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

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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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 Atomic Absorption Spectroscopy (AAS), Thermo Fisher ICE Model 3000. After acid digestion by Nitric acid. 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 that of pineapple was 4.9 times higher than the WHO/FAO permissible limit. There was no significant difference in the concentration of

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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 provided insights into the potential health risk that could be s associated with the consumption of pineapple and banana. However, this risk posed may depend on how often these fruits are consumed. Some studies have reported that chronic exposure to elevated levels of nickel can have adverse effects on human health, including respiratory issues, allergic reactions, and carcinogenicity. Monitoring of heavy metal content of fruits and other foods is recommended to prevent long term build up of nickel and other heavy metals in fruits and food crops.

Keywords: Banana; health risk; nickel; pineapple.

1. 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 [1]. This definition may exclude certain fruits that are seedless in nature. 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 [2]. 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 [2]. 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 [3]. Postharvest Fruits can be processed into juices, jams, and jellies [4]. Waxes, such as those from bayberries (wax myrtles), and vegetable ivory from the hard fruits of a South American palm species (Phytelephas macrocarpa) are important fruit-derived products. Fruits are preserved by dehydration, canning, fermentation, pickling and various new technologies for preserving fruits [5].

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 [6]. Manganese supports metabolism and blood sugar regulation and acts as an antioxidant [7,8]. Pineapple also contains several polyphenolic compounds that have antioxidant and anti-inflammatory properties [9]. Pineapple has a high content of vitamin C, dietary fibre, simple and complex sugars that may be applied for the production of new products [8,10]. 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 [8].

Banana (*Musa sapientum*) is one of the most popular fruits worldwide. They contain essential nutrients that can have a protective impact on health [11]. 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 [12]. 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 [12]. 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 [13].

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 [14].

Pineapple is an important source of sugars, organic acids (citric acid), essential minerals (Cu, Mg, Mn, K), fibre and vitamins (A, C, B-group) for human nutrition [8]. Banana is a popular fruit that are not only delicious but also provide various health benefits due to their nutritional content. According to the USDA (United States Department of Agriculture) National Nutrient Database, a medium-sized banana (7-8 inches long) weighing approximately 118 grams contains the following nutrients [15].

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 [16]. 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 [17]. Pathological alterations of nickel metabolism occur in several common diseases of man, such as acute myocardial infarction and stroke [18].

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. [19], 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 [19].

Similarly, pineapples have also been found to contain significant levels of nickel. A study conducted by Fontana et al. [20] 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 [20]

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 [21].

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 content of fruits 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 o baseline data on nickel contamination of fruits especially banana and pineapple that are widely consumed within the Federal Capital Territory and will provide basis or further studies.to ensure safety of foods.

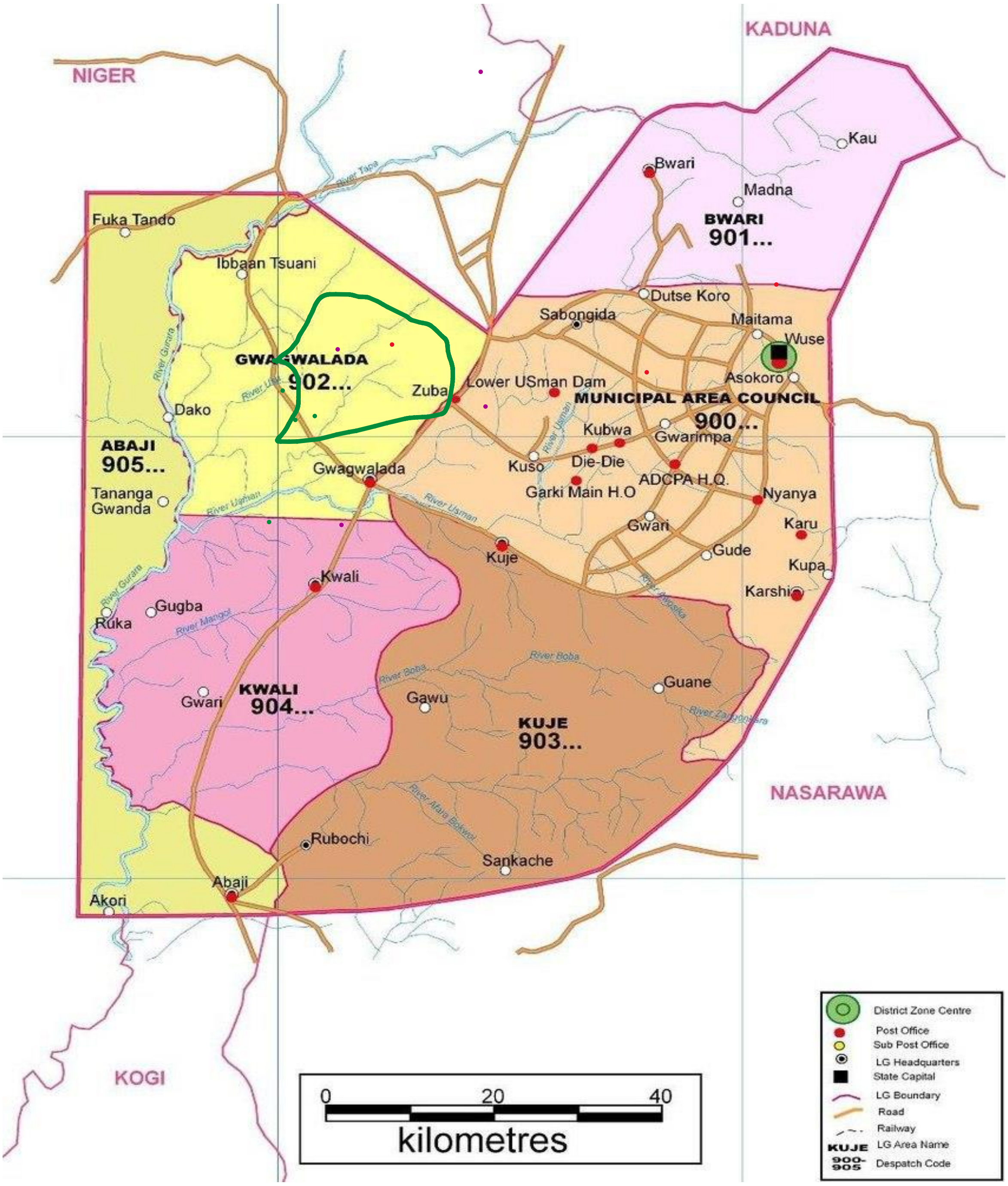
2. METHODS

2.1 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 [22]. The longitude and latitude of Gwagwalada, Abuja, is 8.9647° N, 7.0796° E [23].

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 [24]. 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 [24].



Map 1. Map of study area, Gwagwalada [25]. The yellow area circled in green represents the sampling points

2.2 Experimental Design

Completely randomized design with two treatments and duplicate samples was used. The treatments are pineapple and banana, they were purchased from sellers at locations with distance of 50m apart within Gwagwalada market, Abuja from five different sellers. The number samples that could be collected were restricted by time and cost of a laboratory analysis of the samples.

2.3 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 Science and Technology Complex (SHETSCO) laboratory kwalli, Abuja for pretreatment, digestion and analysis.

2.4 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 intervals 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 Spectrometer (AAS), Thermo Fisher ICE Model 3000.

2.5 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.

2.6 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 sample T-test was used to compare means between samples because the samples were less than thirty and Analysis of variance could not be used. Other descriptive statistical tools were also employed.

3. 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 (Fig. 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 [26] 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 [29]

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

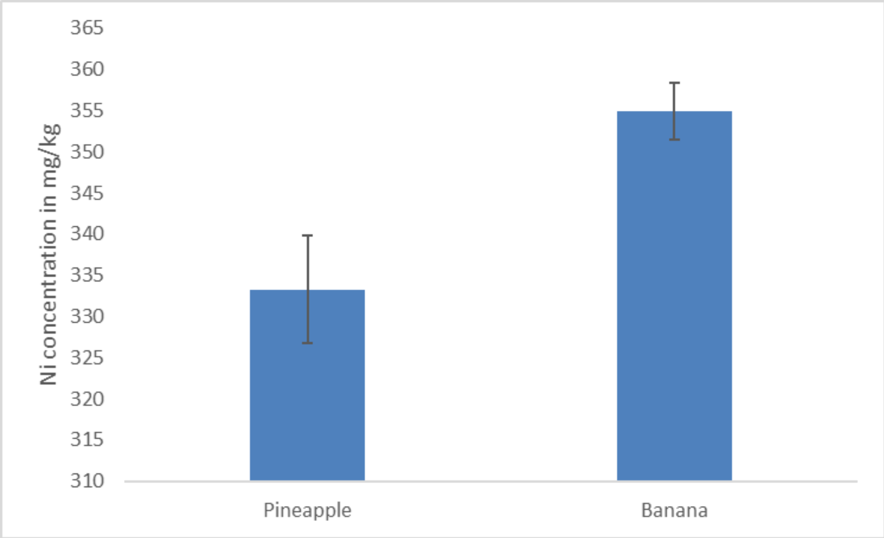


Fig. 1. Comparison of Nickel (Ni) concentration of *Ananas comosus*. L. and *Musa sapientum*. L
Error bars represent 2 standard errors on the mean

4. 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 significant amounts of nickel, although the concentration in bananas was slightly higher than pineapple, though not significantly different. Both fruits are rich in nickel and are good sources of nickwel as a trace element required by plants., animals and humans.

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 [27]. Therefore, the high nickel content found in both fruits in this study raises concerns with respect to the health of consumers. Potential health risk will depend on how often these fruits are consumed.

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 [28,21]. 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. Climate change and other human activities have resulted in soil degradation and contamination, especially in developing nations. Farmers in this part of the world and particularly in those in the study area respond to these environmental changes by deploying several soil fertility enhancing agents e.g inorganic fertilizers which are potential sources of heavy metals to the soil. The use of pesticides of various chemical origin to control of plant pests in this area are also additional sources of heavy metals to the soil, fruits and food crops.

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. The nickel content of these fruits is a fraction of the amount in the soil. It is an indication that the soil on which these fruits were grown might have contained significant amount of nickel. However, the major source of nickel to the soil is not exactly known apart from the general potential sources of heavy metals to farmlands and arable soils. It suggests that monitoring of soil levels of heavy metals will be helpful in preventing excessive accumulation in plants.

Qualitative data showed that these fruits are sometime forced to ripe artificially using chemical agent such as ethylene dicarbide. The practice of artificial ripening of fruits using this potential carcinogen (ethylene dicarbide) widely practiced in the Federal Capital Territory and other regions in Nigeria might also be a significant source of trace and potentially toxic metals in edible fruitsThe relationship between this harmful practice and nickel or heavy metal contamination of fruit is not completely known. This could be an area to further explore in assessing risk to health posed by heavy metals. 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.

5. CONCLUSION

This study revealed that both fruits contain significant 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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