ChemSearch Journal 15(1): 213 – 218, June, 2024
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 17/05/2024 Accepted: 21/06/2024
http://www.ajol.info/index.php/csj

Assessment of some Potentially Toxic/Essential Elements in *Hibiscus sabdariffa* L. from Selected Gardens in Kano Metropolis

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ABSTRACT

Toxic elements have adverse effects on human health and therefore potentially toxic elements (PTEs) contamination in food deserves special attention. The research assessed the concentration of potentially toxic/essential elements in *Hibiscus sabdariffa* L. calyx sourced from five different gardens in Kano metropolis, Nigeria, using Atomic Absorption Spectrophotometry (AAS). Proximate analysis of the calyxes sample yielded 11.8% Ash content, 1.8% fat, 13.9% crude fibre, 4.2% protein, 7.1% moisture and 62.5% carbohydrate. The result of the mineral composition (essential elements) yielded the following in mg/kg of sample: K (106.5±0.2), Na (68.2±0.1), Mg (102±2.0), Ca (4.2±0.1), Fe (7.1±0.3), P (35.5±0.8).The results indicated that the concentrations of targeted PTEs in different gardens were in the range in mg/kg: Cd (0.217±0.039 - 0.020± 0.005), Ni (0.213±0.054 - 0.012± 0.001) and Pb (0.485±0.085- 0.163± 0.024). Both Cd and Ni were within acceptable limit of WHO/FAO in all samples except Pb which was above the limit set by WHO/FAO. There should be adequate monitoring of toxic metals in *Hibiscus sabdariffa* L. samples sourced from the gardens to prevent toxicity into the food chain causing bioaccumulation.

Keywords: Essential Elements, Garden, *Hibiscus sabdariffa* L., Proximate Composition, PTEs

INTRODUCTION

Among different environmental pollutants, potentially toxic elements (PTEs) are a cause for great concern due to their numerous sources, toxicity, non-degradable properties, and accumulation potentials (Yazdanfar *et al.*, 2024). Their persistent toxicity and bioaccumulation is now a pressing local, regional and global worry for ecologists, agriculturists, farmers, researchers and other stakeholders (Sayed *et al*., 2024) . PTEs at a higher concentration have raised profound concerns about the environment and human health (Hanis *et al*., 2023).

Green leafy vegetables like *Hibiscus Sabdariffa* L. called *"Zobo"* in Nigeria (Oyewole and Diosady, 2023), Roselle in English, and Karkade or Carcade in North Africa (Iruoghene *et al*., 2023) is one popular vegetable in West Africa, and many tropical regions which are common diet consumed throughout the world, being essential source of nutrients, metabolites and antioxidant (Atitsogbey *et al*., 2023). PTEs bioaccumulate in humans through consumption of contaminated foods which includes green leafy vegetables (Atitsogbey *et al*., 2023). *Hibiscus sabdariffa* L. belongs to the family *Malvaceae*; it is a shrubby annual species of *Hibiscus* and occurs in many tropical countries which is cultivated mainly for its calyxes that is rich in micronutrients (vitamin C, B1, and B2), and contains colorants (Caballero *et al*., 2024). *H. sabdariffa* has great values in the community for being used as traditional medicine for remedy of certain ailments, including hypertension, diabetes, liver diseases, and bacterial infections (Iruoghene *et al*., 2023). It is rich in protein, calcium, niacin, riboflavin, iron, phenols, amino acids, carotene, and vitamin C, among others (Essiedu and Kovaleva, 2024). *H. sabdariffa* and *M. oleifera* are used in forms of raw materials as vegetable, herbal tea, juice, syrups, flavoring and coloring agent. Studies have been conducted on its antioxidant properties as a beverage (Agunbiade *et al*., 2022), as a potential anti-inflammatory (Arce-reynoso *et al*., 2023), as a beverage to address the prevalence of iron deficiency in sub-Saharan Africa (Oyewole and Diosady, 2023), consumption as a beverage drink (Ocloo *et al*., 2023), food and medicinal herb (Salah *et al*., 2023). Current knowledge regarding the PTEs load of this plant whose leaves have found high consumption in the form of beverages and its usage as a herb in these areas under study especially in these gardens of Kano metropolis are limited and still insufficient. Therefore, this study was designed to assess the levels of Cd, Ni and Pb as potentially toxic elements in the edible tissues (calyx) of this plant based on its wide usage. A Picture of *H. sabdariffa* is shown in Plate 1.

Plate 1: A Picture of *H. sabdariffa*

METHODOLOGY

Study Area

Kano metropolis is located between latitude 11º N to 14º N and extends northward to the international boundary of Niger, Kano has a landmass of about 43,000 squares kilometer. Kano has a rainfall of about 600-1000 mm annually, 4-8 months of dry season maximum and minimum temperature of about 45º and 15.18 ºC respectively. Low temperature of 10 ºC during harmattan has been recorded. As at 2006 census, the metropolis has population of 9,401,288 and currently most populous state in Nigeria.

Sample Collection

The calyx (flowering portion) of *Hibiscus Sabdariffa* L samples were collected from five different gardens within Kano metropolis in January, 2023 the samples were labelled A, B, C, D, and E for Dingim B, FGGC Minjibir, Sauna, Wasai and Bayero University, Kano (Old Site), respectively. The control samples were collected from BUK new site farm. Identification of the collected plant species was done at the Plant Science Department of Bayero University, Kano (BUK) by a taxonomist and a herbarium number (DPB/BUK/01223) was assigned to it. The collected samples were washed with distilled water and dried using micro wave oven. The control was treated in a similar way. The dried samples were made to fine powder using ceramic mortar and pestle. Each sample was transferred into a polyethylene container and labeled accordingly prior to analysis. Standard analytical reagents and distilled water were used throughout the study. All glasswares and plastic containers used were washed with detergent solution followed by rinsing with tap water then 20% v/v nitric acid and finally distilled water.

Proximate Composition

The *Hibiscus Sabdariffa* L. calyx samples were obtained from those cultivated at five different gardens within Kano metropolis. They were subjected to postharvest operations that include proper washing and rinsing in distilled water, sun-drying to 10% moisture content, then they were stored for subsequent analyses. Proximate composition of the extract calyces was determined using standard methods (AOAC, 2000).

Mineral Determination

Samples were digested in 100 mL micro-Kjeldahl flask with $HNO_3/HClO_4$ until the solution became colourless. The samples were cooled and diluted to 25 mL with 0.1M HCl in a volumetric flask. Sodium, potassium, calcium, magnesium and iron were measured by atomic absorption spectrophotometry.

Ashing

The samples were digested using dried air ashing method. About 2g of air-dried ground and sieved samples were transferred into crucibles which was labeled according to the sample marks (A, B, C, D, and E), and the ashing was carried out in a muffle furnace at the temperature of 550ºC for 4hours. Then, the sample were removed from the muffle furnace and allowed to cool for 20minutes after which about $50cm^3$ of 0.25M HNO_3 solution was added to dissolve the ash. The digest then filtered through Whatmann No.1 filter paper into $100cm^3$ volumetric flask and made up to the mark with 0.25M HNO_3 solution. Blank was prepared using the same procedure without the sample. Both samples and the blank were aspirated into the AAS for the determination of Cd, Ni and Pb. The concentrations was obtained and recorded accordingly. (Mohammed and Inuwa, 2018).

Statistical Analysis

All data gathered were analysed statistically using analysis of variance (ANOVA). Microsoft Excel was used to plot all charts.

RESULTS AND DISCUSSION

The results of the analysis of Toxic elements, Cd, Ni and Pb in *Hibiscus sabdariffa* L.

samples obtained from selected gardens in Kano metropolis are presented in the form of Bar charts. Their means and standard deviations were used to assess their level in the various samples obtained. These concentrations are reported in mg/kg of each sample.

Proximate Composition

The proximate analysis of *Hibiscus sabdariffa* L calyces is as presented in Table 1. The *Hibiscus sabdariffa* L calyces were relatively high in carbohydrates, crude fiber and ash. The carbohydrate content of the calyces is high. The high carbohydrate level obtained lends further credence to the fact that the *Hibiscus sabdariffa L* calyces contain high carbohydrate content as reported by other workers (Tounkara and Mountaga, 2022; Afolabi *et al*., 2023).

Table 1: Proximate analysis of *Hibiscus sabdariffa* calyces (g/100g) dry mater

Parameter	Value
Ash Content	11.8
Fat Content	1.8
Crude Fibre	13.9
Protein Content	4.2
Moisture Content	7.1
Carbohydrate Content	62.5

Mineral Determination

Hibiscus sabdariffa L calyces were found to be relatively high in K, Na. Mg, Ca and Fe as presented in Table 2. These values are relatively high implying that *Hibiscus sabdariffa* can be a useful source in fortifying other food products that are deficient in essential minerals (Oyewole and Diosady, 2023). Potassium was found to be the most abundant mineral. This results however is consistent with the findings of Tounkara and Mountaga (2022) who obtained a high value for potassium in a similar research . Potassium is useful in maintenance of normal blood pressure (Sunday *et al*., 2023). It is also a useful electrolyte and also very important in rectifier potassium channels as an example of membrane channels where nutrigenomics plays an essential role (Ferreira, 2023).

Table 2: Mineral of *Hibiscus sabdariffa* calyces (mg/kg) dry mater

Mineral element	Value
Potassium	106.5±0.2
Sodium	68.2±0.1
Magnesium	102±2.0
Calcium	4.2±0.1
Iron	7.1±0.3
Phosphorus	35.5±0.8

The result obtained for sodium (68.2±0.1)mg/kg in this study is also consistent with the findings reported by other workers (Tounkara and Mountaga, 2022). Sodium is involved in diverse biological and metabolic roles in humans such as fluid electrolyte balance (Sunday *et al*., 2023).

The result obtained for calcium (4.2±0.1)mg/kg in this study is lower than that obtained by Tounkara and Mountaga (2022). Calcium, a crucial element of the bone and teeth formation,, maintains the balance of intracellular and extracellular fluids as well as aids in maintaining the structure of cell organelles (Singh and Prasad, 2023). Its deficiency causes several chronic diseases including osteoporosis, arterial hypertension and colon cancer (Singh and Prasad, 2023).

Magnesium was the next mineral element in abundance. The result obtained is also consistent with the findings of Tounkara and Mountaga (2022) who obtained a high value for magnesium in a similar research.

The result obtained for iron (7.1±0.3)mg/kg in this study is lower than that obtained by Tounkara and Mountaga (2022). One of the consequences of iron deficiency is high infant and maternal mortality rates (Oyewole and Diosady, 2023). As for phosphorus, the result obtained in this study (35.5±0.8) mg/kg is higher than that obtained by Tounkara and Mountaga (2022).

Figure 1 shows the concentration of Cd in dried *Hibiscus sabdariffa* L. from selected gardens in Kano metropolis. The cadmium concentrations in dried *Hibiscus sabdariffa* L. samples in the selected gardens were found to be in the order FGGC Minjibir > Wasai > Dingim B > Sauna > BUK Old site > Control, with the highest Cd concentration recorded at FGGC Minjibir with a mean and standard deviation of 0.217±0.039 mg/kg which is just a little above the WHO limit of 0.2mg/kg. The lowest concentration of Cd was recorded for *Hibiscus sabdariffa* L. samples obtained from BUK Old site with a concentration

value of 0.036±0.013 mg/kg. However, all values obtained are still higher than the control. The concentrations of cadmium obtained are lower than the maximum permissible limit of 0.2 mg/kg (WHO/FAO, 2011). This result however is similar with the findings of Atitsogbey *et al.* (2023) for other vegetables which had low Cd levels in the tissues. The deposition of Cd in plants from Cd polluted soil could cause serious problems to the health of animals and humans due to its high mobility in contaminated soils (Ullah *et al.*, 2021).

Therefore, low levels of Cd in *Hibiscus sabdariffa* L. showed that that there is no risk of cadmium toxicity from these gardens which makes it safe for public consumption.

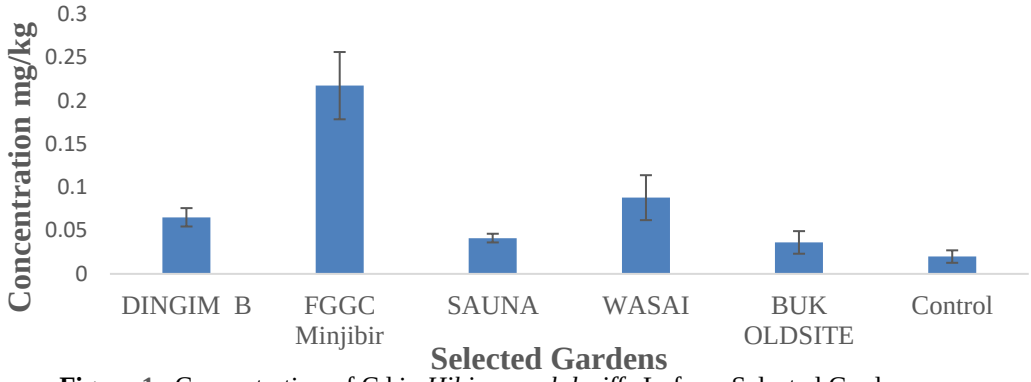

Figure 1 : Concentration of Cd in *Hibiscus sabdariffa* L. from Selected Gardens in Kano City

Figure 2 shows the concentration of Ni in in dried *Hibiscus sabdariffa* L. from selected gardens in Kano metropolis. The cadmium concentrations in dried *Hibiscus sabdariffa* L. samples in the selected gardens were found to be in the order BUK Old Site > FGGC Minjibir > Wasai > Sauna > Control > Dingim B, with the highest Ni concentration recorded at BUK Old Site with a mean and standard deviation of 0.213±0.054 mg/kg. The lowest concentration of Ni was recorded for *Hibiscus sabdariffa* L. samples obtained from *Dingim B* with a concentration value of 0.012±0.001 mg/kg. All values obtained are lower than the Dingim B. The results obtained are much lower than the maximum permissible limit of 67.9 mg/kg for Ni as a contaminant and toxin in foods (WHO/FAO, 2011). When consumed from the environment through the food chain, Ni can have several harmful effects on numerous organs, including the brain, kidneys, lungs, and liver (Mustafa *et al*., 2023). The low levels of Ni in the calyces of *Hibiscus sabdariffa* L. makes it safe for public consumption.

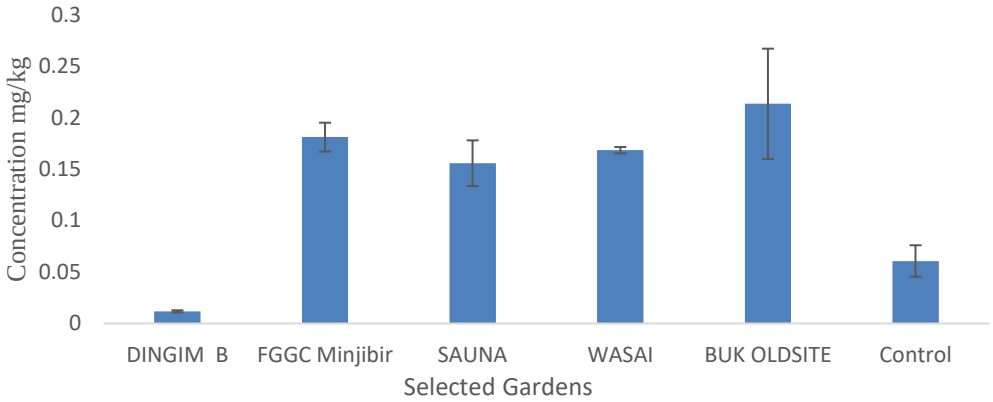

Figure 2 : Concentration of Ni in *Hibiscus sabdariffa* L. from Selected Gardens in Kano City

Figure 3 shows the concentration of Pb in in dried *Hibiscus sabdariffa* L. from selected gardens in Kano metropolis. The cadmium concentrations in dried *Hibiscus sabdariffa* L. samples in the selected gardens were found to be in the order FGGC Minjibir > Sauna > Wasai > Dingim B > BUK Old Site > Control, with the highest Pb concentration recorded at FGGC Minjibir with a mean and standard deviation of 0.485±0.079 mg/kg. The lowest concentration of Pb recorded in *Hibiscus sabdariffa* L. samples was obtained from Control with a concentration value of 0.163±0.024 mg/kg. All values obtained are higher than the control. This results however is still lower than the findings of other workers (10.5 ± 3.0 mg/kg) as reported by Atitsogbey *et al.*, (2023) for other vegetables like *Lactuca* sativa with higher Pb levels in the tissues. The results obtained are above the maximum

permissible of 0.3m g/kg for Pb as a contaminant in foods (WHO/FAO, 2011). According to the Agency for Toxic Substances and Disease Registry (ATSDR), Pb is the second element in the priority list of hazardous substances due to its low solubility, high diffusion, persistence, and toxicity and is classified as carcinogenic and mutagenic (Zakari and Audu, 2021). The high levels of Pb in the calyx of *Hibiscus sabdariffa* L. makes it unsafe for public consumption.

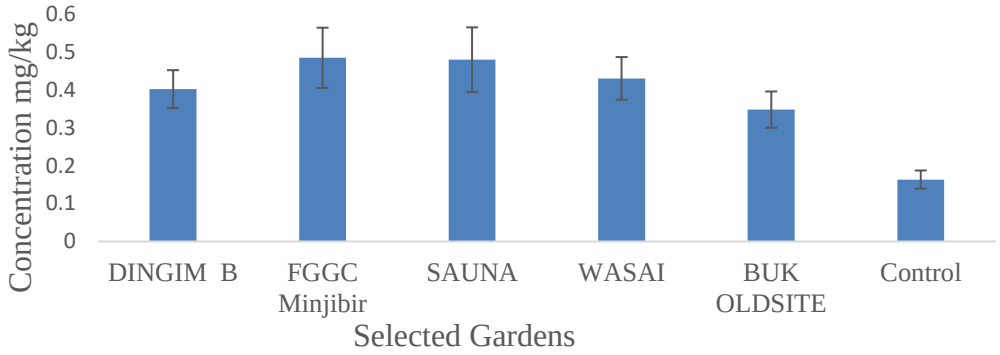

Figure 3: Concentration of Pb in *Hibiscus sabdariffa L.* from Selected Gardens in Kano City

CONCLUSION

Assessment of potentially toxic elements (cadmium, nickel and lead) in *Hibiscus sabdariffa* l. sourced from selected gardens in Kano metropolis was studied. All the toxic metals tested were present in the *Hibiscus sabdariffa* L. samples but in different concentrations. The level of cadmium in Dingim B, Sauna, BUK old site, Wasai and control gardens are lower than the maximum permissible limit however, FGGC Minjibir garden is equivalent to 0.2 mg/kg as laid by (WHO/FAO, 2011). The nickel level in all gardens is below WHO/FAO allowable limit of 67.9mg/kg. The concentration of lead in control is below but all other gardens are above FAO/WHO maximum allowable standard limit of 0.3 mg/kg. The research showed that levels of Pb in all gardens are higher than the standard limit for consumption of 0.3 mg/kg as a contaminant and toxic in foods. This is a cause for concern as regulatory agencies must step up to monitor toxic metal load of this popular plant. The findings from this study also suggest that the minerals and compounds in *Hibiscus sabdariffa* calyces could potentially provide health benefits and find applications in the food industry in the enrichment of other food products that are not rich in essential minerals.

REFERENCES

Afolabi, O. A., Kayode, O. T., Kayode, A. A., and Ajayi, G. O. (2023). *Chemical analysis of novel ginger and Hibiscus sabdariffa bio-preserved tomato powder*. *6*(8).

Agunbiade, H. O., Fagbemi, T. N., and Aderinola, T. A. (2022). Antioxidant properties of beverages from graded mixture of green / roasted coffee and hibiscus sabdariffa calyx flours. *Applied Food Research*, *2*(2), 100163. https://doi.org/10.1016/j.afres.2022.100163

AOAC. (2000). Official Method of Analysis of AOAC International, 17th edition. Association of Official Analytical chemists, Arlington.

Arce-reynoso, A., Mateos, R., Mendivil, E. J., and Zamora-gasga, V. M. (2023). *Bioavailability of bioactive compounds in Hibiscus sabdariffa beverage as a potential anti-inflammatory*. *174*(April). https://doi.org/10.1016/j.foodres.2023.113581

Atitsogbey, P., Kyereh, E., Ofori, H., Johnson, P. T., and Steiner-asiedu, M. (2023). Heliyon Heavy metal , microbial and pesticides residue contaminations are limiting the potential consumption of green leafy vegetables in Ghana : An overview. *Heliyon*, *9*(4), e15466. https://doi.org/10.1016/j.heliyon.2023.e15466

Caballero, P. C., Enciso, C. R., L, G. M., Nakayama, H. D., Caridad, M., González, C., Rossmary, V., Santacruz, O., G, I. C., Ríes, A., and Samudio, A. (2024). *Dataset on the qualitative characteristics of roselle varieties (Hibiscus sabdariffa L .)*. *54*, 1–11. https://doi.org/10.1016/j.dib.2024.110480

WHO. (2011). *Joint Fao / Who Food Standards Programme Codex Committee On Contaminants In Foods Fifth Session The Hague , The Netherlands , 21 - 25*

Essiedu, J. A., and Kovaleva, E. G. (2024). Biocatalysis and Agricultural Biotechnology Physicochemical , antioxidant activity , and sensory characteristics of mead produced with Hibiscus sabdariffa and Betula pendula (Birch sap). *Biocatalysis and Agricultural Biotechnology*, *58*(April), 103189.

https://doi.org/10.1016/j.bcab.2024.103189

Hanis, N., Uvarajan, T., and Chuan, C. (2023). Roles and significance of chelating agents for potentially toxic elements (PTEs) phytoremediation in soil : A review. *Journal of Environmental Management*, *341*(May), 117926. https://doi.org/10.1016/j.jenvman.2023.117926

Iruoghene, G., Oghenekeno, P., Ngukuran, A., Ossai, S., Orezimena, M., Uwomano, E., Ovoke, P., Othuke, P., Ugbune, U., Okeoghene, G., Ogheneoruese, F., Johnson, J., Efeoghene, A., and Essaghah, A. (2023). Proximate composition and health benefit of Roselle leaf (Hibiscus sabdariffa). Insight on food and health benefits. *Food Chemistry Advances*, *3*(April), 100437. https://doi.org/10.1016/j.focha.2023.100437

Mohammed, M. I., and Inuwa, Y. (2018). Assessment of metals pollution in some herbs from Kano metropolis. *Bayero Journal of Pure and Applied Sciences*, *10*(1), 356. https://doi.org/10.4314/bajopas.v10i1.71s

Mustafa, A., Zulfiqar, U., Zahid, M., Radziemska, M., Ullah, F., Holatko, J., Hammershmiedt, T., Naveed, M., Ali, H., Kintl, A., Saeed, Q., Kucerik, J., and Brtnicky, M. (2023). Chemosphere Nickel (Ni) phytotoxicity and detoxification mechanisms : A review. *Chemosphere*, *328*(April), 138574. https://doi.org/10.1016/j.chemosphere.2023.138574

Ocloo, F. C. K., Appiah, V., Asantewaa, B., and Quayson, E. T. (2023). Microbial quality of gamma-irradiated dried Roselle (Hibiscus sabdariffa L .) calyx powder. *Radiation Physics and Chemistry*, *202*(September 2022), 110519. https://doi.org/10.1016/j.radphyschem.2022.110519

Oyewole, A. O., and Diosady, L. L. (2023). Evaluating the potential of Hibiscus sabdariffa beverage to address the prevalence of iron deficiency in sub-Saharan Africa. *LWT*, *188*(April), 115433. https://doi.org/10.1016/j.lwt.2023.115433

Salah, R., Haleem, A. M., and Mazin, H. (2023). Potential effect of Roselle (Hibiscus sabdariffa) ethanol extract against Streptococcus mitis and Streptococcus oralis. *Journal of Herbal Medicine*, *41*(February 2022), 100710. https://doi.org/10.1016/j.hermed.2023.100710

Sayed, A., Zinat, A., Khatun, B., Akter, S., Chandra, A., Satter, A., and Haque, A. (2024). Heliyon Ecological and public health risk assessment of potentially toxic elements in the surface sediments of the Pasur river estuary , Bangladesh. *Heliyon*, *10*(8), e29278. https://doi.org/10.1016/j.heliyon.2024.e29278

Singh, P., and Prasad, S. (2023). Journal of Food Composition and Analysis Review article A review on iron , zinc and calcium biological significance and factors affecting their absorption and bioavailability. *Journal of Food Composition and Analysis*, *123*(December 2022), 105529. https://doi.org/10.1016/j.jfca.2023.105529

Sunday, O., Thomas, O., David, I., Ramaite, I., Sarah, O., Eanas, P., Mojapelo, L., and Olaolu, I. (2023). Heliyon Potassium , sodium , calcium and magnesium levels of commonly consumed foods and estimates of dietary intakes of selected Nigerian adults. *Heliyon*, *9*(3), e13729. https://doi.org/10.1016/j.heliyon.2023.e13729

Tounkara, F., and Mountaga, M. (2022). *Physico-chemical and Nutritional Properties of Unfermented and Fermented Roselle (Hibiscus sabdariffa Linn) Seeds*. *21*(9), 1–10. https://doi.org/10.9734/AFSJ/2022/v21i930447

Ullah, F., Liqun, C., Coulter, J. A., Alam, S., Wu, J., Zhang, R., Wenjun, M., and Farooq, M. (2021). Ecotoxicology and Environmental Safety Cadmium toxicity in plants : Impacts and remediation strategies. *Ecotoxicology and Environmental Safety*, *211*, 111887. https://doi.org/10.1016/j.ecoenv.2020.111887

Yazdanfar, N., Sadighara, P., Mirzaei, G., Limam, I., and Mohamadi, S. (2024). Assessment of potentially toxic elements (PTEs) concentrations in Maize as an animal feed in Tehran , Iran. *Applied Food Research*, *4*(1), 100418. https://doi.org/10.1016/j.afres.2024.100418

Zakari, A., and Audu, A. A. (2021). *Assessing the potential of Albizia lebbeck in phytoremediation of heavy metals under borehole water and tannery effluent Irrigation . Arab. J. Chem. Environ. Res. 08*(2), 259–274.