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HEAVY METAL IN BANANA (*Musa acuminata*) VARIETIES SOLD BY FRUIT VENDORS IN ENUGU STATE, NIGERIA

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ABSTRACT

Background: The use of ripening agents to trigger uniform and quick ripening of banana have been associated with heavy metal intoxication. Determining the levels of heavy metals in banana which is a common fruit consumed in Enugu State and Nigeria guides relevant authorities to regulate the use of pesticides and ripening agents used by banana sellers to make every food safe for consumption.

Objective: The study evaluated the presence of heavy metals in four varieties of banana consumed in Enugu State.

Methods: Samples of each banana variety were obtained from different banana vendors at different markets in Enugu State respectively. Edible portion of similar varieties from different vendors were homogenized after removing the peel. The homogenized samples were analyzed for heavy metal (arsenic, mercury, lead and cadmium) content using standard methods. The weight of the banana varieties were measured to estimate the average size of the edible portion of a single banana. The data were subjected to statistical analysis to compare the mean of the heavy metal scores of the banana samples. A p-value <0.05 was considered significant.

Results: Green Mutant banana variety had the lowest lead content (0.0107 mg/kg). Mercury was not present in all the banana samples. Arsenic was only found in Red Dacca banana variety, (0.0007 mg/kg). Red Dacca banana variety presented the highest value (0.0030 mg/kg).

Conclusion: The study provided invaluable information on the heavy metal composition of banana varieties commonly consumed in Enugu state. The findings revealed that Red Dacca banana variety contains a significant amount of heavy metals which can contribute significantly to its build up in body cells.

Keywords: *Banana; heavy metals; food contaminants; fruits*

INTRODUCTION

Fruits are vital to the human diet due to its composition of carbohydrate, minerals, vitamins and trace elements which are important for the maintenance of health, prevention and treatment of diseases (1–3). Banana is a perennial monocotyledonous treelike plant belonging to the Musaceae family (4). Banana is widely cultivated in more than 130 countries and is the most produced fruit second only to citrus. and serves as a rich source of energy and nutrients (5,6). It also provides as a valuable source of income through local and international trade (7). Banana is widely consumed in Nigeria either as snack consumed alone or with roast groundnut or used in fruit salad.

In different parts of the world, banana has many varieties and their common or local names differ from place to place. The most commonly consumed species of banana in Nigeria include *Musa paradisiaca, and Musa acuminata* (4,8,9). In Enugu state, Nigeria, the most commonly available varieties are Gros Michel, Red Dacca, Green Mutant and Ladies Finger banana. Gros Michel is the most popular variety in Enugu State which is cultivated for its rich taste, wide acceptance and keeping quality. It is invariably seen in every market, relatively expensive and treasured among banana consumers. Red Dacca is a variety of banana widely known for its red peel, unusually large size and creamy taste when consumed. Red Dacca is relatively inexpensive because it is believed to be a banana for diabetics and does not have the same awesome taste as other species. It is commonly seen in local markets and purchased by locales who cannot afford the commonly consumed banana species. Green Mutant banana is a

variant of Red Dacca, the major difference being that while Red Dacca has a red peel, which brightens when the banana is ripe, Green Mutant has a green peel which turns bright yellow just like Gros Michel when ripe. Lady's Finger as the name implies, is a variety of banana known for its small size. The peel splits to expose the banana pulp when ripe, undergoes browning when the pulp comes in contact with air and has a sweet-sour taste when consumed. Lady's Finger turns from green to slight yellow when ripe and the peel does not completely pull away from the banana fruit when ripe necessitating the use of a knife when consuming.

Fruit ripening is a genetically programmed irreversible process involving the initiation of senescence, hence, transforming the fruits from the unripe form to the attractive, creamy or juicy ripe form depending on the fruit (10). Most rural and urban banana retailers in Nigeria are known to use ripening agents to trigger ripening depending on market demand. Ripening agents such as application of ethylene gas in ripening room is the most popular method used by developed countries (10). Ripening room is designed with techniques to control humidity, temperature and ethylene gas concentrations and are equipped with proper ventilation (10). However, calcium carbide which produces acetylene, an ethylene analogue when hydrolysed is also a ripening agent widely used in developing countries due to its affordability (10).

Heavy metals are defined as metals with a specific density greater than $5g/cm^3$. They are non-biodegradable, have long biological half-life and can accumulate in different body organs leading to health threatening side effects (3,11). Many factors have been associated with contaminating foods with heavy metals. Some of which includes; absorption of heavy metals from contaminated water during irrigation, addition of fertilizers and metal-based pesticides, fallouts of industrial and urban emissions, harvesting process, storage and during sales (3,12). Heavy metals of nutrition concern include Arsenic (As), Mercury (Hg), Lead (Pb), and Cadmium (Cd) (3). Studies have reported that the commercial grades of calcium carbide used in artificial ripening of banana are considered hazardous as they contain traces of arsenic and phosphorus hydride which are poisonous to humans and causes health related issues including cardiovascular disorders, cancers, gastrointestinal disorders and renal failure (13–15). Artificial ripening with calcium carbide greatly affects the taste and keeping quality of banana. Presently, there are no regulation on the quality of fruits sold in most Nigerian markets. Information about heavy metal composition of foods is important for nutrition education, training and research. Hence, this study determined the heavy metal concentration of selected banana varieties widely consumed in Enugu State, Southeastern Nigeria.

MATERIALS AND METHODS

Study Design

The study adopted the experimental design

Procurement, Identification and Preparation of Samples

Four banana varieties were selected for the study and purchased from Ogige and Afor Opi markets in Nsukka Local Government Area, Enugu state, Nigeria. The banana samples were identified at the Department of Plant Science and Biotechnology of the University of Nigeria, Nsukka as Gros Michel (musa *acuminata* AAA genome), Red Dacca (musa *acuminata* AAA genome), Lady's Finger (musa *acuminata* AA genome) and Green Mutant (musa *acuminata* AAA genome). The length, width and weight of the banana varieties were measured to estimate the average size of the edible portion of a banana finger. The banana samples were peeled and the pulp blended for homogenization before analysis. Analysis was done using the Atomic Absorption Spectrophotometer (721A, VIS spectrophotometer).

Heavy Metals Determination

Lead cadmium and arsenic was determined by Spectrophotometric method (16,17). Titrimetric method was used in mercury determination (18).

Statistical Analysis

Statistical analysis was carried using IBM SPSS statistics software version 22. Descriptive statistics (mean and standard deviation) was used to describe the data obtained. One-way Analysis of Variance (ANOVA) was used to compare the means of the heavy metal composition result of the banana samples. Post-Hoc analysis was done with turkey HSD. A $p < 0.05$ was considered statistically significant.

RESULT

Table 1 shows the measurement of serving portion of Gros Michel, Red Dacca, Lady's Finger and Green Mutant banana species at a glance. Gros Michel banana weighed 37 g, Red Dacca, 68 g, Lady's Finger, 40 g and Green Mutant banana weighed 76 g.

Table 1: Measurement of Serving Portion of Gros Michel, Red Dacca, Lady's Finger and Green Mutant

Parameters	Gros Michel (g) Mean ± SD	Red Dacca (g) Mean ± SD	Lady's Finger (g) Mean ± SD	Green Mutant (g) Mean ± SD
Whole weight edible portion + peel	61.08 ± 4.81	102.08 ± 7.29	55.50 ± 6.87	119.67 ± 37.78
Weight of waste (peel)	23.33 ± 1.72	34.08 ± 2.39	15.25 ± 1.60	43.33 ± 3.87
Weight of edible portion= whole wt. -peel	37.75 ± 3.19	68.00 ± 8.08	40.25 ± 5.79	76.33 ± 34.20

Table 2 shows the heavy metal content of Gros Michel, Red Dacca, Lady's Finger and Green Mutant banana. Green Mutant had the lowest lead content (0.0107 mg/kg) while Red Dacca had the highest value (0.0303 mg/kg). Mercury was absent in the banana samples. Arsenic was present only in Red Dacca banana specie with a value of 0.0007 mg/kg. Gros Michel and Lady's finger had the lowest value for cadmium (0.0007 mg/kg) while Red Dacca presented the highest value (0.0030 mg/kg).

Table 2: Heavy Metal Composition of Gros Michel, Red Dacca, Lady's Finger and Green Mutant

Varieties	Lead (mg/kg)	Mercury (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
Gros Michel	0.0293^{b} ± 0.00	0.0000 ± 0.00	0.0000^{a} ± 0.00	0.0007^{a} ± 0.00
Red Dacca	0.0303^{b} ± 0.00	0.0000 ± 0.00	0.0007^{a} ± 0.00	0.0030^{b} ± 0.00
Lady's Finger	0.0157^{a} ± 0.00	0.0000 ± 0.00	0.0000^{a} ± 0.00	0.0007^{a} ± 0.00
Green Mutant	0.0107^{a} ± 0.00	0.0000 ± 0.00	0.0000^{a} ± 0.00	0.0020^{b} ± 0.00

Mean ± SD of triplicate determinations
Mean values with different superscript letters (a-b) differed significantly ($p < 0.05$)

Table 3 shows the heavy metal composition of serving portion of the banana varieties under study. Gros Michel and Red Dacca banana species contained the highest lead content (0.0776 mg) and (0.0446 mg) respectively for mean weight of the edible portion.

Table 3: Heavy Metal Composition of Serving Portion of Gros Michel, Red Dacca, Lady's Finger and Green Mutant

Varieties	Lead (mg)	Mercury (mg)	Arsenic (mg)	Cadmium (mg)
Gros Michel	0.0776	0.0000	0.0000	0.0019
Red Dacca	0.0446	0.0000	0.0010	0.0044
Lady's Finger	0.0390	0.0000	0.0000	0.0017
Green Mutant	0.0140	0.0000	0.0000	0.0026

Mean of triplicate determinations

DISCUSSION

Fruits are essential component of human diet due to their vitamins and minerals composition which have immune boosting potentials (6). Consumption of artificially ripened fruit poses many life-threatening consequences, in particular an increased risk of non-communicable diseases due to accumulation of toxic agents in the body (19). This study assessed the heavy metal content of commonly consumed banana varieties in Enugu state of South-Eastern Nigeria; the trend of heavy metals contamination decreased in the banana varieties where lead was the highest and mercury was not detected in all the samples.

The soil and rain water in atmospheric polluted areas and industrial grade fertilizers are probable sources of lead contamination (20,21). Lead was detected in all the banana samples under study but in varying amounts. The highest levels of lead were observed in Red Dacca variety, 0.0303 mg/kg. The lead content of the banana fruits were lower than the recommended value of 0.3 mg/kg established by Joint Expert Committee on Food Additives (22), and 0.1mg/kg recommended by Food Standards Australia New Zealand (23). Furthermore, the lead content of banana varieties in this study were lower than that reported by Elbagermi, Edwards, and Alajtal, (24), Radwan and Salaman, (25) and Sobukola et al. (11). Also, a study on the heavy metal levels of some fruits and leafy vegetables sold in Lagos markets revealed the lead concentration in banana to be 0.118 mg/kg while Uroko et al, (2019) reported no traces of lead in ten samples of fruits purchased from various markets in Umuahia market, Abia state, Nigeria. Lead is known to induce renal tumors, reduce cognitive development, increase blood pressure and cardiovascular diseases in adults (26,27). Due to the delicate nature of the internal organs of children, they are more vulnerable than adults to the toxic effects of lead as it is easily absorbed by the body system (28). A continuous exposure to lead has been correlated to decreased intellectual development as well as behavioral disorders in young children (29,30). Though the lead content of banana varieties in the present study are within the permissible limit, caution should be taken as accumulation of this toxic substance can occur over time through constant consumption.

Mercury was negligible in the banana varieties studied. Mercury is more toxic in its organic form than inorganic form because it is readily absorbed through ingestion and this is harmful to fetal and children development (31). However, high exposure of organic and inorganic mercury may cause neurological disorders including seizures and death (26).

The International Agency for Research in Cancer (IARC) has classified Arsenic as a human carcinogen because of increased incidence of cancers as a result of exposure to arsenic at work environment and through diet (32). Long term low level exposure can cause skin cancer, arteriosclerosis and nervous system disorders (33–35). According to the Joint Expert Committee on Food Additives, the maximum acceptable limit of arsenic in food is 0.1 mg/kg (22). The arsenic content in the varieties under study was lower than maximum acceptable limit. Contamination may be due to the solid waste disposal into the soil, arsenic contaminated water and use of chemicals for ripening (19).

The cadmium content of the banana samples was lower than the values reported by Elbagermi et al. (24), Radwan and Salaman (25) and Sobukola et al. (11). Cadmium content of Red Dacca (0.0030 mg/kg) and Green Mutant varieties (0.0020 mg/kg) were high when compared to the Gros Michel and Lady's Finger varieties. The findings from the research revealed that cadmium concentration in the banana varieties were lower than the maximum acceptable limit of cadmium in foods which is 0.1 mg/kg according to International Standards for Heavy Metals in Food (22), and the safe limit of 0.2 mg/kg provided by the Food Safety Authority Ireland (32). Excessive intake of cadmium results in renal dysfunction, bone demineralization and to a lower extent dysfunction of the reproductive system (26,36).

CONCLUSION

The study determined the heavy metal composition of banana varieties commonly sold in Enugu state, south eastern Nigeria. The study revealed that the four varieties of banana contained significant amount of lead. Interestingly, the banana varieties are low in mercury and arsenic as against the popular belief that calcium carbide is widely used to ripen fruits. However, Red Dacca contains the highest amount of heavy metals, thus it should be consumed with caution to avoid accumulation of heavy metals in the body cells overtime. The study should be replicated in other regions of Nigeria and also should be carried out routinely to serve as a form of quality control.

Conflict of Interest

Authors declare no conflict of interest.

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