



SOCIOECONOMIC FACTORS INFLUENCING HEAVY METALS CONTAMINATION OF TRADITIONAL NIGERIAN SPICES IN ILORIN

*Nwahia Ogechi CORDELIA¹, Atanda Abimbola SABURI¹, Akinniyi Jane NNAMANI², Abel Igbele GRACE¹, Badmos Omolola FATIMAH¹, Sanni Lateef OLADIMEJI¹

¹Nigerian Stored Products Research Institute (NSPRI), Ilorin, Kwara State, Nigeria

²School of Agriculture, Animal and Environmental Sciences, Anglia Ruskin University, United Kingdom

*Corresponding author: godstime_ogefine@yahoo.com

Received 09 January 2026, accepted 30 September 2026

Abstract: *The increasing challenges of food insecurity in Nigeria have become a major national concern, this is largely attributable to its impact on human well-being. Recently, evidence of heavy metals contaminants exceeding threshold values in foods has posed significant threats to food safety and human well-being. Therefore, this research was designed to examine the socioeconomic factors influencing heavy metals contamination of traditional Nigerian spices in Ilorin. A multi-stage sampling procedure was adopted to select the required respondents for the study, and spice samples were purchased and tested for selected heavy metals such as lead (Pb), cadmium (Cd), and arsenic (As) using Atomic Absorption Spectroscopy (AAS). Primary data were collected from the producers of traditional Nigerian spices via questionnaires and interviews and analysed using descriptive statistics (means and standard deviation) and inferential statistics (regression model). The results revealed that the traditional Nigerian spices from the respondents were contaminated with heavy metals but were still within the limits set by the World Health Organization (WHO) and European Food Safety Authority (EFSA). These heavy metals contamination is influenced by producer's age (significant at 5%), household size (1%), and processing environment conditions (1%). The study therefore suggests that governmental and non-governmental organizations should provide training on proper hygiene and food products handling to traditional Nigerian spices producers. Additionally, producers should adopt sanitation practices in the processing environment to prevent food contamination.*

Keywords: *food contamination, determinants, producers, health, local spices.*

1. Introduction

Food contamination has been reported by various researchers as a major problem in Sub-Saharan Africa and in developing countries [1], [2]. The contamination usually results from different production systems, improper handling, and poor processing methods, all of which are commonly witnessed across the food value chains [1], [3]. Food contamination is often caused by heavy metals from sources such as agriculture, industry, mining, landfills, transportation, and urban activities, among others [4], [5], [1], [3], [6]. According to the chemical definition, heavy metals refer to approximately 40 elements with a density greater than 5 g/cm³ [6]. However, them

toxicity depends on the chemical species and daily dose [6]. Although the contamination of foods by heavy metals cannot be entirely avoided, there is a great need to minimize it in order to reduce its effect on human health [3]. Researchers have reported that heavy metals enter processed foods through contaminated water, the surrounding environment, and the materials used in food processing, and they can accumulate in humans over time [7], [8], [3]. Heavy metals play a significant role in plant growth, human nutrition, and the general homeostasis of living cells. However, they are capable of inducing adverse environmental effects and toxicities, thereby harming living cells and

organisms [9-12]. Recently, a number of pollutants in the form of heavy metals have been reported to cause harmful effects on crop quality, which in turn affects both food security and human health [11]. Most essential micronutrients, such as copper (Cu), chromium (Cr), and nickel (Ni), are highly toxic at elevated concentrations [10], [3]. Evidence of chromium, cadmium, copper, lead, and mercury detected in natural foods suggests that they are environmental contaminants, especially in open markets [11], [3]. Foods sold in open markets usually originate from different areas and are processed in various locations using unhealthy methods. Consequently, final consumers may be exposed to heavy metals, depending on the origin of the food and the method of food preparation [3]. In Nigeria, particularly in the southwest region, the most important traditional Nigerian spices are *iru* and dried pepper. They are commonly used by the people to cook various dishes. These traditional Nigerian spices are processed locally through diverse methods, including fermentation and open-air drying, and are typically sold in an open market, which exposes them to heavy metals contamination [13]. *Iru* and dried pepper, being essential dietary components, are particularly vulnerable to contamination due to their unhygienic processing methods, exposure to polluted environments, and the use of potentially contaminated water. Therefore, it is crucial to conduct studies in this area to ascertain whether these traditional Nigerian spices are safe for human consumption. Although heavy metals contamination in food products and water sources has been widely studied in Nigeria due to its severe health implications, and studies have documented high levels of heavy metals in various food items, including cereals, vegetables, seafood, and condiments [14], [1], [13], [15]. However, studies on heavy metals

contamination of traditional Nigerian spices, particularly *iru* and dried pepper, remain insufficient in the literature, which makes this research significantly important. Furthermore, the producers' socioeconomic determinant of heavy metals contamination in traditional Nigerian spices have not been extensively evaluated in the literature. It is in this regard that this research work aimed to assess the socio-economic factors influencing heavy metal contamination of traditional Nigerian spices in Ilorin.

2. Materials and methods

2.1 Study area and heavy metals tested

The study was conducted in Ilorin, Kwara State. The traditional Nigerian spices examined were *iru* and dried pepper, and they were tested for heavy metals such as lead (Pb), cadmium (Cd), and arsenic (As). The selection of these heavy metals was based on the fact that they are classified as highly toxic metals by the U.S. Environmental Protection Agency (EPA). Also, they are very common in foods and food materials due to inadequate regulatory frameworks and environmental pollution [2] [6].

2.2. Sampling procedures

A multi-stage sampling procedure was adopted in this study. Firstly, three markets within Ilorin were purposively selected based on the dominance of traditional Nigerian spices in the area. Thus, Mandate, Ipata, and Oja-Oba markets were selected. Secondly, the traditional Nigerian spices producers were segregated into different strata within each market using a randomized stratified sampling method. *Iru* and dried Pepper producers were grouped into three strata (small, medium and large producers due to the diverse producing strength that exists in the study area), the categorization of producers into each stratum were based on the researchers' discretion, and supported by other work [16]:

Strata 1 - Small producers: Those producing and selling less than 5 kg of their products daily.

- Strata 2 - Medium producers: Those producing and selling 5 kg - 10 kg of their products daily.
- Strata 3 - Large producers: Those producing and selling above 10 kg of their products daily.

Thirdly, 8 *iru* producers were randomly selected from each stratum using random cards selected without replacement, and samples of the products were purchased. Thus, 24 *iru* samples (12 in leaf packaging material and 12 in nylon) were obtained. For the dried pepper, 12 producers were randomly selected from each stratum using random cards selected without replacement, and samples were purchased. Thus, 36 dried pepper samples (9 packaged in nylon, 9 ground and packaged in nylon, 9 whole some in open display, and 9 ground whole some in open display) were purchased for heavy metals testing. In total, 60 samples of traditional Nigerian spices were used in the study. The approach chosen for the study ensures that variability is accounted for in each of the traditional Nigerian spices and that the results are reproducible. Approximately 5 g each of *iru* and dried pepper were purchased from each producer in the three selected markets. Unequal sample sizes were chosen for the two traditional Nigerian spices, firstly because of the existing variability across *iru* and dried pepper. There are two sources of variability for *iru* in the study area (leaf-packaged and nylon-packaged samples), whereas four sources of variability were identified for dried pepper (whole pepper packaged in nylon, ground pepper packaged in nylon, whole pepper displayed openly, and ground pepper displayed openly). Secondly, due to the imbalance in the populations of *iru* and dried pepper producers, the different categories were disproportionately represented in the study area. Lastly, the sample size was also

constrained by the costs associated with laboratory testing.

These reasons were supported by [16].

2.3. Data collection and analysis.

Primary data were collected from the producers of traditional Nigerian spices (*iru* and dried pepper) using questionnaires and interviews. The data were recorded in Microsoft Excel 2008 (Microsoft Corporation, WA, USA) and imported into STATA 14 for analysis. Descriptive statistics (means and standard deviations) and inferential statistics (regression model) were used in the analysis. Heavy metal concentrations in the traditional Nigerian spices were determined using Atomic Absorption Spectroscopy (AAS).

Sample preparation followed strict protocols: traditional Nigerian spices were homogenized, oven-dried at 120 °C for 1 hour until constant weight was obtained, and digested with acids. The digestion used nitric and perchloric acids, followed by heating to 120 °C until complete (the fumes dissipated). Samples were then filtered, diluted with deionized water, and analysed using Graphite Furnace Atomic Absorption Spectroscopy (GFAAS) for selected heavy metals (lead, cadmium, and arsenic).

2.4. Model specification

The regression model combined the study's traditional Nigerian spices because the same unit of measurement was used for them, and the same unit of measurement was also used for all the heavy metals tested.

Thus, the model conceptualized traditional Nigerian spices and heavy metals as a single entity, the reason for its combination. This is statistically appropriate because regression estimates are weighted by the total sample size (N), and not by equal sample sizes across groups. Likewise, the socioeconomic factors considered in the model are homogeneous across *iru* and dried pepper producers in the study area. This is statistically appropriate and has been applied by [17].

The regression model was chosen because multiple socioeconomic factors were considered, and the dependent variable is continuous. The model is specified thus:

$$\text{LnY} = B_0 + B X_i \quad (1)$$

$$\text{LnY} = B_0 + B X_1 + B X_2 + B X_3 + B X_4 + B X_5 + B X_6 + B X_7 + B X_8 + B X_9 \quad (2)$$

Where LnY (dependent variable) = log of quantity/level of heavy metals in traditional Nigerian spices (*Iru* and dried pepper)

B_0 = Constant

B = Coefficients

X_i = independent variables (i ranges from 1 - 9)

X_1 = age of the respondents (years)

X_2 = Years in Formal Education (years)

X_3 = Years of experience in local spices production (years)

X_4 = Household size (Number)

X_5 = Household Income (in Naira)

X_6 = Processing environment conditions (a dummy, neat 1, dirty 0)

X_7 = Packaging material used (Polyethylene 3, leaf 2, open container display 1)

X_8 = Water type used (tap 1, cistern 2, borehole 3, rivers 4)

X_9 = Processing methods (a dummy, improved 1 otherwise 0)

3. Results and discussion

3.1. Heavy metals contamination in the traditional Nigerian spices

The heavy metal contamination in the purchased traditional Nigerian spices was determined with Atomic Absorption Spectroscopy (AAS). The results of the analysis are presented in Table 1. The results in Table 1 revealed that *iru* were contaminated with heavy metals in all three selected markets in the study area. However, *iru* packaged in nylon from Mandate market had the highest Arsenic, lead, and cadmium contaminants with values of 0.0085 mg/kg, 0.012 mg/kg, and 0.0040 mg/kg, respectively, compared to *iru* in the same packaging material from Ipata and Oja Oba markets.

Table 1

Amount of heavy metals contamination in traditional Nigerian spices in Ilorin

Samples/Items	Market/Location	Arsenic concentration (mg/kg)	Lead concentration (mg/kg)	Cadmium concentration (mg/kg)
<i>Iru</i> in nylon	Mandate	0.0085(0.0003)	0.0126(0.0013)	0.0040(0.0002)
<i>Iru</i> in leaf	Mandate	0.0081(0.0003)	0.0037(0.0005)	0.0037(0.0002)
<i>Iru</i> in nylon	Ipata	0.0078(0.0003)	0.0037(0.0002)	0.0037(0.0002)
<i>Iru</i> in leaf	Ipata	0.0074(0.0004)	0.0121(0.0007)	0.0035(0.0001)
<i>Iru</i> in nylon	Oja Oba	0.0080(0.0003)	0.0124(0.0011)	0.0036(0.0001)
<i>Iru</i> in leaf	Oja Oba	0.0075(0.0005)	0.0117(0.0004)	0.0036(0.0002)
Pepper in nylon	Mandate	0.0040(0.0002)	0.0060(0.0003)	0.0018(0.0002)
W. Pepper	Mandate	0.0021(0.0002)	0.0075(0.0003)	0.0021(0.0001)
G.Pepper in nylon	Mandate	0.0055(0.0002)	0.0083(0.0003)	0.0024(0.0001)
G.W Pepper	Mandate	0.0058(0.0003)	0.0087(0.0005)	0.0025(0.0002)
Pepper in nylon	Ipata	0.0043(0.0006)	0.0065(0.0009)	0.0018(0.0003)
W. Pepper (open)	Ipata	0.0052(0.0007)	0.0079(0.0010)	0.0022(0.0004)
G.Pepper in nylon	Ipata	0.0048(0.0005)	0.0073(0.0008)	0.0021(0.0002)
G.W Pepper (open)	Ipata	0.0059(0.0003)	0.0088(0.0005)	0.0025(0.0002)
Pepper in nylon	Oja Oba	0.0052(0.0004)	0.0079(0.0005)	0.0022(0.0002)
W. Pepper (open)	Oja Oba	0.0060(0.0004)	0.0090(0.0006)	0.0026(0.0002)
G. Pepper in nylon	Oja Oba	0.0056(0.0006)	0.0084(0.0010)	0.0025(0.0002)
G.W Pepper (open)	Oja Oba	0.0067(0.0003)	0.0101(0.0004)	0.0029(0.0001)

Source: Field Work, 2025. NB: G (ground); G.W (ground wholesome); W (wholesome). Values were represented as Mean (Standard Error).

Thus, although there was high heavy metal contamination in *iru* from the three selected markets, these contaminants were still within the limits set by the European Food Safety Authority (EFSA) (0.1 mg/kg of lead, 0.1 mg/kg of cadmium) and the World Health Organization (WHO) (0.3 mg/kg of arsenic; 0.2 mg/kg of lead; 0.1 mg/kg of cadmium). Nevertheless, caution should be taken to avoid exceeding the threshold. Studies have shown that high exposure to lead can disrupt biological systems, including the nervous, cardiovascular, and renal systems [18]. Chronic exposure to arsenic increases the risk of diverse cancers and impairs cardiovascular and respiratory function. While, exposure to cadmium can cause kidney dysfunction and the development of renal diseases [18 - 20]. Likewise, the dried pepper samples from the three selected markets were contaminated with the tested heavy metals, but ground wholesome pepper in an open display had higher contamination of heavy

metals (0.006 mg/kg of arsenic, 0.0101 mg/kg of lead, and 0.0029 mg/kg of cadmium) compared to other dried pepper samples in different packaging materials. The contaminated dried peppers in the study area were all within the limits set by the European Food Safety Authority (EFSA) (0.3 mg/kg of lead, 0.5 mg/kg of cadmium) and the World Health Organization (WHO) (0.3 mg/kg of lead, 0.1 mg/kg of cadmium). This work is in line with [6].

3.2 Factors influencing heavy metals contamination in traditional Nigerian spices (*Iru* and Pepper)

Multiple regression was used to analyse the factors influencing heavy metals contamination in traditional Nigerian spices. The model was chosen because multiple socioeconomic factors were considered and the dependent variable is continuous. Four functional forms of multiple regression were tested, and the semi-log functional form gave the best fit. The results are presented in Table 2.

Table 2

Variables	Coefficient	Standard deviation	t-statistics
age	0.0090	0.0044	2.04**
Years in formal education	-0.0024	0.0071	-0.34
Years of experience	-0.0047	0.0033	-1.41
household size	-0.0332	0.0123	-2.70***
Income	7.07e-07	1.57e-06	0.45
Processing environment conditions	-0.2047	0.0440	-4.65***
Packaging material used	-0.0270	0.0416	-0.65
Water type used	0.0489	0.0297	1.64
Processing methods	-0.0859	0.0678	-1.27
Constant	-3.7137	0.2817	-13.18***
No of observation	60		
F(8, 26)	14.86		
Prob>F	0.0000***		
R-squared	0.8206		
Adj. R-squared	0.7654		
Root MSE	0.1474		

Source: Field Survey, 2025. Note: *** and ** is significant at 1% and 5%.

The multiple regression results in Table 2 show that the Prob>F is significant at the 1% level. The R^2 is 0.8206, and the adj. R^2 is 0.7654. This implies that the overall model is well fitted and explains the factors

influencing heavy metal contamination in traditional Nigerian spices in the study area. The Adj. R^2 shows that about 77% of the variations in heavy metals contamination in traditional Nigerian spices in Ilorin were

explained by the variables included in the model. Among the variables in the model, producer's age, household size, and processing environment conditions were statistically significant, meaning that the variables significantly influence heavy metals contamination in traditional Nigerian spices in Ilorin. However, education, years of experience, monthly income, packaging material, water type, and processing method were not statistically significant. This implies that they do not significantly influence heavy metal contamination in traditional Nigerian spices in Ilorin. These findings contradict [3] and [21].

The results in Table 2 show that the coefficient of producer's age was positive and significant at the 5% level. This implies that the contamination by heavy metals increases as the age of the producers increases. Although this goes against expectations, this may be because concerns about hygiene of their products and the processing environment were less pronounced among older producers than among younger producers. The results show that an increase of one (1) year in the producers' age will increase heavy metal contamination of traditional Nigerian spices by 0.01 units. Also, the results in Table 2 reveal that the coefficient for household size was negative and statistically significant at the 1% level. This implies that the contamination by heavy metals decreases as the household size of the producers increases. Thus, an increase of one person in household size will reduce heavy metal contamination of traditional Nigerian spices by 0.03%. This may be because larger households have more people to help keep processing equipment and the environment clean to reduce contamination. Likewise, the coefficient for processing environment conditions was negative and significant at the 1% level. This implies that unclean processing environment conditions increase heavy metal contamination, while clean processing environment conditions decrease

heavy metal contamination in traditional Nigerian spices in Ilorin. The results show that an unclean processing environment increases heavy metals contamination in traditional Nigerian spices in Ilorin by 0.21%. This is likely due to the presence of more toxic substances in an unclean environment. These findings are consistent with [6].

4. Conclusions

Heavy metal contaminants in food beyond threshold values pose serious health risks to humans. The research, which centred on socioeconomic factors influencing heavy metal contamination of traditional Nigerian spices in Ilorin, concluded that traditional Nigerian spices from the respondents were contaminated with heavy metals but were still within the limits set by the World Health Organization (WHO) and European Food Safety Authority (EFSA). Also, the study concluded that this heavy metal contamination is influenced by several socioeconomic factors, namely producers' age, household size, and processing environment conditions.

Recommendations

- (1) For the government and NGOs: governmental and non-governmental organizations should provide training on proper hygiene and food product handling to the producers of traditional Nigerian spices, especially the elderly ones, to eliminate heavy metal contamination in their products.
- (2) For the producers of traditional Nigerian spices: sanitation of the processing environment should be adopted to prevent contamination.

5. Acknowledgments

The authors pooled their own resources to fund this research, with additional funding from friends and family.

6. References

- [1]. Anukwuorji, C.A., Okigbo, R.N., Chikwendu, A.E., C. L. Anuagasi, C.L., Heavy Metals Contamination of Some Food Materials from Markets

- in South Eastern Nigeria. *European Journal of Nutrition & Food Safety*, vol. 12(2): 94-101, (2020). DOI: 10.9734/EJNFS/2020/v12i230197.
- [2]. FAO. Heavy metals in foods: Assessing health risks. *Rome: FAO Publications*, (2020).
- [3]. Begum, R., Akter, R., Dang-Xuan, S., Islam, S., Siddiky, N.A., Uddin, A.S.M.A., Mahmud, A., Sarker, M.S., Grace, D., Samad, M.A., and Lindahl, J.F., Heavy metal contamination in retailed food in Bangladesh: a dietary public health risk assessment. *Frontiers in Sustainable Food Systems*, 7:1085809, (2023). doi: 10.3389/fsufs.2023.1085809.
- [4]. Zheng, N., Wang, Q., Zhang, X., Zheng, D., Zhang, Z., Zhang, S., et al., Population health risk due to dietary intake of heavy metals in the industrial area of Huludao city, China. *Sci. Total Environ.* 387, 96–104, (2007). doi: 10.1016/j.scitotenv.2007.07.044.
- [5]. Islam, M. S., Ahmed, M. K., Habibullah-Al-Mamun, M., and Masunaga, S., Trace metals in soil and vegetables and associated health risk assessment. *Environmental Monitoring and Assessment*. 186, 8727–8739, (2014). doi: 10.1007/s10661-014-4040-y.
- [6]. Mititelu, M., Neacsu, S.M., Busnatu, S.S., Scafa-Udriste, A., Andronic, O., Lăcraru, A.E., Ionită-Mindrican, C.B., Lupuliasa, D., Negrei, C., Olteanu, G., Assessing Heavy Metal Contamination in Food: Implications for Human Health and Environmental Safety. *Toxics* 13,333 (2025). <https://doi.org/10.3390/toxics13050333>.
- [7]. Kachenko, A. G., and Singh, B., Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water Air Soil Pollut.* 169, 101–123, (2006). doi: 10.1007/s11270-006-2027-1.
- [8]. Kumar, S.R., Agrawal, M., and Marshall, F., Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicology and Environmental Safety Journal*, 66, 258–266, (2007). doi: 10.1016/j.ecoenv.2005.11.007.
- [9]. Ji, K., Kim, J., Lee, M., Park, S., Kwon, H. J., Cheong, H. K., et al., Assessment of exposure to heavy metals and health risks among residents near abandoned metal mines in Goseong, Korea. *Environmental Pollution Journal*, 178, 322–328, (2013). doi: 10.1016/j.envpol.2013.03.031.
- [10]. Rahman, M. A., Rahman, M. M., Reichman, S. M., Lim, R. P., and Naidu, R., Heavy metals in Australian grown and imported rice and vegetables on sale in Australia: health hazard. *Ecotoxicology and Environmental Safety Journal* 100, 53–60, (2014). doi: 10.1016/j.ecoenv.2013.11.024.
- [11]. Munir, N., Jahangeer, M., Bouyahya, A., El Omari, N., Ghchime, R., Balahbib, A., Aboulaghras, S., Mahmood, Z., Akram, M., Ali Shah, S.M., et al., Heavy Metal Contamination of Natural Foods Is a Serious Health Issue: A Review. *Sustainability*, 14, 161, (2022). <https://doi.org/10.3390/su14010161>.
- [12]. Vanisree, C.R., Mahipal S.S., Prashant, S., Ekta, B., Jadhav, Rohit K.V., Kumud K.A., Garima, A., and Varad, N., Heavy Metal Contamination of Food Crops: Transportation via Food Chain, Human Consumption, Toxicity and Management Strategies. A Paper published by *Intech Open*, pg 1 -23, (2022). DOI: <http://dx.doi.org/10.5772/intechopen.101938>.
- [13]. Adepoju, A. O., and Adeniyi, O., Heavy metal contamination of water sources in Nigeria: Implications for public health. *Journal of Environmental Health Science*, 15(2), 215-229, (2021).
- [14]. PubMed. Heavy metal contamination of selected spices obtained from Nigeria, (2016). Retrieved from <https://pubmed.ncbi.nlm.nih.gov/27546329>.
- [15]. Nnorom, I. C., Uwakwe, A. A., and Igwe, J. C., Heavy metal contamination in Nigerian food products: A review of sources and health implications. *Environmental Science and Pollution Research*, 29(3), 4551-4565, (2022).
- [16]. Nwahia, O.C., Impact Assessment of USAID-Markets II on Productivity and Poverty Status of Rice Farming Households in Ebonyi State, Nigeria. A Ph.D Thesis Submitted to the Department of Agricultural Economics. Ahmadu Bello University, Zaria, (2021).
- [17]. Mohan, J., Abbott, P., and Feng, X. O., A framework for the identification and classification of homogeneous socioeconomic areas in the analysis of health care variation. *International Journal of Health Geographics*, 17(1), 1-15, (2018).
- [18]. Mason, L.H.; Harp, J.P.; Han, D.Y., Pb neurotoxicity: Neuropsychological effects of lead toxicity. *BioMed Research International*, 2014, 2014, 840547. CrossRef.
- [19]. Speer, R.M.; Zhou, X.; Volk, L.B.; Liu, K.J.; Hudson, L.G., Arsenic and cancer: Evidence and mechanisms. *Advances in Pharmacology and Pharmacy*. 96, 151–202, (2023).
- [20]. Satarug, S. Is Chronic Kidney Disease Due to Cadmium Exposure Inevitable and Can It Be Reversed?, *Biomedicines* 2024, 12, 718, (2024).
- [21]. Scutarasu, E.C and Trinca, L.C., Heavy metals in Foods and Beverages; Global Situation, health risk and reduction methods. *Foods* 12 (18)3340, (2023).