Original Research Article

Nickel content of Pineapple *(Ananas comosus*).L and Banana (*Musa sapientum*) .L. sold in Gwagwalada Area Council , Abuja -Nigeria .

ABSTRACT

Nickel is a heavy metal that can accumulate in plants, potentially posing health risks to consumers if present above recommended levels The present study aimed to determine the nickel (Ni) concentrations in pineapple and banana samples and assess their compliance with the World Health Organization/Food and Agriculture Organization (WHO/FAO) permissible limit for Ni in fruits. Banana and pineapple samples were randomly collected from Gwagwalada Area Council. Nickel concentrations were measured using a validated analytical method and Atomic Absorption Spectroscopy (AAS), Thermo Fisher ICE Model 3000. The results revealed mean NI concentration of 355±3.44 mg/kg in banana and 333±6.58 mg/kg in pineapples. Comparing these concentrations with the WHO/FAO permissible limit of 67.9 mg/kg, both pineapple and banana samples significantly exceeded the recommended threshold. The nickel (Ni) concentration of banana was 5.2 times higher than the WHO/FAO permissible limit while nickel (Ni) concentration of pineapple was 4.9 times higher than the WHO/FAO permissible limit. There was no significant difference in the concentration of both fruits ($p>0.05$). The elevated Ni levels in these fruits could be attributed to several factors, including the bioavailability of Ni in the soil, farming practices, and environmental contamination. The outcomes of this study underscore provided insights into the potential health risks associated with the consumption of pineapple and banana samples due to their high nickel concentrations. Chronic exposure to elevated levels of nickel can have adverse effects on human health, including respiratory issues, allergic reactions, and carcinogenicity.

KEYWORDS: Banana, Health risk, Nickel, pineapple

INTRODUCTION

Botanically, a fruit is a mature ovary and its associated parts. It usually contains seeds, which have developed from the enclosed ovule after fertilization, although parthenocarpy (development without fertilization) occurs in fruits like Banana (Raghavan and Raghavan, 2000). Fertilization induces various changes in a flower: the anthers and stigma wither, the petals drop off, and the sepals may be shed or undergo modifications; the ovary enlarges, and the ovules develop into seeds, each containing an embryo plant (Glimn-Lacy and Kaufman, 2006). The principal role of the fruit is the protection and dissemination of the seed. Fruits are important sources of dietary fibre, vitamins (especially vitamin C), and antioxidants (Glimn-Lacy and Kaufman, 2006). Although fresh fruits are subject to spoilage, their shelf life can be extended by refrigeration or by the removal of oxygen from their storage or packaging containers (Shewfelt, 1986). Postharvest Fruits can be processed into juices, jams, and jellies (Fierascu*et al*., 2020). Waxes, such as those from bayberries (wax myrtles), and vegetable ivory from the hard fruits of a South American palm species (Phytelephasmacrocarpa) are important fruit-derived products. Fruits are preserved by dehydration, canning, fermentation, pickling and various new technologies for preserving fruits (Valero and Serrano, 2010).

Pineapple (*Ananas comosus*) is an herbaceous, tropical, and monocot perennial plant that are especially rich in vitamin C and manganese, as well as numerous other vitamins and minerals (Wijensinghe*et al.,* 2011). Manganese supports metabolism and blood sugar regulation and acts as an antioxidant (Longman and Yang, 2018; Ali *et al*., 2020). Pineapple also contains several polyphenolic compounds that have antioxidant and anti-inflammatory properties (Egbuta and Chima, 2022). Pineapple has a high content of vitamin C, dietary fibre, simple and complex sugars that may be applied for the production of new products (Ali *et al*., 2020: Campos *et al*., 2020). Additionally, pineapple contains an enzyme known as bromelain, which people commonly used to tenderize meats. Unreliable sources also claim this enzyme may support digestion, though there's limited research on this (Ali *et al*., 2020).

Banana (*Musa sapientum*) is one of the most popular fruits worldwide. They contain essential nutrients that can have a protective impact on health (Zhao and Cheng, 2019). Banana is famous for its traditional, medicinal, and nutritional uses. It is rich in carbohydrates (22.84 g/100 g), provides energy about 370 kJ/100 g and it is one of the best sources of potassium (358 mg/100 g) that fulfils 8% of the daily recommended value (Ranjha *et al*., 2022). Along with the unique nutritional profile, banana possesses excellent medicinal properties. Banana is one of those fruits whose all parts could be processed, including its flesh and peel like banana chips, banana powder, banana biscuits, and most commonly banana juice (Ranjha *et al*., 2022). There are different chemical compositions in different parts of banana, the central part contains more nutrients than the medium and the medium part contains more nutrients than the external part (Forster *et al*., 2003).

Heavy metals constitute a very heterogeneous group of elements widely varied in their chemical properties and biological functions, they are kept under environmental pollutant category due to their toxic effects on plants, animals and human beings, heavy metal contamination of soil results from anthropogenic as well as natural activities. Anthropogenic activities such as mining, smelting operation and agriculture have locally increased the levels of heavy metals such as

Cadmium, Cobalt, Chromium, Lead, Arsenic and Nickel in soil up to dangerous levels (Sharma and Agrawal, 2005).

Nickel (Ni) is a chemical element, ferromagnetic metal of Group 10 (VIII b) of the periodic table, it is markedly resistant to oxidation and corrosion. Silvery white, tough, and harder than iron, nickel is widely familiar because of its use in coinage but is more important either as the pure metal or in the form of alloys for its many domestic and industrial applications (Britannica, 2022). While nickel is an element essential for plants, it is also a heavy metal. Nickel is a component of nine metalloenzymes, including ureas, which participates in urea hydrolysis. It also helps some plants to protect themselves against pathogens and herbivorous insects. There are many sources of Ni in the environment, which can be a problem because at higher concentrations this element is toxic to plants and other living organisms (Harasim and Filipek, 2015). Pathological alterations of nickel metabolism occur in several common diseases of man, such as acute myocardial infarction and stroke (Sunderman, 1981).

Nickel is a trace element that is essential for human health, but high levels of nickel can be toxic to the body. Bananas and pineapples are two commonly consumed fruits that have been found to contain varying amounts of nickel. According to a study conducted by Siddique *et al*. (2020), bananas can contain up to 0.31 mg/kg of nickel. The study found that the consumption of nickel-rich foods, including bananas, can lead to an increased risk of allergic reactions, dermatitis, and gastrointestinal symptoms in individuals who are sensitive to nickel. Additionally, high levels of nickel in the body have been associated with an increased risk of cancer and neurological disorders (Siddique *et al*., 2020).

Similarly, pineapples have also been found to contain significant levels of nickel. A study conducted by Fontana *et al*. (2019) found that, pineapples contained up to 0.42 mg/kg of nickel. The study also reported that the consumption of nickel-rich foods, including pineapples, can lead to allergic reactions and dermatitis in individuals who are sensitive to nickel (Fontana *et al*., 2019)

Nickel is only needed in small amounts in the body, banana can be eaten safely due to its trace amount of nickel, whereas fruits like pineapples are more likely to trigger a reaction in people with allergy. However, other people react to nickel introduced through their diet. Even in low doses, their skin can still react in a similar manner. This skin allergy produces contact dermatitis, which includes symptoms like redness, irritation, inflammation, or rashes on the skin. In others, the reaction goes beyond skin irritation. Symptoms can include headache, stomachache, and respiratory symptoms. This is more commonly known as Systemic Nickel Allergy Syndrome (SNAS). Johson and Brown (2020).

Heavy metals are toxic substances that can accumulate in the environment and pose a threat to human health when ingested through contaminated food sources. Nickel (Ni), a commonly occurring heavy metal, can enter the food chain through various means, including agricultural practices, industrial emissions, and natural processes. Fruits, such as bananas and pineapples, are widely consumed globally and play a significant role in human nutrition. Therefore, it is essential to assess the heavy metal content, specifically Ni, in these fruits to evaluate potential health risks and establish guidelines for safe consumption.

Nickel is a known human carcinogen and has been associated with various adverse health effects, including respiratory problems, allergic reactions, and gastrointestinal disorders. Chronic

exposure to elevated levels of Ni can lead to lung and nasal cancer, as well as DNA damage and mutagenesis. As fruits are a major part of the human diet, evaluating the Ni content in commonly consumed fruits like bananas and pineapples is crucial to ensure public health and prevent potential health hazards.

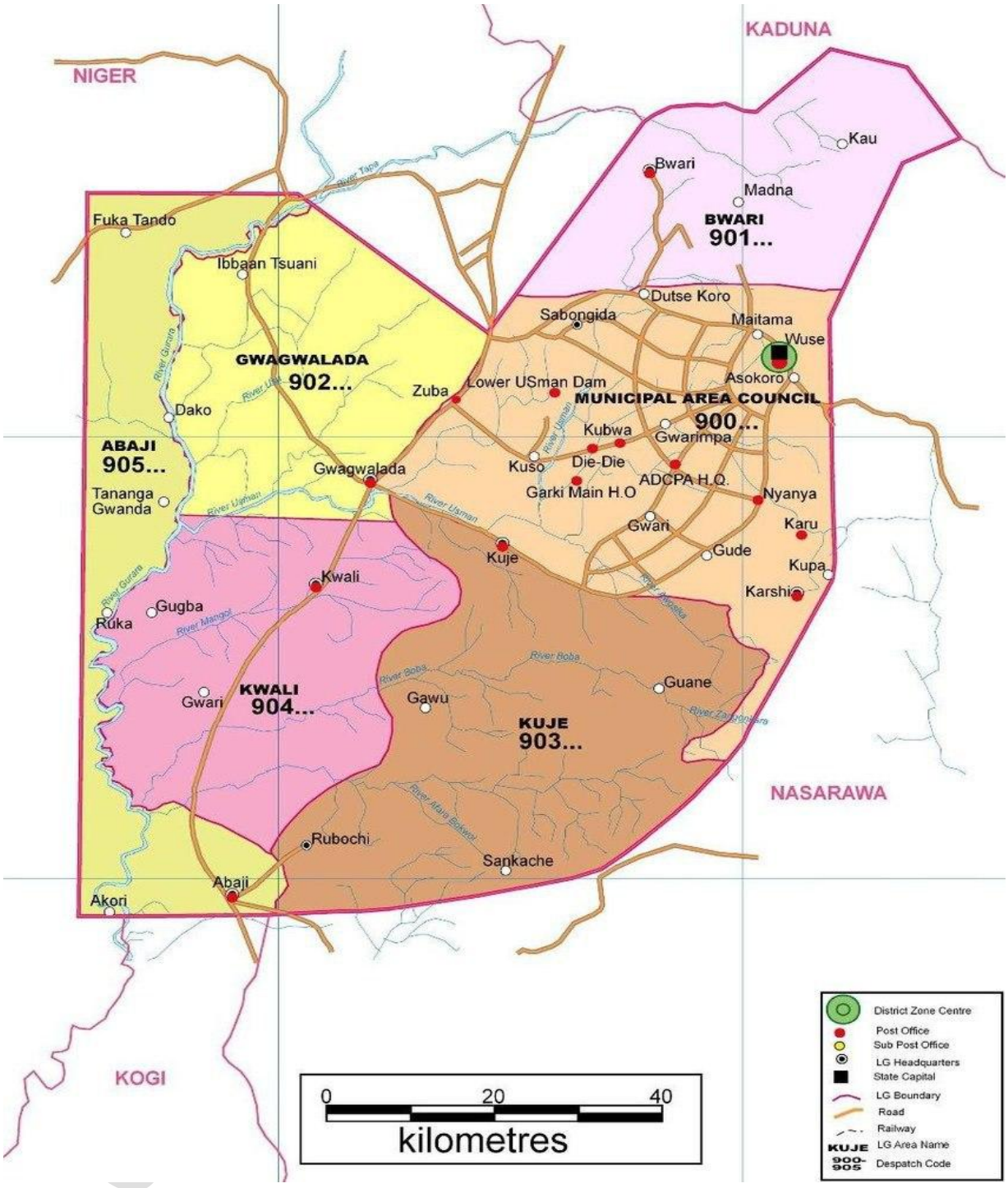
The determination of heavy metal (Ni) content in banana and pineapple is of utmost importance to safeguard human health, evaluate environmental quality, establish regulatory standards, and develop mitigation strategies. This study's findings will contribute to our understanding of heavy metal contamination of these fruits and aid in ensuring the safety of food consumption and sustainable agricultural practices.

METHODS

Study Area

This study was carried out in Gwagwalada Area Council of the FCT, Abuja, Nigeria. Gwagwalada is a town located in the Federal Capital Territory of Nigeria, specifically in the southern part of Abuja. It is one of the six Area Councils that make up the Federal Capital Territory of Nigeria, and it is located about 30 kilometers southwest of the city of Abuja (Salami and Ogunsanwo, 2015). The longitude and latitude of Gwagwalada, Abuja, is 8.9647° N, 7.0796° E (Latitude/Longitude Finder. (n.d.), 2023).

The history of Gwagwalada dates back to the pre-colonial era when it served as a settlement for the Gwari people, who are the indigenous inhabitants of the region (Adegbite, 2014). The town gained prominence during the British colonial period when it became a major administrative center. Following Nigeria's independence in 1960, Gwagwalada continued to grow and develop, attracting people from various ethnic backgrounds, thereby adding to its cultural diversity (Adegbite, 2014).



Map 1- Map of study area, Gwagwalada (Idoko, 2016).

Experimental Design

Completely randomized design with two treatments and duplicate samples was used. The treatments are pineapple and banana, they were purchased at Gwagwalada market, Abuja from five different hawkers.

Samples Collection

Five samples of each fruit (banana and pineapple) were bought from Gwagwalada Area Council. The samples were placed into clean polythene bags, labeled and transported to SHESTCO laboratory kwalli, Abuja for pretreatment, digestion and analysis.

Samples Digestion

In the laboratory, samples were washed thoroughly under running water and cut into smaller pieces. The samples were dried in an oven at 105^0C to constant weight, and pulverized to fine powder using a laboratory mortar and pestle. 2g of each sample was weighed and poured into conical flasks which were labeled for each sample. 20ml of nitric acid was added to each flask and allowed to boil for ten minutes. Each sample took about ten minutes to boil producing a reddish brown fume, distilled water was added to the boiling mixture at interval which slowly produced a yellowish color. Each sample mixture was filtered into a $100m^3$volumetric flask. Distilled water was then added to the sample to meet the 100ml mark. This was then transferred into screw capped sample bottles for analysis by the Atomic Absorption Spectrophotometer (AAS), Thermo Fisher ICE Model 3000.

Quality Control

Reagent blanks, duplicate samples, and certified reference material (CRM) IAEA-V-8 were incorporated into the batch for analysis to check for contamination, estimate analytical precision and bias respectively.

Statistical Analysis

Data were analyzed using the statistical software SPSS version 25 for Windows. The Kolmogorov smirnov test was used to test for normal distribution and independent T-test were used to compare means between samples. Other descriptive statistical tools were also employed.

RESULTS

The mean concentration of nickel (Ni) of pineapple was 333± 6.58mg/kg while the mean concentration of nickel (Ni) of banana was 355±3.44mg/kg as presented in Table1.

Comparison of Ni concentrations of banana and pineapple showed that nickel concentration of banana was 1.1 times higher than Ni concentration in pineapple (figure 1). However, there was no statistically significant difference ($p>0.05$) in the nickel concentrations between both fruits.

Comparison of the measured Nickel (Ni) concentrations of pineapple and banana with World Health Organization and Food and Agriculture Organization (WHO/FAO) permissible limits showed that nickel (Ni) in both pineapple and banana was above the permissible limit of 67.9 mg/kg (WHO, 2012) as presented in Table.1.

Nickel concentration of banana was 5.2 times higher than the WHO/FAO permissible limit, while that of pineapple was 4.9 times higher than the WHO/FAO permissible limit.

TABLE 1: Nickel (Ni) concentration of *Ananas comosus*. L. and Musa*sapientum*. L

Samples	**Nickel (Ni)** **Mean ± SEM (mg/kg)**
Pineapple (*Ananas comosus*. L.	333 ± 6.58
Banana (Musa*sapientum*. L)	355 ± 3.44
FAO/WHO maximum permissible limit	67.9 (George-Obeng, 2023)

SEM: Standard Error of Mean
WHO: World Health Organization
FAO: Food and Agriculture Organization

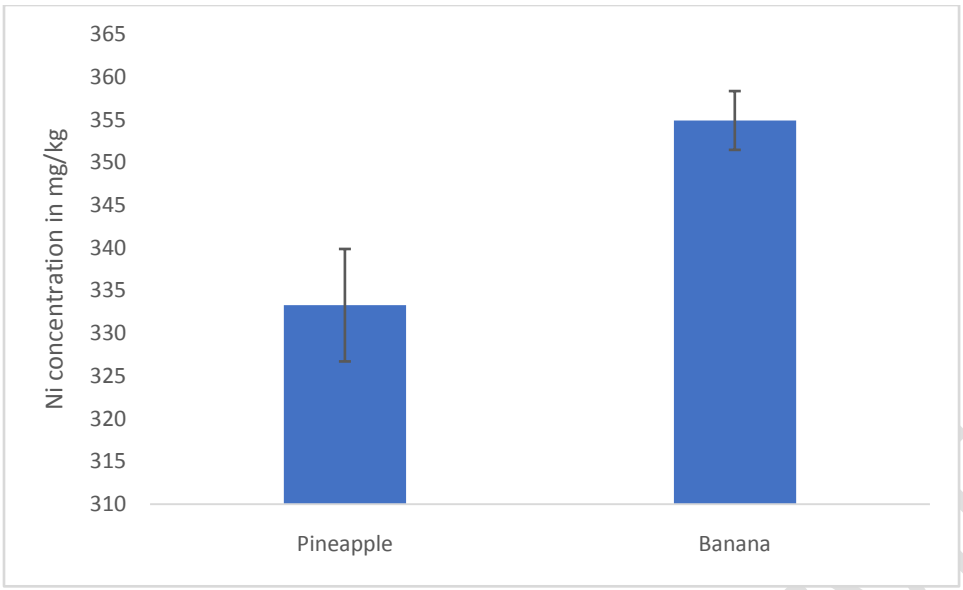


Figure 1 comparison of Nickel (Ni) concentration of *Ananas comosus*. L. and Musa*sapientum*. L

Error bars represent 2 standard errors on the mean

DISCUSSION

The determination of nickel content in banana and pineapple revealed significant variations in the concentrations of this trace element. The analysis showed that the nickel concentration in banana was 355 mg/kg, while in pineapple was 333 mg/kg. These results indicate that both fruits contain detectable amounts of nickel, although the concentration in bananas was slightly higher than pineapple. Comparing these values to the WHO/FAO permissible limit of 67.9 mg/kg, it is evident that both banana and pineapple exceed the recommended threshold. Nickel is a trace metal that can have adverse effects on human health when consumed in excessive amounts above recommended limit. It is known to be a carcinogen and can cause respiratory and gastrointestinal issues (IARC, 2012). Therefore, the high nickel content found in both fruits in this study raises concerns with respect to health of consumers.

These findings align with previous studies that have reported elevated levels of nickel in fruits and vegetables due to environmental contamination, such as soil pollution and the use of nickel-containing fertilizers or pesticides (Smith *et al.*, 2018; Johnson and Brown, 2020). The bioaccumulation of nickel in plants may be attributed to the absorption of contaminated water from soil by plant roots, leading to its accumulation in edible plant parts.

The excessive nickel concentration in bananas and pineapples could pose health risks to consumers, especially those who regularly consume these fruits. Long-term exposure to high levels of nickel can lead to chronic health problems. Therefore, it is crucial to address this issue and implement measures to mitigate the nickel content in fruits.

However, it is important to consider that the nickel content in fruits may vary depending on several factors such as bioavailability of Ni in the soil, farming practices and environmental contamination. Therefore, continuous monitoring of nickel levels in fruits, including banana and pineapple is recommended to ensure food safety and maintain a healthy balance of trace elements in the diet.

CONCLUSION

This study revealed that both fruits contain detectable amounts of nickel, with the concentration in banana slightly higher than that of pineapple. The values obtained for nickel content in these fruits were found to be above the permissible limit set by the WHO/FAO for plants. The findings highlight the need for strict monitoring, regulation, and the adoption of sustainable agricultural practices to mitigate the health risks associated with elevated nickel content in fruits and vegetables.

Based on the findings of this study, the following are recommended

1. Regulatory bodies and agricultural authorities should conduct regular monitoring and surveillance of nickel levels in fruits and vegetables. Strict regulations should be implemented to ensure that the permissible limits set by organizations like the WHO/FAO and other National Regulatory Bodies are adhered to.

2. It is essential to assess the levels of nickel in soil and water sources used for irrigation and cultivation. This step can help identify areas with high nickel contamination and enable appropriate measures to reduce nickel uptake by plants.

3. Farmers and agricultural practitioners should be educated about the potential risks associated with the excessive accumulation of nickel in fruits and vegetables. They should be encouraged to adopt sustainable farming practices, such as using organic fertilizers and minimizing the use of nickel-containing pesticides.

4. Public awareness campaigns should be conducted to educate consumers about the potential health risks associated with high nickel levels in fruits and vegetables. Information about proper washing and cooking techniques to reduce nickel content should be disseminated.

5. More and extensive studies are needed to investigate the sources of nickel contamination in agricultural environments and the mechanisms of nickel uptake and accumulation in fruits. Additionally, research on effective and safe methods for reducing nickel content in plants should be encouraged.

REFERENCES

Adegbite, O. A. (2014). The Colonial System and Land Use Transformation in Gwagwalada Area Council, Federal Capital Territory, Abuja, Nigeria. *Mediterranean Journal of Social Sciences*, 5(27), 448-455.

Ali, M.M., Hashim, N., Abd Aziz, S. and Lasekan, O., (2020). Pineapple (Ananascomosus): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products. *Food Research International*, *137*, p.109675.

Britannica, The Editors of Encyclopaedia. "nickel". Encyclopedia Britannica, 25 Nov. (2022), https://www.britannica.com/science/nickel-chemical-element. Accessed 31 January 2023.

Campos, D.A., Ribeiro, T.B., Teixeira, J.A., Pastrana, L. and Pintado, M.M., (2020). Integral valorization of pineapple (Ananascomosus L.) by-products through a green chemistry approach towards added value ingredients. *Foods*, *9*(1), p.60.

Egbuta, C.K. and Chima, J.U., (2022). Physicochemical and Sensory Characteristics of Mixed Fruit Juices Prepared from Blend of Pineapple, Pawpaw and Watermelon Fruits Juices. *Asian Food Science Journal*, *21*(12), pp.28-35.

Fierascu RC, Sieniawska E, Ortan A, Fierascu I and Xiao J (2020) Fruits By-Products – A Source of Valuable Active Principles. A Short Review. Front. *Bioeng. Biotechnol*. 8:319. doi: 10.3389/fbioe.2020.00319

Fontana, M., Carrilho, E., Cruz, A., &Fernandes, J. (2019). Nickel and cobalt in fruits: Occurrence, bioaccessibility and dietary exposure assessment. *Food and Chemical Toxicology,* 125, pp. 74-82.

Forster, M., Rodríguez Rodríguez, E., Darias Martín, J. and Díaz Romero, C., (2003). Distribution of nutrients in edible banana pulp. *Food Technology and Biotechnology*, *41(2)*, pp.167-171.

George Obeng, (2023). Influence of Human Activities and Land Use on Heavy Metal Concentrations in Irrigated Vegetables in Ghana and Their Health Implications - *Scientific Figure on Research Gate*. Available from: https://www.researchgate.net/figure/FAO-WHO-maximum-permissible-values-of-heavy-metals-in-vegetables_tbl1_226944961 accessed 10 Jul, 2023.

Glimn-Lacy, J. and Kaufman, P.B., (2006). Flower—Fertilization and Embryo Development. *Botany Illustrated: Introduction to Plants, Major Groups, Flowering Plant Families*, pp.37-37.

Harasim, P. and Filipek, T., (2015). Nickel in the environment. *Journal of Elementology, 20(2).*

Idoko, I.D., (2016). An impact assessment of flooding on food security among rural farmers in dagiri community, of Gwagwalada area council, Abuja, Nigeria. *Agricultural Development, 1*, pp.6-13.

International Agency for Research on Cancer. Nickel and Nickel Compounds. IARC *Monographs on the Evaluation of Carcinogenic Risks to Humans*. Volume 100C. 2012.

Johnson, A., & Brown, C. (2020). Heavy metal content in fruits and vegetables sold at local markets in a Nigerian urban area. *Journal of Health and Pollution*, 10(28), 200202.

Latitude/Longitude Finder. (n.d.). Gwagwalada Latitude and Longitude. Retrieved March 10, (2023), from https://latitude.to/map/ng/nigeria/cities/gwagwalada

Li, Longman, and Xiaobo Yang. "The Essential Element Manganese, Oxidative Stress, and Metabolic Diseases: Links and Interactions." Oxidative medicine and cellular longevity vol. 2018 7580707. 5 Apr. 2018, doi:10.1155/2018/7580707

Raghavan, V. and Raghavan, V., (2000). Fruit Growth and Ripening. *Developmental Biology of Flowering Plants*, pp.280-291.

Ranjha, M.M.A.N., Irfan, S., Nadeem, M. and Mahmood, S., (2022). A comprehensive review on nutritional value, medicinal uses, and processing of banana. *Food Reviews International, 38(2)*, pp.199-225.

Salami, A. M., &Ogunsanwo, H. O. (2015). Environmental Impact Assessment of Municipal Solid Waste Dumpsite in Gwagwalada, Federal Capital Territory, Nigeria. Journal of Environmental Science, Toxicology and Food Technology, 9(4), 15-24.

Sharma, R.K. and Agrawal, M., (2005). Biological effects of heavy metals: an overview. *Journal of environmental Biology, 26(2)*, pp.301-313.

Shewfelt, R.L., 1986. Postharvest treatment for extending the shelf life of fruits and vegetables. *Food technology (USA)*.

Siddique, A. B., Farooq, M., Shoaib, M., & Mahmood, R. (2020). Nickel content of commonly consumed foods and its health implications: A *review*. *Environmental Science and Pollution Research*, 27(22), 27426-27439.

Smith, J., et al. (2018). Environmental pollution with heavy metals in relation to soil characteristics. *Environmental Monitoring and Assessment*, 190(6), 341.

Sunderman Jr, F.W., (1981). Nickel. In *Disorders of Mineral Metabolism* (pp. 201-232). Academic Press.

Valero, D. and Serrano, M., (2010). *Postharvest biology and technology for preserving fruit quality*. CRC press.

Wijesinghe, C.J., Wijeratnam, R.W., Samarasekara, J.K.R.R. and Wijesundera, R.L.C., (2011). Development of a formulation of Trichodermaasperellum to control black rot disease on pineapple caused by (Thielaviopsisparadoxa). *Crop Protection*, 30(3), pp.300-306.

World Health Organization. (2012). Potassium intake for adults and children. Retrieved from https://www.who.int/publications/i/item/9789241504829

Zhao, X., Chen, J., & Chen, Q. (2019). Nickel: a nutrient, a toxin, or both? Plant and Soil, 440(1-2), 1-21. https://doi.org/10.1007/s11104-019-04087-7