Accepted: 13th Dec, 2024
Published: 26th Jan, 2025

Health Risk Assessment of Metal Content in Ginger (*Zingiber officinale*) cultivated in Maro Farmlands Kajuru LGA, Kaduna State, Nigeria

[1]Uduma, A. U., [2]Godwin Asoconom Allems and [3]Maria B. Uduma

https://doi.org/10.33003/frscs_2025_0401/02

1. Department of Industrial Chemistry, Federal University Dutsin-Ma, P.M.B 5001, Katsina State,
2. Department of Chemistry, Kaduna State College of Education, Gidan Waya, P.M.B 1024, Kafanchan, Nigeria.
3 Department of Biology, Federal University of Education, Kano, Nigeria.

Corresponding Author:
Dr Uduma A. Uduma
udumas96@gmail.com

FRsCS Vol. 4 No. 1 (2025)
Official Journal of Dept. of Chemistry, Federal University of Dutsin-Ma, Katsina State.
http://rudmafudma.com

ISSN (Online): 2705-2362
ISSN (Print): 2705-2354

Abstract

Ginger (*Zingiber officinale*) is a flowering plant in the Scitamineae order and Zingiberaceae family. Ginger is utilized in a variety of culinary, cosmetic, and medical applications. It's available in Kajuru LGA, Kaduna state, Nigeria's Maro ward. The goal of this study was to determine the levels of Na, Mg, K, Ca, and Fe metals in a few selected farmlands in the area, including Maro, Chibiya, Karamai, and Angwan Gamu. Perkin Elmer pin AAcle 900H was used to analyze four ginger samples acquired from diverse locations and submitted to AAS analysis after wet digestion to assess metal content. The data was examined statistically using analysis of variance (ANOVA). The abundance of metal in *Zingiber officinale*, according to the findings, is as follows: K>Ca>Mg>Fe>Na, The maximum level suggested by the World Health Organization (WHO) for all metals has not been surpassed. At P>0.05, there was no significant difference in metal content in Ginger among farmlands. All metals had THQ values of less than one. Because the Fe HI values of the samples under research were less than 1, consumers will not be exposed to any potential health hazards as a result of ingesting particular metals through *Zingiber officinale* eating. Other metal concentrations in Ginger rhizomes should be studied in the future.

.**Keywords:** *Zingiber officinale*, Ginger powder, metal concentration, Health risk

Introduction

The Ginger (*Zingiber officinale*) is a flowering plant in the Scitamineae order and Zingiberaceae family. It's a tropical monocotyledonous and herbaceous perennial with annual stems. The rhizome of *Zingiber officinale* is made up of many short finger-like structures or branches that grow horizontally near the soil's surface. Two commercial kinds are widely grown in Maro. The yellow ginger variety known as "Tafin Giwa" is robust and has short internodes, with a bright yellow rhizome flesh. With a dull-grey rhizome, the black ginger cultivar "Yatsun Biri" is popular in the area. Due to its great production capacity and pungency, the yellow variety is more popular than the black kind (Ahmed, 2018). The plant *Zingiber officinale* is native to Southeast Asia. It originated in southern China and has since spread throughout Asia, West Africa (Nigeria), and the Caribbean. The main components of *Zingiber officinale* are 6-gingerol, 6-shogaol, and 6-paradol, all of which have considerable antioxidant activity (Prasad and Tyagi, 2015) and provide health benefits. Other nutrients found in *Zingiber officinale* include protein, lipids, insoluble and soluble fibers, carbohydrates, and vitamins (Shirin and Jamush, 2010; Ajayi et al., 2013). Essential elements including Na, K, Cu, Zn, Ca, Mg, Fe, and Mn, as well as non-essential or poisonous elements like Hg, Cd, Pb, and Cr metals, are found in spices (Longhurst, 2010; Belay and Tadesse, 2014).

One of the oldest oriental spices known to Europeans was *Zingiber officinale*. In the 16th century, the Portuguese introduced the crop to West Africa and eventually to other parts of the tropics, including the West African sub-region and Nigeria. It has become a well-established crop among the inhabitants of Kaduna State's southern region since its introduction into the country. Southern Kaduna had earned the reputation of being Nigeria's traditional "home of ginger production." Though *Zingiber officinale* had been produced for home reasons in Southern Kaduna for a long time, its commercial production began in earnest in 1927. It had been produced in tiny quantities as a garden crop in the United States prior to that. It may interest you to know that in 1928/29, the first consignment of ginger (5 tons) for export was sent from Gantan, a village in Southern Kaduna (sambo, 2017). Gantan is a hamlet in Kaduna State's Kachia local government area.

Zingiber officinale is now grown in Jama'a, Jaba, Kagarko, Kachia, Kajuru, and Zangon Kataf Local Government Areas, as well as in other parts of Nigeria, such as Keffi and Akwanga Local Government Areas in Nasarawa State (Ahmed, 2018). Abia, Plateau, Abuja, Niger, and Benue are among the other states. Within Longitude 03^{o} 02'E – 09 30'E and latitude 4^{o}37'N – 10^{o} 04'N in Nigeria, *Zingiber officinale* can be found growing from low altitude (5m above sea level) in the Southern coastal plains of the rainforest to mid-height (823m above sea level) in the Derived Savanna (Olojede and Nwokocha, 2011). Trace and heavy metals are abundant in *Zingiber officinale*. Regular use of these metals causes metal deposition in human organs, which can lead to major health concerns. Because of their essentiality or poisonous nature, trace metals are particularly significant in food composition. Environmental pollution is the primary source of heavy metal contamination in the food chain. The levels of trace metals vary depending on the food item and their introduction during the cultivation, transport, processing, and fortification of food. In addition, other methods that are used to transform raw food into a finished product can dramatically raise the total trace metal content of the meal. There is virtually little information on the metal concentrations in spices, particularly *Zingiber officinale* grown in Maro. Rhizomes are used as spices in the main meal of the Maro people and Nigeria as a whole. Because of this high consumption, it's crucial to figure out how much metal is in *Zingiber officinale* powder. Maro is a significant *Zingiber officinale* producing village in the southern portion of Kaduna State, Nigeria, it is critical to ensure product quality. However, no report on metal levels in *Zingiber officinale* grown from Maro. As a result, the primary goal of this research was to measure the levels of selected metals and to assess the potential health risks associated with their ingestion.

MATERIALS AND METHOD

Sample Selection

In June 2021, *Zingiber officinale* rhizomes were collected from four (4) separate locations in Maro ward, Kajuru LGA, Kaduna state. The study area includes Maro, Chibiya, Karamai, and Angwan Gamu. Four (4) samples (each from a separate location) were collected and tested for metals using Atomic Absorption Spectroscopy (AAS). The study area is depicted in the diagram below.

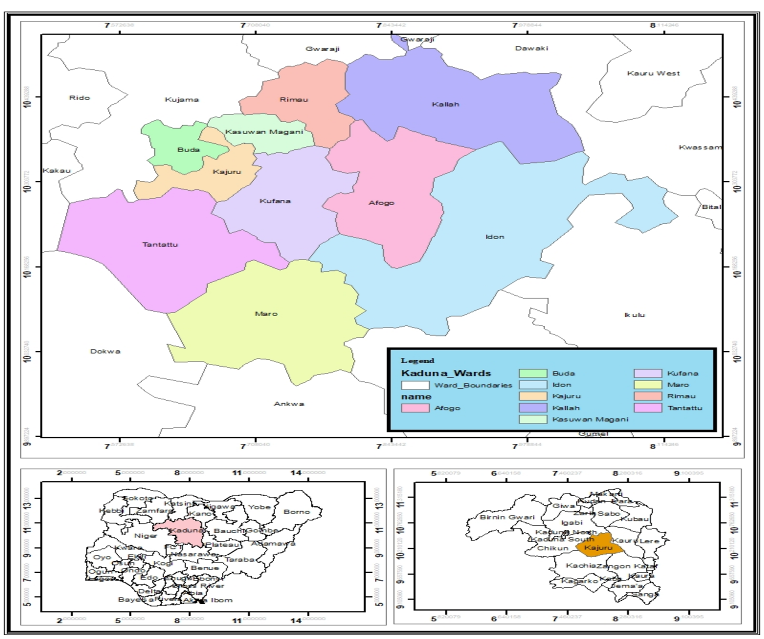

Fig 1: (Source: field work 2021)

Sample Preparation

Each *Zingiber officinale* rhizome was washed with tap water and then distilled water in the laboratory. Farmland in Maro Sample A was given to the *Zingiber officinale*, whereas Chibiya farmland was given to the *Zingiber officinale* Sample B, Karamai farmland, was designated as *Zingiber officinale* Sample C, while Angwan Gamu farmland was Sample D. To make drying easier, the four samples were cut into pieces. The samples were dried individually at room temperature in the laboratory. All of the samples were dried after ten days. To obtain fine powder, the samples were ground using a mortar and a pestle according to the label and sieved.

Procedure

In an analytical balance, 1.0 g of *Zingiber officinale* powder was weighed and transferred to a 250 ml conical flask. In a fume hood, 5 ml concentrated HNO_3 was added to each sample slowly at first, followed by 10 ml of 60% concentrated perchloric acid until foaming stopped. At 200.^{0}C for 80 minutes, a hot plate was used to heat the sample until HNO_3 evaporated. The sample was heated to $HClO_4$ white fumes. The digested samples were then chilled and filtered using filter paper before being quantitatively transferred to a 100.0 ml volumetric flask. To obtain four digested samples, the above technique was used on the other sample.

Determination

The sample was analyzed in triplicate to provide an average of each metal concentration, which was then used to determine the mean, standard deviation, and ANOVA to correlate *Zingiber officinale* concentration.

Statistical Analysis

The data was examined statistically using analysis of variance (ANOVA). Then a one-sample t-test was used to see if the quantities of these metals exceeded the World Health Organization's (WHO) recommended maximum allowable limit. Finally, the F (Fischer) test was employed to determine whether the metal concentration data acquired by AAS from different farmlands differed significantly.

Health Risk Assessment of Ginger

The estimated daily intake (EDI) of metal, target hazard quotient (THQ), and Hazard Index (HI) were used to analyze the potential health consequences of metal consumption through spices. The EDI value of *Zingiber officinale* is determined by element concentrations, daily consumption, and body weight. Equation (1) was used to calculate the EDI values of the metals studied.

$EDI = C_{metal}$ x IR /BW. .... (1)

where EDI is for estimated daily intake, Cmetal (mg/kg) stands for average weighted heavy metal concentration in spices, IR stands for average daily spice consumption (gram/day individual), and BW stands for average body weight (Kg) (Amer et al., 2019). Spice IR for adults is 10 g/day/person of dry weight, which is consistent with the research. The average adult body weight was 60.0 kg (Meseret et al., 2020). THQ was used to calculate non-carcinogenic risks associated with long-term exposure to pollutants in *Zingiber officinale* using Equation (2).

THQ = EDI /RfD. .... (2)

RfD stands for reference dose levels (mg/kg/day) for each metal of interest. The RfD for Na, Mg, K, Ca were not specified (NS) and Fe 0.70 mg/kg per day (Hindawi 2021). The HI was created to evaluate the overall non-carcinogenic risk to human health from multiple pollution exposures. As indicated in Equation (3), HI is the sum of all heavy metal hazard quotients in Ginger.

HI=THQ(Na)+THQ (Mg) +THQ(K)+THQ(Ca)+THQ(Fe) .... (3)

If the values of THQ/HI > 1 indicate that the population will pose potential adverse health effects, while if THQ/HI < 1, the population is unlikely to experience obvious adverse effect (Ghasemidehkordi et al., 2018; Khan et al., 2009; Mohammadi et al., 2019).

RESULTS AND DISCUSSION

The following are the results of an analysis that was conducted to quantify metals in *Zingiber officinale* powder accessible in Maro ward, Kajuru LGA, Kaduna state, Nigeria. As a result, four different *Zingiber officinale* farmlands were investigated. The analysis was performed on three batches from each brand. AAS was used to determine the metals sodium (Na), magnesium (Mg), potassium (K), calcium (Ca), and iron (Fe).

Estimation of Metals

The metals (Na, Mg, K, Ca and Fe) contents batch and location which were determined by AAS are listed in Tables 2 and 3 respectively.

Table 1: Metal Content in *Zingiber officinale* by AAS

LOCATION(Batch)		Na(mg/l)	Mg(mg/l)	K(mg/l)	Ca(mg/l)	Fe(mg/l)
A	**1**	1.565±3.6	1.377± 5.2	29.98± 80.6	5.196± 13.9	2.670± 7.2
	2	1.565± 3.6	2.489± 5.2	29.98± 80.6	6.194± 13.9	2.670± 7.2
	3	1.576±3.6	2.588± 5.2	39.98± 80.6	6.198± 13.9	3.670± 7.2
B	**1**	1.023± 4.1	1.102± 2.6	0.652± 1.5	1.085± 4.4	2.098± 5.4
	2	2.023± 4.1	1.102± 2.6	0.652± 1.5	2.196± 4.4	2.398± 5.4
	3	2.043± 4.1	1.156± 2.6	0.692± 1.5	2.196± 4.4	2.398± 5.4
C	**1**	1.455± 3.3	1.604± 4.8	1.021± 2.5	3.476± 8.5	3.192± 7.6
	2	1.455± 3.3	1.704± 4.8	1.121± 2.5	3.676± 8.5	3.197± 7.6
	3	1.459± 3.3	2.704± 4.8	1.121± 2.5	3.679± 8.5	3.297± 7.6
D	**1**	1.229± 5.0	1.594± 3.7	0.751± 1.6	1.617± 3.9	2.593± 6.2
	2	1.229± 5.0	1.594± 3.7	0.751± 1.6	1.617± 3.9	2.593± 6.2
	3	3.289± 5.0	1.594± 3.7	0.751± 1.6	1.787± 3.9	2.693± 6.2

Results means ± standard deviation of three determinations are calculated at significantly different (p <0.05).

Table 2: Average Metal Content in Different *Zingiber officinale* Farmland by AAS

LOCATION	Na(mg/l)	Mg(mg/l)	K(mg/l)	Ca(mg/l)	Fe(mg/l)
A	1.569± 3.6	2.152± 5.2	33.31± 80.6	5.863± 13.9	3.003± 7.2
B	1.696± 4.1	1.120± 2.6	0.665± 1.5	1.822± 4.4	2.265± 5.4
C	1.456± 3.3	2.004± 4.8	1.008± 2.5	3.610± 8.5	3.230± 7.6
D	1.916± 5.0	1.594± 3.7	1.084± 1.6	1.674± 3.9	2.626± 6.2

Results average means ± standard deviation of three determinations are calculated at significantly different (p <0.05).

Table 3: Summary of ANOVA

Source	SS(sum of square)	df(degree of freedom)	MS(mean square)	F(Fisher)
Properties	149.94	4	37.49	37.49/53.32= 0.703
Error	799.73	15	53.32	
Total	949.67	19		

Table (t) value =2.90

According to the findings, the mean value of Na concentration in *Zingiber officinale* cropland ranged from 1.456 to 1.916 mg/l. Location D had the greatest mean amount of Na at 1.916 mg/l, whereas sample C had the lowest mean value at 1.456 mg/l, which is similar to Goroya 2019. The Mg levels ranged from 1.120 to 2.152 mg/l, with sample A having the highest mean concentration of 2.152 mg/l and sample B having the lowest mean concentration of 1.120 mg/l, similar to Zhao (2016). The K concentration ranged from 0.665 to 33.31 mg/l. Due to fertilizer application, sample A had the greatest mean level of 33.31 mg/l and sample B had the lowest mean level of 0.665 mg/l for K. The outcome is comparable to Goroya 2019. The greatest concentration levels of Ca varied from 1.674 to 5.863 mg/l. Sample A had the greatest mean concentration of 5.863 mg/l, whereas sample D had the lowest value of 1.674 mg/l, which is similar to Eddouks (2012). *Zingiber officinale* samples had Fe levels ranging from 2.265 to 3.230 mg/l. Sample C had the greatest mean concentration of 3.230 mg/l, whereas sample B had the lowest mean concentration of 2.265 mg/l. According to the World Health Organization, the maximum allowed limit for Fe in spices is 3.00 mg/l (WHO). The metal content in *Zingiber officinale* was compared using analysis of variance (ANOVA) at 95 % confidence level (P>0.05) in Table 6. Using F (Fisher), the value of F calculated (0.703) is less than f-table value (2.90), hence there is no significant difference in metal content in various farmland in Maro ward.

HEALTH RISK ASSESSMENT

Table 5: EDI, and THQ Values of Metals in Different Locations in Maro Farmlands

Location	Na		Mg		K		Ca		Fe	
	EDI	**THQ**	**EDI**	**THQ**	**EDI**	**THQ**	**EDI**	**THQ**	**EDI**	**THQ**
A	0.262	N.S	0.359	N.S	5.55	N.S	0.977	N.S	0.5005	0.715
B	0.283	N.S	0.187	N.S	0.11	N.S	0.304	N.S	0.3775	0.539
C	0.243	N.S	0.334	N.S	0.17	N.S	0.602	N.S	0.5383	0.769
D	0.319	N.S	0.265	N.S	0.18	N.S	0.279	N.S	0.4377	0.625

***N.S** meaning Not specified.*

HI=THQ (Na)+THQ(Mg)+THQ(K)+THQ(Ca)+THQ(Fe)
HI=N.S+N.S+N.S+N.S+N.S+2.6486
HI= 2.6486

From Table 5, the EDI values of Na, Mg, K, Ca and Fe were calculated to be 0.2427 -0.3193, 0.1108- 5.5517, 0.2790- 0.9772 and 0.3775-0.5393 respectively. The THQ values were not able to be calculated because no specified Rfd for Na, Mg, K, and Ca. Except for the THQ values of Fe ranged from 0.5393 - 0.7690 hence the THQ values in all locations were less than one, indicating that consumption of *Zingiber officinale* in such farmland locations do not impose a potential health risk It can be seen that the HI values of all metals were 2.6486. In general, serious chronic health impact has been suggested when the value of HI is > 10. Therefore, THQ and HI values suggested that the exposed population is assumed to be safe.

CONCLUSION AND FURTHER WORK

Based on the analyzed result, it can be concluded that Maro ward in Kajuru LGA *Zingiber officinale* contains metals such as Na, Mg, K, Ca and Fe. According to the statistical analysis, all the metals do not exceed the maximum permissible limit significantly recommended by WHO from the exceeding values. It was evident that the metal content in *Zingiber officinale* do not vary. According to the *Zingiber officinale* data, K is the metal with the highest concentration in site A (Maro) with 33.31 mg/l, and the lowest K concentration in location B (Chibiya) with 0.665 mg/l, which could be due to fertilizer application. Location A (Maro) has the highest concentration of Ca at 5.863 mg/l, Location A (Maro) has the highest concentration of Mg at 2.152 mg/l, Location C (Karamai) has the highest concentration of Fe at 3.230 mg/l, and location D (Agwaan Gamu) has the highest concentration of Na at 1.916 mg/l. According to the statistical analysis, there was no difference in metal levels between the different locations of each sample, but there was a significant difference between individual farmlands, K>Ca>Mg>Fe>Na. Overall, the study's findings indicate that there is no health risk to people consuming Maro *Zingerber officinale*. The determination of micro and hazardous components in *Zingiber officinale* in Maro ward, Kajuru LGA, Kaduna state, should be the focus of future research
.

Reference

Ahmed Maigari Ibrahim,2018. Ginger farming practice in jaba region, kaduna state, Nigeria. Department of environmental management, Beyero University Kano, Nigeria.Duste. journal of pure and applied science (DUJOPAS),vol.4 No.2 155 - 168.December 2018.

Ajayi OB,Seun FA, Funmilayo TA (2013). Food value of two varieties of ginger (Zingiber officinale) commonly consumed in Nigeria. Hindawi, 359727.Available at: http://dx.doi.org/10.5402/2013/359727.

Amer, M., Sabry B., Marrez D., Hathout A. (2019) A. Fouzy, Exposure assessment of heavy metal residues in some Egyptian fruits, Toxicol. Rep. 6 (2019) 538–543.

Banake E. Sambo(2017).Highlights of a Presentation at the International Ginger Business Development and Investment Summit; organized by TAK Integrated Agriculture Solutions Limited (TAK-IASL); in collaboration with the Ginger Growers Association and Ginger Off-takers Association under the theme: “The Development of Ginger Value Chain in Nigeria”; at Hotel Seventeen, Lafia Road, City Centre, Kaduna-Nigeria; Tuesday 25thJuly, 2017.

Belay K, Tadesse A (2014). Comparison of digestion methods for determination of Pb (II), Cr (VI) and Cd (II) contents in some Ethiopia spices using atomic absorption spectroscopy. International Journal of Academic Scientific Research 2(3):42-53.

Chattopadhyay, D., & Eddouks, M. (2012). Cellular nutrition and nutritional medicine in diabetes and related complications: An overview in phytotherapy in the management of diabetes and hypertension, Chapter 1, Bentham Science Publication, 3-59,

Ghasemidehkordi, B., Malekirad, A., Nazem, H., Fazilati, M, Salavati, H., Shariatifar N., Rezaei, M., Fakhri, Y., Khaneghah, A. (2018). Concentration of lead and mercury in Collected vegetables and herbs from Markazi province, Iran: a non-Carcinogenic risk assessment, Food Chem. Toxicol. 113 204–210.

Human vitamin and mineral requirements. Report of a joint FAO/WHO expert consultation. Bangkok, Thailand, pp. 151-267. https://www.hindawi.com/journals/bmri/2021/6678931/tab6/

Khan S., Farooq, R., Shahbaz S., Khan M., Sadique M. (2009).Health risk assessment of Heavy metals for population via consumption of vegetables, World Appl. Sci. J. 6 1602–1606.

Kusse Gudishe Goroya, Zewde Mitiku and Yoseph Alresawum Asresahegn, (2019). Determination of concentration of heavy metals in ginger using flame atomic absorption spectroscopy. African Journal of Plant Science. Vol.13(6), pp. 163-167.

Longhurst R (2010). Global Leadership for Nutrition: The UN’s Standing Committee on Nutrition (SCN) and its Contributions. Available at:

http://opendocs.ids.ac.uk/opendocs/handle/123456789/5387.

Meseret M., Ketema, G., Kassahun H., (2020) Health risk assessment and determination some heavy metals in commonly consumed traditional herbal preparations in Northeast Ethiopia, J. Chem. 2020 (2020) 1–7.

Mohammadi, A., Zarei, A., Majidi, S., Ghaderpouryd, A., Hashempour, Y., Saghi, M., Alinejad, A., Yousefih, M., Hosseingholizadehi, N., Ghaderpoori M. (2019). Carcinogenic and non-Carcinogenic health risk assessment of heavy metals in drinking water of Khorramabad, Iran, MethodsX 6 1642–1651.

Olojede, A. O. and C. C. Nwokocha (2011) A decade of research on minor root and tuber crops at NRCRI: The contribution towards food sufficiency and economic empowerment in Nigeria, In: Root and Tuber Crops Research for Food Security and Empowerment. C.OAmadi, K. C. Ekwe, G. O. Chukwu, A. O. Olojede, C. N. Egesi (Eds). 2011.387-396.

Prasad S, Tyagi AK. (2015). Ginger and its constituents: Role in prevention and treatment of gastrointestinal cancer. Hindawi, 142979. Available at: http://dx.doi.org/10.1155/2015/142979.

Shirin APR, Jamush P (2010). Chemical composition and antioxidant properties of ginger root. Journal of medical plant research 4(24):2674-2679. http://www.academicjournals.org/JMPR.

Zhao, W. Z., Zhang, R. X. and Yu, Z. P. (2016). “Research progress on chemical constituents and bioactivity of Ginger,” Food In-dustry Technology, vol. 37, no. 11, pp 383–387.