

An Assessment of Trace Elements in Selected Leafy Vegetables from Lagos State, Nigeria

T.F. Ogunjimi^{1,3}, S.A. Ferreira-Leite², E.G. Pereira³

¹ Geography Department, University of Lagos, Akoka, Lagos, Nigeria
University of Lagos, Lagos, Nigeria

²Instituto de Ciências Exatas e Tecnológicas, Universidade Federal de Viçosa, (UFV), Florestal, Minas
Gerais, Brazil

³Instituto de Ciências Biológicas e da Saúde, UFV, Florestal, Minas Gerais, Brazil

Date Received: 23-01-2025

Date Accepted: 27-04-2025

DOI: <https://doi.org/10.48198/NJPAS/25.A01>

Page | 5352

ABSTRACT

Trace elements have been identified as one of the major contaminants of leafy vegetables that can accumulate in human organs with potential health risks. Thus, this study assessed the levels of cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu), zinc (Zn), and iron (Fe) in 5 commonly consumed leafy vegetables' samples of *Telfairia occidentalis*, *Celosia argentea*, *Corchorus olitorius*, *Talinum triangulare*, and *Vernonia amygdalina* from two markets in Lagos State. The Atomic Absorption Spectrophotometer (AAS) was used in metal determination and the data were analyzed using ANOVA and tested with the Tukey test ($p < 0.05$). Cd levels were below the detectable limit, but Pd and Cr were observed in *T. Occidentalis* (20.82 mg kg⁻¹) and *C. olitorius* (7.89 mg kg⁻¹) from Oyingbo and Mile 12, respectively. Fe levels were the highest in all the vegetables, with a range of 392.66 – 2,072.97 mg kg⁻¹ and 573.13 – 1,255.38 mg kg⁻¹ in Mile 12 and Oyingbo, respectively. Zn concentration was significantly different among the vegetables in both markets, with the highest concentration in *C. argentea* (308.33 mg kg⁻¹) and *T. triangulare* (303.96 mg kg⁻¹), and lowest concentration in *C. olitorius* (97.1 mg kg⁻¹) and *V. amygdalina* (102.33 mg kg⁻¹) in Mile 12 and Oyingbo, respectively. Cu had the lowest concentration ranging between 4.55 – 33.34 mg kg⁻¹ and 0.17 – 7.34 mg kg⁻¹. The Pb, Cr, Zn, and Fe levels were above allowable limits by FAO/WHO (1996). Thus, there are potential risks of toxicity from these vegetables and it's a major concern for public health and safety.

Keywords: Trace metals, Leafy vegetables, Markets, Lagos.

Introduction

Globally, leafy vegetables are part of the daily meal in many households, offering nutrients such as vitamins, fibers, and amino acids (Shuaibu *et al.*, 2013). They have medicinal properties and are quite affordable (Aslam *et al.*, 2020). However, vegetables can accumulate trace metals at high concentrations, posing health risks

(Guerra *et al.* 2012). Plants are exposed to trace metals through wet deposition from rainfall in polluted areas, dry deposition from dust, fossil fuel burning, the use of pesticides, and fertilizers. Trace metals such as manganese (Mn), zinc (Zn), copper (Cu), and iron (Fe) are necessary for biological processes in the human body. But they induce toxicity at high concentrations. Excessive concentration of lead (Pb) and cadmium (Cd) in

Corresponding Author: T.F. Ogunjimi

University of Lagos, Lagos, Nigeria. Email: temitope.ogunjimi@ufv.br

food is associated with the disruption of the cardiovascular, nervous, and respiratory systems (Bouida *et al.*, 2022). Short-term vulnerability to Cu toxicity causes gastrointestinal problems but studies on its toxicity in humans are limited. High Ni level in humans is also associated with cardiovascular diseases, asthma, lung fibrosis, and respiratory tract infection (Chen *et al.*, 2017). Cr causes respiratory diseases and skin cancer (Shekhawat, 2015). Pb toxicity affects the digestive, respiratory, and reproductive systems (Mandal *et al.*, 2022). The absorption of trace metals depends on plants and environmental factors (Tangahu *et al.*, 2011). Trace elements reach the food chain through several biochemical activities.

Leafy vegetables are often cultivated in urban and peri-urban areas. Hence, they are vulnerable to contamination. They are also highly consumed, and that's why it is important to monitor these vegetables continuously to present recent data on their trace elements' concentration for public health safety. Thus, the study investigated the levels of Cd, Cr, Pb, Cu, Zn, and Fe in five (5) commonly consumed vegetables in Lagos, Nigeria, in line with established safe limits. The objectives were to determine the trace elements concentration and compare their contents among the selected vegetables and between two markets.

Materials and Methods

The leafy vegetables examined were *T. occidentalis*, *C. argentea*, *C. olitorius*, *T. triangulare* and *V. amygdalina*.

Study Area

This study was conducted with the selected vegetable samples from two markets in Lagos State, Nigeria. Lagos State is geographically situated in the southwestern part of Nigeria, between longitude 3.45°E and 3.750°E of the Greenwich Meridian and between latitude 6.35°N and 6.583°N of the equator (Figure 1). Mile 12 International market and Oyingbo market are

located in Kosofe Local Government Area (LGA) and Mainland LGA of Lagos State, respectively, as shown in Figure 1. These two markets were chosen because of their size, patronage, and location in Lagos State.



Figure 1: Map of Lagos state (in Nigeria) indicating the locations of the two markets

Sample Collection and Preparation

Three replicates of each vegetable were obtained from three (3) vendors in each market to ensure precision. The leaves were removed from the stalk and cut into small pieces. The samples were air-dried for two hours and dried in the oven at 100°C until the weight was constant. Each dried sample was ground into a fine form and allowed to cool. The samples were then stored in labeled plastic bags for further analysis.

Samples Digestion and Elemental Analysis

The laboratory analysis was carried out according to Carmo *et al.*, (2000). 4 mL of nitric acid (HNO₃) was added to about 0.2g of the samples and cooled. The samples with the nitric acid were then heated at a temperature of 120°C for 510 minutes. Thereafter, 2 ml of perchloric acid (HClO₄) was added and the temperature was increased to 180°C on a hot plate in a fume hood until the content was transparent and halved. The digested sample was then allowed to cool and thereafter diluted with 25 ml of deionized water.

The working standards for each trace metal detection were prepared using a dilution method according to Carmo *et al.*, (2000), and the concentrations of the metals in each digested

sample were evaluated using an Atomic Absorption Spectrophotometer (AAS, Model AA-7000 Shimadzu, Japan). The calibration range for each element and their detection limit was calculated and the ion concentration was determined and converted to mg kg⁻¹.

Data Analysis

The data obtained were analyzed descriptively (mean and standard deviation). Analysis of variance (ANOVA) was conducted and tested with the Tukey test where the difference was significant ($p < 0.05$)

Result and Discussion

The mean values and Standard Deviation (SD) of each metal in different vegetables in the two markets are presented in Table 1.

Table 1. The vegetable samples ' mean and SD of Trace Elements concentration (mg kg⁻¹).

Leavy vegetables	Copper (Cu)		Zinc (Zn)		Chromium (Cr)	
	Mile 12 Mean ± SD	Oyingbo Mean ± SD	Mile 12 Mean ± SD	Oyingbo Mean ± SD	Mile 12 Mean ± SD	Oyingbo Mean ± SD
<i>T. occidentalis</i>	14.6 ± 3.8	0.2 ± 0.3	146.8 ± 37.8	139 ± 34.9	ND	ND
<i>C. argenta</i>	28.5 ± 16.7	7.3 ± 5.3	308.3 ± 13.5	150.7 ± 120.8	ND	ND
<i>C. olitorius</i>	33.3 ± 24.3	0.5 ± 0.9	97.1 ± 9.88	152.6 ± 89.4	7.9 ± 13.7	ND
<i>T. triangulare</i>	6.4 ± 1.34	0.8 ± 0.6	143.65 ± 36.67	303.9 ± 7.2	ND	ND
<i>V. amygdalina</i>	4.6 ± 1.06	2.3 ± 1.34	99.6 ± 29.6	102.3 ± 5.4	ND	ND
WHO/FAO	10-40 mg kg ⁻¹		50 mg kg ⁻¹		2.3 mg kg ⁻¹	
	Lead (Pb)		Iron (Fe)		Cadmium (Cd)	
<i>T. occidentalis</i>	ND	20.82 ± 20.47	721.9 ± 171	967.1 ± 260.5	ND	ND
<i>C. argenta</i>	ND	ND	421.3 ± 355.7	607.9 ± 93.8	ND	ND
<i>C. olitorius</i>	ND	ND	2072.9 ± 517.8	828.1 ± 671.8	ND	ND
<i>T. triangulare</i>	ND	ND	638.5 ± 225.5	1255.4 ± 152.1	ND	ND
<i>V. amygdalina</i>	ND	ND	392.7 ± 95.3	573.1 ± 149.3	ND	ND
WHO/FAO	5 mg kg ⁻¹		10 -450 mg kg ⁻¹		0.2 mg kg ⁻¹	

ND- Non detectable

5355

Cadmium (Cd) was below the detection limit of the analytical technique (AAS) in all the vegetables. Pb was found only in two samples of *T. occidentalis* (21.53 mg kg⁻¹ and 40.93 mg kg⁻¹) from Oyingbo market, with concentrations greater than the FAO/WHO safe limits of 5 mg kg⁻¹. This was similar to a study by Doherty *et al.*, (2012). Chromium (Cr) was found at a high concentration in one sample of *C. olitorius* (23.68 mg kg⁻¹) in Mile 12 only. This differs from the Alani *et al.* (2020) report, where Cr was found in all the vegetables sampled in farmlands in Lagos.

The other trace elements, namely Cu, Zn, and Fe, were detected in all the vegetables at varying concentrations, confirming some of the nutritional and medicinal benefits of these vegetables (Aslam *et al.*, 2020). Their levels were in the order, Cu < Zn < Fe in the selected vegetables as observed by Amos-Tautua *et al.* (2014) and Alani *et al.* (2020). The highest concentrations of Cu were observed in *C. argentea* (17.9 mg kg⁻¹), Zn and Fe highest levels were observed in *T. triangulare* (223.8 mg kg⁻¹) and *C. olitorius* (1450.5 mg kg⁻¹), respectively.

Absence of Cd differs from reported studies in Lagos State, where Cd was detected within a range of 0.001 – 0.05 mg kg⁻¹, below the safe limits of 0.2mg kg⁻¹ (Sobukola *et al.*, 2010; Ladipo and Doherty, 2011; Doherty *et al.*, 2012; Otitolaju *et al.*, 2012; Adewale *et al.*, 2023). However higher levels above this limit were reported by Alani *et al.*, 2020, and Ebabhi *et al.*, 2020, from vegetables sourced from some farmlands in Lagos state.

Pb and Cr were found in one vegetable from each market. Pb and Cr are highly toxic, and their presence in these leafy vegetables is a cause for concern. The presence of Pb in this market might be due to the closeness to industrial activities, as lead is associated with the combustion of leaded hydrocarbon and the production of herbicides and fertilizers, some of which are more common in Oyingbo than in Mile 12. The absence of Pb in

the other vegetables differs from previous studies; Subukola *et al.* (2010) reported a range of Pb concentration from 0.07– 0.27 mg kg⁻¹ in leafy vegetables, with the highest in *T. occidentalis* (0.21 mg kg⁻¹). Alani *et al.* (2020) reported a range between 27 – 42 mg kg⁻¹, and Ladipo & Doherty (2011) reported the absence of Pd in *T. occidentalis* in Lagos state.

Comparative Concentration of Essential Trace Elements among the Different Vegetables in the Two Markets

The concentrations of Cu were higher in vegetables from Mile 12 than in Oyingbo as shown in Figure 2. There was a significant difference in the mean concentrations of Cu among the vegetables in Oyingbo. The highest Cu concentration was observed in *C. olitorius* (33.34 mg kg⁻¹) and *C. argentea* (7.34 mg kg⁻¹), while the lowest values were observed in *V. Amygdalina* (4.55 mg kg⁻¹) and *C. olitorius* (0.49 mg kg⁻¹) in Mile 12 and Oyingbo, respectively. Also, the levels were generally lower to cause toxicity risks to humans as they were below the allowable limits in plants of 10–40 mg kg⁻¹ (WHO,1996). The levels were higher in Mile 12 than what was reported by Sobukola *et al.*, (2010) and Doherty *et al.*, (2012), but lower than the report of Alani *et al.*, (2020).

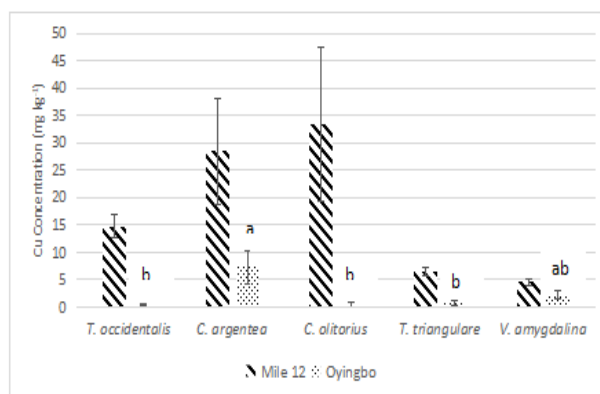


Figure 2: The copper (Cu) concentration means differences among the vegetables in both markets.

The highest Zn level was observed in *C. argentea* (308.33 mg kg⁻¹) and *T. triangulare* (303.96 mg

kg⁻¹), whilst the lowest Zn concentration was observed in *C. olerius* (97.1 mg kg⁻¹) and *V. amygdalina* (102.34 mg kg⁻¹) in Mile 12 and Oyingbo, respectively. The levels were higher in both markets than were reported by Sobukola *et al.* (2010) and Doherty *et al.* (2012), who reported values ranging between 0.03 - 0.13 mg kg⁻¹ and 0.03-0.091 mg kg⁻¹, respectively. But similar to the highest observed in *C. argentea* as observed in Mile 12. The Zn concentration observed in this study was higher than the allowable limits of 50 mg kg⁻¹ (WHO,1996). Also, there is a significant difference in Zn concentration ($p<0.05$) among the vegetables in both markets, as shown in Figure 3.

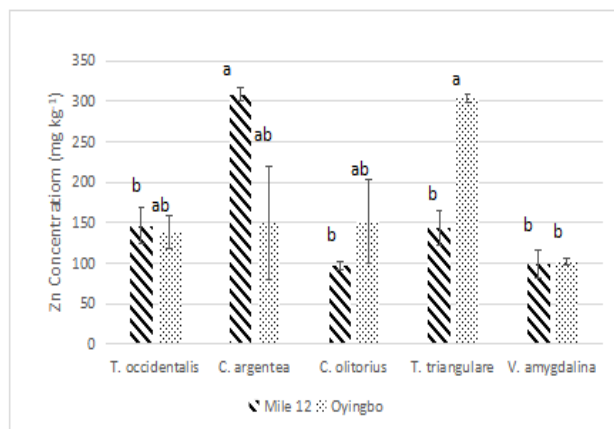


Figure 3: Zn concentration means differences among the vegetables in both markets

The highest concentrations of Fe were observed in *C. olerius* (2,072.97 mg kg⁻¹) and *T. triangulare* (1,255.38 mg kg⁻¹) in Mile 12 and Oyingbo, respectively. The lowest values of 392.66 mg kg⁻¹ and 573.13 mg kg⁻¹ were observed in *V. amygdalina* in Mile 12 and Oyingbo, respectively. The concentrations found were higher than what was reported by Shuaibu *et al.* (2013 and Olasupo *et al.* (2020), but similar to Alani *et al.* (2020), who reported a range of 2,685 – 4,567.2 mg kg⁻¹. Some of the values observed were higher than the permissible limits of 10- 450

mg kg⁻¹ (FAO/WHO,1999). There is a significant difference in Fe concentration ($p<0.05$) between *C. olerius* and the other vegetables in Mile 12, but no significant difference among the vegetables in Oyingbo as shown in Figure 4.

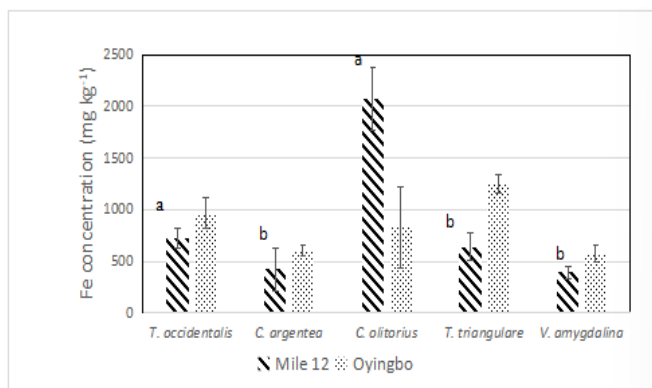


Figure 4: Fe concentration means differences among the vegetables in both markets

Conclusion

This study revealed that the evaluated trace element contents of the selected leafy vegetables were above allowable limits except for Cu. This implies that consumption of these vegetables could pose potential health risks. Thus, there is a need for public awareness of the vulnerability of leafy vegetables to trace metal contamination. Also, regular monitoring of these vegetables is necessary. Moreover, research that evaluates not just the vegetable samples but also all the environmental sources of contamination of plants, such as soil and water used for cultivation, should be explored. Furthermore, research on how to mitigate the absorption of trace metals by leafy vegetables and regular reviews of policies and regulations on environmental contamination should be conducted.

Conflict of Interest

The authors declare no conflict of interest that could have influenced this work.

References

- Adewale P. S, Makinde S.C.O., Kusemiju V. O. (2023). Assessment of Heavy Metal Residues in Soil and Leaves of Vegetables Along Urban and Peri-Urban Gradient of Lagos State Nigeria. *Issues and climate change*. 2(1), 70-77.
- Alani R.A, Nwude D, Abati A, Akinrinade O.E (2020) Heavy Metal Concentration of Vegetables Planted in Lagos Soils and Their Potential Pollution Risks. *Ife Journal of Agriculture*, 32(3), 12-30.
- Amos-Tautua, B.M.W. and Onigbinde A.O. (2014). Estimation of Iron, Copper and Zinc in Some Vegetables Commonly Consumed in Amassoma, Niger Delta, Nigeria. *Pakistan Journal of Nutrition*, 13 (12): 742-745.
- Aslam T., Maqsood M., Jamshaid I., Ashraf K., Zaidi F., Khalid S., Ul Hassan F., Shahsaba Noureen S. (2020) Health Benefits and Therapeutic importance of green leafy vegetables (GLVs). *European Academic research*. 8 (7).
- Carmo, C. A., Araújo, W. S., Campos Bernard, A. C. and Saldanha M. F. (2000). Métodos de análise de tecidos vegetais utilizados na Embrapa Solos 41 p. – (Embrapa Solos. Circular Técnica; 6). CDD (21. ed.) 631.42.
- Chen, Q.Y., Brocato, J., Laulicht, F., and Costa, M. (2017). Mechanisms of nickel carcinogenesis. In *Essential and Nonessential metals. Molecular and Integrative Toxicology*; Mudi palli, A., Zelikoff, J.T., Eds.
- Doherty, V.F. Sogbanmu, T.O., Kanife, U.C., & Wright O. (2012). Heavy Metals in Vegetables Collected from Selected Farm and Markets Sites in Lagos, Nigeria. *Global Advanced Journal of Environmental Science and Toxicology* 1(6):137-142.
- Ebabhi A.M., Kanife U.C. and Salako S.T. (2020). Bio-Assessment of Heavy Metals in Leafy Vegetables from Selected Agricultural Farms in Lagos State, Nigeria. *Nig. J. Pure & Appl. Sci.* 33(1).
- FAO/WHO (1999). Joint Expert Committee on Food Additives, “Summary and Conclusions”, In *Proceedings of the 53rd Meeting of Joint FAO/WHO Expert Committee on Food Additives*, Rome, Italy.
- Guerra, F., Trevizam A. R., Muraoka, T., Marcante, N. C., Canniatti-Brazaca, S. G. (2012). Heavy metals in vegetables and potential risk for human health *Sci. Agric.* 69(1), 54-60.
- Idakwoji P.A., Sheneni V.D., Nweje-Anyalowu P. C., Odo C. E, Ihuomah V. E. (2018). Assessment of Heavy Metal Levels of Green Leafy Vegetables Sourced from Different Markets in Lokoja, Kogi State, Nigeria. *Int. J. Adv. Res. Biol. Sci.* 5(8): 5 -15.
- Ladipo, M.K., & Doherty V.F., (2011). Heavy Metal Levels in Vegetables from Selected Markets in Lagos, Nigeria. *African Journal of Food Science and Technology*, 2(1): 081-021.
- Mandal, G.Mandal (Nandi), A., Chakraborty, A. (2022). The toxic effect of lead on human health- A review. *Human Biology and Public Health* 3. *Journal of the Auxological Society*. Vol3 pp.1-11 <https://doi.org/10.52905/hbph2022.3.45>.
- Nwoko, C. O., Emenyonu E. N. and Umejuru C. E. (2014). Trace Metal Contamination of Selected Vegetables Grown Around Owerri Municipality, Nigeria. *Journal of Agriculture and*

Ecology Research International 1(1): 18-29.

Ohiagu F.O., Chikezie P.C., Ahaneku C.C., Chikezie C.M. (2022). Human exposure to heavy metals; toxicity mechanisms and health implications. *Material Sc & Eng International Journal*. 6(2), 78-87

Ojiego, B.O., Ogu G.I., Dantanko F., Okolo J.C., Audu K.E. (2022). Health Risk Assessment for Selected Heavy Metals in *Telfairia Occidentalis* (Fluted Pumpkin) Leaf Retailed in Markets Within Lokoja Metropolis. *SVU-International Journal of Agricultural Sciences*, 4 (3): 125-134.

Olasupo O. V, Olagoke I. O., Aina T. A. Ojewole I. K. Lawal and O. A. Owolabi (2020) Assessment of Trace Metals in Selected Green Leafy Vegetables *International Journal of Academic and Applied Research* (IJAAR). 4 (5): 26-30

Otitolaju, O., Akpanabiatu, G.T.O., Otitolaju, J.I., Ndem, A.F., Uwah, E.O., Akpanyung Ekanem J.T. (2012). Heavy Metal Contamination of Green Leafy Vegetable Gardens in Itam Road Construction Site in Uyo, Nigeria. *Research Journal of Environmental and Earth Sciences*, 4(4): 371-375.

Shekhawat K., Chatterjee S., and Joshi B. (2015). Chromium Toxicity and its Health Hazards. *International journal of*

advanced research. 3(7): 167-172. Shuaibu, I. K., Yahaya, M. and Abdullahi, U. K. (2013). Heavy metal levels in selected green leafy vegetables obtained from Katsina central market, Katsina, Northwestern, Nigeria. *African Journal of Pure and Applied Chemistry*. 7(5): 179-183.

Sobukola O. P, Adeniran O. M., Odedairo A. A, and Kajihausa O. E. (2010). Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *African Journal of Food Science*. 4(2), pp. 389 – 393.

Tangahu, B. V., Abdullah, S.R.S., Idris, H.B.M., Anuar, N. & Mukhlisin, M. (2011). A review on heavy metals (As, Pb, and Hg) uptake by plants through phytoremediation. *International Journal of Chemical Engineering*, 31: 1-31.

WHO (1996). World Health Organization, Geneva. Guidelines for drinking water quality, 2nd edition, vol 2, Sydney: WHO

Zaidi M.I., Asrar A., Mansoor A., Farooqui M.A. (2005). The heavy metal concentrations along roadsides trees of Quetta and its effects on public health. *J. Appl. Sci.* 5(4): 708-711.