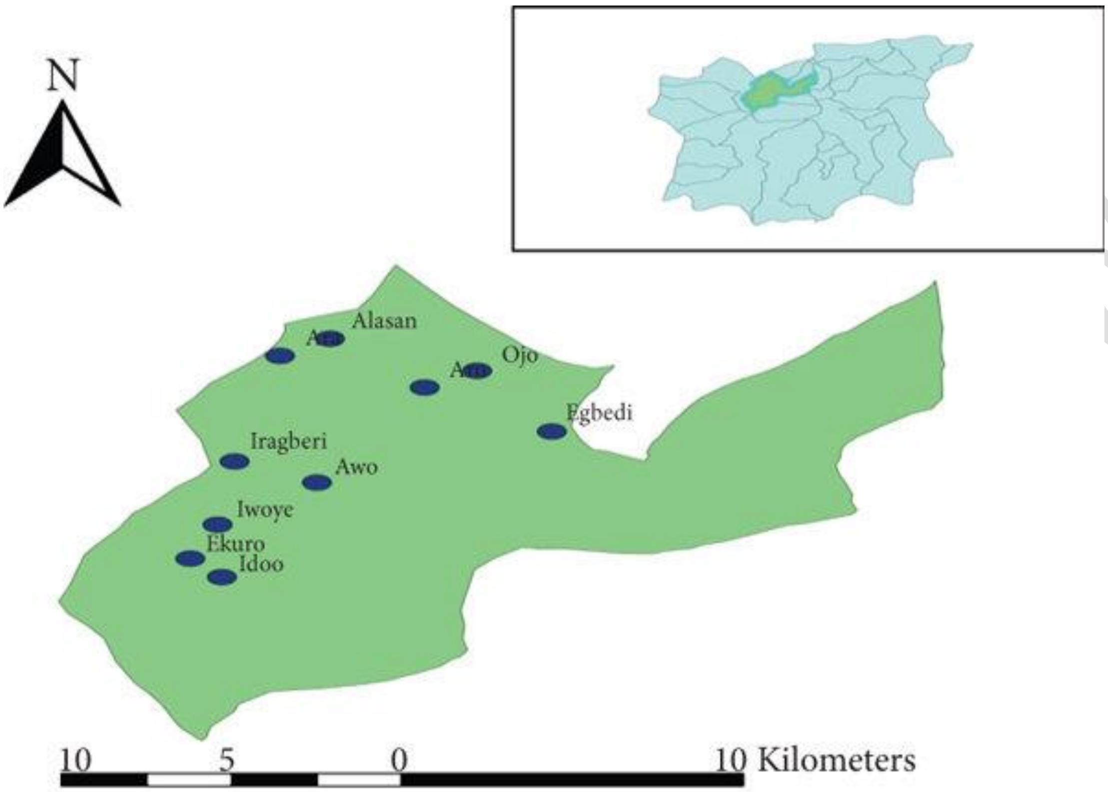
Long-term exposure to heavy metals, especially through the consumption of fruits and vegetables with high metal concentrations, can result in chronic accumulation, leading to damages in various organs and systems such as the heart, nervous system, liver, kidneys, blood, lungs, bones, and spleen. Adverse effects include mutagenesis, carcinogenesis, and teratogenesis, contributing to human illnesses, disorders, deformities, and organ failures due to metal poisoning (Makki and Ziarati, 2014). Among the heavy metals, lead, arsenic, mercury, cadmium, and tin stand out as primary threats to human health (Fathabad et al., 2018).

2. MATERIALS AND METHODS

Study Area

The study focused on the Okinni area in the Egbedore Local Government Area of Osun State, Nigeria. Okinni is a town in Osun State, situated near Erin-Osun and Ifon. Geographically, it is located at approximately 7° 50' 0'' North and 4° 32' 0'' East. The selection of this study area was based on factors such as the availability of fruits, sampling cost considerations, and the proximity of the study area.

Fig 1. Map of the Study Area



Apparatus and Instruments

The project utilized various apparatus and instruments for the study, including polyethylene bottles, micro pipettes, vials, volumetric flasks, beakers, pipettes, different-sized measuring cylinders, funnels, graduating cylinders, thermometers, Whatman filter papers no. 42, refrigerators, hot plates, and an Inductive Coupled Plasma Atomic Absorption Spectrophotometer.

Chemicals

High-purity analytical grade reagents were employed for the analysis, including HNO_3 (69% LR, Breckland Scientific Supplies, UK) and H_2O_2 (30%), which was used for the digestion of samples and blanks. Certified reference materials (Cd, Zn, Pb, and Ni) from a European accredited lab were used for preparing standard samples. Tap water, distilled water, and deionized water were utilized for washing, rinsing, and sample preparation.

Data Collection

Data was collected through a well-structured closed-ended questionnaire, gathering information about the vendors' sources of fruits, farming practices, and the storage and transportation methods employed. This information aimed to identify potential sources of heavy metal contamination and provide recommendations for minimizing contamination in the fruits.

Oranges, apples, and watermelon samples were randomly collected from different market stalls in the Okinni area, Egbedore Local Government Area, Osun State. For each fruit variety, two samples were obtained and placed into appropriately labeled sacks, conveyed to the laboratory for analysis.

Sample Treatment

The treatment process involved washing the fruits with tap water and distilled water, followed by squeezing the juice into separate beakers. About 200 mL of juice was obtained from each sample. The juice was filtered, mixed well, and stored in a refrigerator prior to analysis.

A 50 mL sample was placed into a 250 mL beaker, and aqua regia prepared from analytical-grade concentrated 36% HCl and concentrated 63% HNO_3 was added. The mixture underwent a heating and reflux process on a hot plate. The solution was cooled, 10 mL of 30% H_2O_2 (AR) was added, and the heating continued until complete digestion.

The digest was filtered using Whatman No. 4 filter paper into a 50 mL volumetric flask and diluted with double-distilled water to the 50 mL mark. Three samples each of the juice from orange, watermelon, and apple, as well as spiked samples and a blank, were digested using this method.

Analysis

All the digested samples were analyzed for arsenic (As), lead (Pb), chromium (Cr), and zinc (Zn) using an Inductive Coupled Plasma Atomic Emission Spectrometer (ICP).

RESULTS AND DISCUSSION

The discussion of findings in this study centers on the interpretation and implications of the heavy metal concentrations in fruits (orange, watermelon, and apple) in Okinni, Egbedore Local Government Area, Osun State, based on the data collected and analyzed.

Table 1 showing responses of the respondents to Questionnaires

S/N	VARIABLE	RESPONDENT
1	Occupation	Farmer 29%, Vendor 62% Others 9%
2	Source of fruits	local forms 51%, Wholesale 15% Others area 34%
3	Fertilizers / pesticides usage	Yes 46%, No 54%
4	fruits transportation before selling	In plastic bags 35%, In baskets 55%Other 10%
5	Selling fruits	Daily 61% Weekly 24% Monthly 15%
6	Years of selling fruits	Less than 1 year 24%, 1-5 years 47% More than 5 years 29%
7	Training received on food safety and hygiene	Yes 45%, No 55%
8	Information about heavy metals on fruits	Yes 65%, No 35%

9	Safety of fruits for consumption	Strongly agree 29%, agree 35% neutral 6%, disagree 24% and strongly disagree 6%
10	Testing of fruits for heavy metals	Regularly 6% occasionally 35% never 59%
11	Method used for testing heavy metals in fruits	Laboratory analysis 6% visual inspection 35% others 21% not applicable 47%
12	Measures taken to prevent heavy metal contamination in fruits	Regulate use of organic fertilizer 24%, proper disposal of chemical waste 6%, regular cleaning of storage container 12%, Others 7%, None 53%
13	Regulation and guideline regarding heavy metal	Strongly Agree 51%, Agree 38%, Neutral 8%, Disagree 2%, strongly disagree 1%
14	Heavy metals contamination option	Regulate organic fertilizer 34%, proper disposal of chemical waste 26%, Regular cleaning of storage container 19%, Provision of training on food safety & hygiene 14% Regular testing of fruits for heavy metal container 7%

The results observed that occupation of the respondents was vendor with 62%. They sourced their fruits especially from the local farmers (54%), with an indication of fertilizer (54%) usage. The respondents made use of basket (55%) to convey their fruits from the farm to their destination/ markets, where they sell daily (61%) and weekly (24%) Moreso, 47% of the respondents have been selling the fruit for more than 5 years. 45% of them have received training on Food Safety and hygiene. 65% of the respondents heard about the heavy metal contamination in fruits, which makes 35% of them agrees that those fruits sold by roadsides vendors in Okinni are safe for consumption. They never test their fruits for heavy metal contamination 59%. 47% of the respondents did not use any method to test for heavy metal contamination in your fruits. No measures is taken to prevent heavy metal contamination in fruits are 53% of the respondents. 51% of the respondents agreed that there should be regulations & guidelines regarding heavy metal contamination in fruits sold by roadside vendors. And 34% of the respondents makes used of organic fertilizer to reduce the risk of metal contamination in fruits.

Presentation of Laboratory Analysis

Table 2 Comparison of Concentrations of Heavy Metals in Fruits with WHO/FAO Permissible Limits

Fruits	Samples	Heavy Metals			
		As (mg/kg)	**Cr (mg/kg)**	**Zn (mg/kg)**	**Pb (mg/kg)**
Oranges	1	0.4363	*ND*	0.2381	ND
	2	0.6809	0.1058	0.2855	ND
	Mean ± SE	0.5586 ±0.1723	0.0529 ± 0.075	0.2618 ± 0.0335	0 ±0
WHO/FAO Permissible limits (mg/kg)		1.30	0.10	0.20	0.30
Watermelon	1	0.2868	ND	ND	ND
	2	0.088	ND	0.2524	ND
	Mean ± SE	0.1874± 0.1406	0.000 ±0.0000	0.1262 ±0.1785	0.0000 ±0.0000
WHO/FAO Permissible limits (mg/kg)		1.50	0.20	0.20	0.50

Apple	1	0.2168	ND	0.2629	ND
	2	0.1000	0.1253	0.1730	ND
	Mean ±SE	0.1584 ± 0.0826	0.0854±0.000	0.21795±0.0636	0.00±0.000
WHO/FAO Permissible limits (mg/kg)		1.50	0.10	0.20	0.30

The discussion of the study's findings offers valuable insights into the concentrations of heavy metals in commonly consumed fruits (orange, watermelon, and apple) in Okinni, Egbedore Local Government Area, Osun State. This analysis is crucial for understanding the potential health implications associated with the consumption of these fruits and, subsequently, for establishing guidelines to ensure food safety.

The demographic characteristics of the respondents, primarily vendors (62%) sourcing fruits from local farms (51%), shed light on the prevalent practices within the fruit supply chain in the study area. The use of fertilizers or pesticides by more than half of the respondents (54%) and the predominant storage and transportation method using baskets (55%) are indicative of agricultural practices and post-harvest handling. Additionally, the majority selling fruits daily (61%) and having an average selling experience of 1-5 years (47%) underlines the consistent presence of these fruits in the local market.

Awareness of heavy metal contamination among the respondents (65%) highlights a degree of knowledge within the community. However, the infrequent testing of fruits for heavy metal contamination (6%) and the lack of preventive measures by a significant portion of respondents (53%) underscore potential gaps in safety practices.

Interestingly, despite these findings, a substantial majority of respondents (71%) express confidence in the safety of fruits sold by roadside vendors. This suggests a level of trust in the local fruit supply, perhaps driven by habitual consumption patterns or community familiarity.

The laboratory analysis of the fruits reveals concentrations of heavy metals within permissible limits, as outlined by WHO/FAO standards. Chromium (Cr) levels, though present, are consistently below the permissible limit of 0.10 mg/kg, aligning with previous research (Akinyele and Shokunbi, 2015). Notably, lead (Pb) was undetected in all fruit samples, ensuring compliance with the WHO maximum permissible limit of 0.30 mg/kg.

The absence of lead in the fruits contradicts findings from other regions, emphasizing the need for localized studies considering variations in environmental factors and agricultural practices. Furthermore, the study's outcomes align with previous research indicating potential health risks associated with the chronic accumulation of heavy metals in the human body, emphasizing the importance of continuous monitoring and regulatory measures (Satarug et al., 2010).

While the concentrations of heavy metals in the examined fruits appear within acceptable limits, the study recommends ongoing monitoring, especially given the potential health risks associated with prolonged exposure. This is particularly crucial in regions where anthropogenic activities, such as agricultural practices and industrial emissions, may contribute to heavy metal contamination.

Recommendations

Enhanced Monitoring and Regulation

Given the potential health risks associated with heavy metal contamination, it is recommended that regulatory bodies strengthen monitoring mechanisms for fruits in the Okinni region. Regular assessments and stringent enforcement of safety standards will contribute to the overall well-being of consumers.

Educational Campaigns

Conducting awareness campaigns on safe agricultural practices, including the judicious use of fertilizers and pesticides, would benefit both farmers and vendors. Educating the community about the risks of heavy metal accumulation in fruits and promoting preventive measures could further enhance food safety.

Periodic Training for Vendors

Organizing periodic training sessions for fruit vendors on food safety and hygiene practices would empower them to adopt measures that minimize the risk of heavy metal contamination. This could include proper washing techniques, suitable storage practices, and understanding the sources of potential contamination.

Collaboration with Agricultural Stakeholders

Establishing collaborations with local agricultural stakeholders, such as farmers and suppliers, can facilitate a collective effort to reduce heavy metal contamination. This could involve promoting the use of organic fertilizers and environmentally friendly farming practices.

Conclusion

In conclusion, the study provides valuable insights into the concentrations of heavy metals in commonly consumed fruits in Okinni, Egbedore Local Government Area, Osun State. The results indicate that, overall, the fruits (orange, watermelon, and apple) exhibit concentrations of heavy metals within acceptable limits, aligning with WHO/FAO standards.

Despite this generally positive outcome, the study underscores the need for continuous monitoring and regulatory measures, considering the potential health risks associated with prolonged exposure to heavy metals. The community's confidence in the safety of fruits sold by roadside vendors emphasizes the importance of aligning local dietary practices with comprehensive safety measures.

As Okinni continues to be a hub for fruit consumption, the recommendations put forth aim to further fortify the safety and well-being of the community. By implementing these measures, stakeholders can collectively contribute to ensuring that the fruits remain a healthy and safe component of the local diet.

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