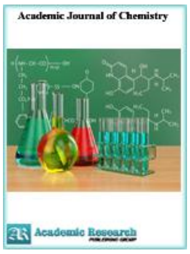

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Level of Nutritious and Non- Nutritious Elements in Banana Grown in Zanzibar

Abdul A. J. Mohamed*
Department of Natural Sciences, The State University of Zanzibar, Tanzania

Mariam H. Ali
Department of Natural Sciences, The State University of Zanzibar, Tanzania

Sara A. Khamis
Department of Natural Sciences, The State University of Zanzibar, Tanzania

Ali, Abdalla I.
Department of Natural Sciences, The State University of Zanzibar, Tanzania

Abstract: Banana play important role in providing dietary needs to the individuals from vitamins, iron, calcium, potassium, sodium and some others nutritious elements that are needed in the daily food as dietary supplementation, or as an important elements that form some hormones or enzymes in small concentration. However, if they exist beyond the recommended levels they can pose bad health effects. This study aims at assessing level of selected nutritious and non-nutritious elements in banana grown in different areas of Unguja-Zanzibar using Energy Dispersive X- Ray Fluorescence (EDXRF) machine. Nutritious elements (NEs) included sodium (Na), potassium (K), iron (Fe), manganese (Mn), zinc (Zn), and selenium (Se), while non-nutritious elements (NNEs) were; cadmium (Cd), lead (Pb), and chromium (Cr). These elements were observed and recorded from Jumbi (six sampling sites), Ndijani (six sampling sites), Masingini (four sampling sites), as well as Mpigaduru (four sampling sites). Concentration of elements investigated in all banana samples were above limit recommended by FAO/WHO and USDA. The sound reason for the elevated levels of the analyzed parameters is suggested to be due to solid wastes dumped at the study sites. From the statistical data analysis, the levels (in mg/kg) of the analyzed elements in their decreasing order were; K: 10537.62; Na: 8723.50; Pb: 106.151; Cr: 90.747; Fe: 61.548; Mn: 58.949; Cd: 14.995; Zn: 9.478; and Se: 2.01. This order is summarized as; K > Na > P b> Cr > Fe > Mn > Cd > Zn > Se. Elevated levels of these elements in banana might had been attributed to the repeated use, and addition of wastes as fertilizers in banana agricultural areas. The data analysis showed that the levels of some elements namely, Cr, Fe, Pb and Na in banana were significantly different ($p < 0.05$). Nevertheless, the present study remarkably pointed out the age of the dumping site has a positive correlation with the levels of both NEs and NNEs found in the analyzed samples. These findings will provide the baseline information about the presence of nutritious and non-nutritious elements in banana grown in different areas of Unguja- Zanzibar. Moreover, it is important for nutritional classification, compliance with the standard of identification and ensuring that the products meet human consumption specification.

Keywords: EDXRF; Nutritious and non-nutritious elements; selenium; potassium; lead.

1. Introduction

Banana (Musa spp) is an edible fruit produced by several kinds of large herbaceous flowering plants of the genus Musa. All widely cultivated banana today fall under the two wild banana, *Musa acuminata* and *Musa balbisiana* [1]. Banana is a tropical herbaceous plant; its stem is composed of concentric layers of leaf sheaths and a fruit is usually elongated and curved. The fruit contains a good amount of soluble dietary fiber that helps normal bowel movements, thus reducing constipation problems. Moreover, it is a rich source of potassium which helps to control heart rate, blood pressure, and countering bad effects of sodium [2]. Minerals play an vital role in maintaining proper function, and good health in the human body [3]. According to Zheng, *et al.* [4], approximately 98% of the calcium (Ca) and 80% of the phosphorus (P) in the human body are found in the skeleton.

Bananas are rich sources of vitamins, minerals, and fibers and have beneficial ant oxidative effects [5, 6]. Adequate consumption of banana fruits can significantly reduce the incidence of chronic diseases, such as cancer, cardiovascular diseases and other aging-related pathologies [7]. Inadequate intake of minerals in the diet is

*Corresponding Author

often associated with an increased susceptibility to infectious diseases due to the weakening of the immune system. Plants, animal foods, and drinking water are an important source of essential elements [8].

Nowadays, some banana farmers apply wastes directly to the field areas. These contaminants change nutritional properties of banana fruits, which might lead serious health effects to human beings like cancer, skin irritation, liver disease, kidney disease, gastrointestinal irritation with nausea, vomiting, diarrhea, cardiac abnormalities etc. [9]. The occurrences of NNEs-enriched ecosystem components, firstly, arise from rapid industrial growth, advances in agricultural chemicalization, or the urban activities of human beings. These agents have led to NNEs dispersion in the environment and, consequently, impaired health of the population by the ingestion of foodstuff contaminated by harmful elements [10].

Comparatively, banana plants that are grown in polluted areas have elevated levels of non-nutritious elements than those grown in unpolluted environment [11]. Reported sources of non-nutritious elements in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents and atmospheric sources [12]. Moreover, elevated levels of NNEs (heavy metals) in banana sold in the market at Riyadh city in Saudi Arabia were caused by atmospheric deposition [13]. In addition, [14] have reported that atmospheric deposition can significantly elevate the levels of heavy metals (non-nutritious elements) contamination in banana commonly sold in the markets of Varanasi, India.

Among the non-nutritious elements Cd, Cr, and Pb occupy a special place because they belong to the so-called potentially harmful elements. Potentially harmful metal contents in soils may come not only from the bedrock itself, but also from anthropogenic sources like solid or liquid waste deposits, agricultural inputs, and fallout of industrial and urban emissions [15]. Excessive accumulation of wastes in agricultural soils may result not only in soil contamination, but has also consequences for food quality and safety. Therefore, it is essential to monitor food quality, knowing that plant uptake is one of the main pathways through which non-nutritious elements (NNEs) enter the food chain [16]. At least five transition metals—arsenic, cadmium, chromium (VI), lead and nickel—are accepted as human carcinogens in one form or another or in particular routes of exposure [17].

This study aims at assessing the levels of selected nutritious and non-nutritious elements in banana grown in different areas of Unguja-Zanzibar to get the base line information for their suitability for the human and animal consumption. This is an attempt to ascertain good monitory of food quality. Nutritious elements (NEs) which are, sodium (Na), potassium (K), iron (Fe), manganese (Mn), zinc (Zn), and selenium (Se), while non-nutritious elements (NNEs) included; cadmium (Cd), lead (Pb), and chromium (Cr).

The present study covers some areas in urban west region of Zanzibar Island and its territories, whereby, the assessment of selected nutrients contained in banana grown on land field areas has taken a remarkable consideration. This exercise is crucial in reduction and prevention strategies of contaminated foodstuff to help in maintaining good health status for the consumers.

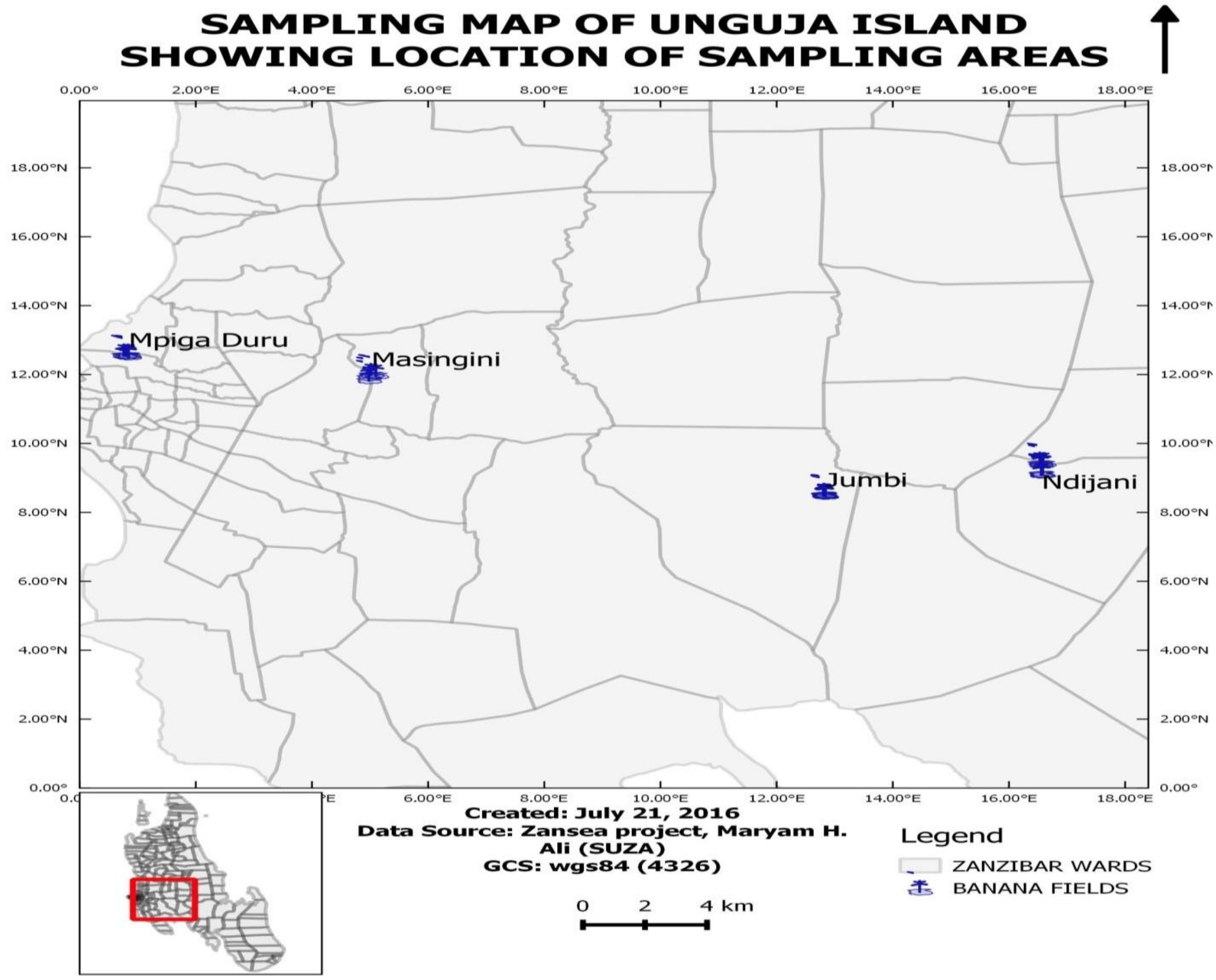
2. Materials and Methods

2.1. Area of the Study

The study was conducted in different banana fields of Unguja Island in Zanzibar. Zanzibar lies between latitude 6.16°S and longitude 39.2° E. Unguja (also referred to as Zanzibar Island or simply Zanzibar) is the largest and most populated island of the Zanzibar archipelago, in Tanzania. Unguja is a hilly island, about 85 kilometres (53 mi) long (North-South) and 30 kilometres (19 mi) wide (east-west) at its widest, with an overall area of about 1,666 square kilometres (643 sq mi) [18].

Banana samples were collected from four different areas of Unguja namely; Jumbi, Ndijani, Masingini and Mpigaduru. The geographical positioning system (GPS) was used to locate the sampling stations (Fig. 1).

Figure-1. Banana sampling sites in Unguja Island



2.2. Sample Collection and Preparation

Twenty samples were collected randomly from different banana farms in Unguja Island (six samples from Ndijani, six samples from Jumbi, four samples from Mpigaduru and four samples from Masingini).

At Tanzania Atomic Energy Commission (TAEC) laboratory Arusha banana samples were placed in the electric oven until the moisture were completely removed, then 4.0 g of dry standard powder for each banana samples were weighed using the most accurate electric balance. 0.9 g of binder including starch powder was weighed and mixed well with the sample powder in a well-labeled plastic holder. The weighed samples together with the binder were mixed together in a single labeled plastic holder and transferred into the special mortar having four ball bearing ,which was used to introduced into the homogizer machine for a thoroughly homogization of the sample powder. The minimum Detection Limit (MDL) (mg/kg) of the EDXRF used in this study to determine concentration of nutritious and non-nutritious elements in banana.

3. Results and Discussion

Table-1. Summary of the Statistical Data Analysis

Element	Sample Number(N)	Mean (mg/Kg)	Std Dev.	Min.(mg/Kg)	Max.(mg/Kg)	Sig.
Na	20	8723.50	3986.69	1707.90	14651.00	0.0101
K	20	10537.62	1839.11	7101.50	14864.80	0.6133
Cr	20	90.75	26.03	1.50	122.40	0.0002
Cd	20	15.00	9.84	0.20	32.70	0.1485
Pb	20	106.15	38.88	0.30	210.90	0.0104
Fe	20	61.55	17.69	0.80	102.90	0.0001
Zn	20	9.48	20.73	2.80	99.40	4.1500
Mn	20	58.95	216.02	0.60	1000.00	4.7800
Se	20	2.01	0.65	1.50	3.30	0.2177

3.1. Levels of Nutritious and Non-nutritious Elements in Banana in the study sites

The findings concerning the levels of nutritious elements (Na, K, Mn, Zn, Fe and Se) and non-nutritious elements (Cd, Cr and Pb) in banana samples collected from different areas of
Unguja -Zanzibar aimed at quantifying the levels of nutritious and non-nutritious elements. All results in this study are given in milligram per kilogram (mg/kg) of dry weight. Moreover, the minimum and maximum level of the analyzed elements were also highlighted (Table 1). The mean values of the analyzed elements were then compared with FAO/WHO and USDA standards limits to assess the safety of the banana for human consumption, and even for animal consumption (Table 2).

Table-2. Comparison between the analyzed elements with FAO/WHO and USDA

Elements	Mean Concentration (mg/kg)	MTLs (mg/kg)
K	10537.62	3580[b]
Na	8723.50	10[b]
Pb	61.548	0.3[a]
Cr	90.747	1.5[a]
Fe	61.548	2.6[b]
Cd	14.995	0.2[a]
Mn	58.949	2.7[b]
Zn	9.478	1.5[b]
Se	2.01	0.01[b]

a and b denote FAO/WHO and USDA respectively

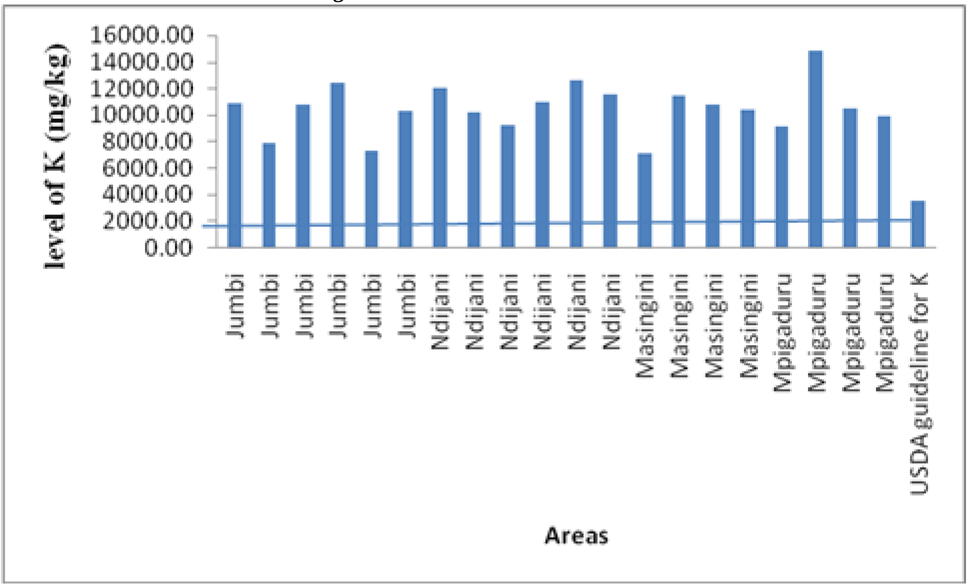
3.1.1. Potassium (K)

Among all nutritious elements, potassium was found to be of highest concentration in all analyzed samples with the range of potassium was 7101.5 to 14864.8 mg/kg. In increasing order, the levels of K was:

Mpigaduru > Ndijani > Jumbi > Masingini (Figure 2).

The highest level of K might have been contributed by presence of solid wastes dumped at Mpigaduru.

Figure-2. Level of Potassium in banana



On other hand, there was no significant difference for the level of K in the studied area. ($P=0.613$, $P> 0.05$). The concentration of K in this study is above the maximum tolerable limit set by USDA. It was also observed by Selema and Farago [19] that among the nutritious elements in banana, K is the first nutrient with highest concentration of about 38100 mg/kg.

3.1.2. Sodium (Na)

Sodium level in banana samples in all selected sampling areas ranged between 1707.9 to 14651 mg/kg. In increasing order, the level of Na was:

Jumbi > Masingini > Ndijani > Mpigaduru

The highest concentration of Na in banana was found in Jumbi (Figure 3), and the lowest concentration was in Mpigaduru. The highest level of Na might have been contributed by presence of solid wastes dumped at Jumbi.

Figure-3. Banana planted at Jumbi area (Photo by Mariam H. Ali)

Therefore, banana of Jumbi had highest concentration of Na, while banana at Mpigaduru had lowest concentration of Na. The level of Na was also at the risk level since it was above the permissible concentration set by USDA, and also there was significant difference for the Na level in the studied areas where ($P = 0.010$, $P < 0.05$). This value might be due to the presence of sodium containing compounds, and accumulation of wastes within agricultural fields. Additionally, [20] have showed the highest concentration of sodium in banana in Malaysia. On some banana cultivars demonstrated the effect of salinity on both fruits and chemical properties, the greater quantity of sodium in soils has been testified to prevent plant's progress in growth, uptake of nutrients, physiological as well as metabolic processes [21].

3.1.3. Zinc (Zn)

Level of Zn in all samples reported in this study ranged between 2.8 to 99.4 mg/kg

Therefore, in increasing order, the level of Zn was:

Mpigaduru > Masingini > Ndijani > Jumbi

Therefore, banana of Mpigaduru was of highest Zn level while that of Jumbi was of lowest level. The mean concentration of Zn in this study exceeded the USDA maximum limits.

On other hand, there was no significant differences for the level of zinc in the studied areas where ($P= 4.78$, $P > 0.05$). Available literatures, In Egypt by Radwan and Salama [22] have also reported Zn levels of 5.59 mg/kg, which also exceeds the limit of USDA.

3.1.4. Iron (Fe)

The level of iron in all banana samples in this study ranged from 0.8 to 102.9 mg/kg, which is above the maximum permissible limit set by USDA. In increasing order the level of Fe was;

Masingini > Jumbi > Ndijani > Mpigaduru

The highest level of Fe might have been contributed by presence of solid wastes dumped at Masingini. Also, there was significant difference for iron level in different studied areas where ($P=0.0001$, $P < 0.05$).This might be due to the application and disposal of municipal wastes in those banana fields which contribute the level of Fe. This is also showed in Pakistan by Zahir, *et al.* [23]; Ismail, *et al.* [24] which were 16.508 mg/kg and 163.0 mg/kg in banana respectively.

3.1.5: Manganese (Mn)

In this study, level of Mn in all banana samples ranged from 0.6 to 1000 mg/kg. Therefore, in increasing order the level of Mn was:

Jumbi > Masingini > Mpigaduru > Ndijani

The highest level of Mn might have been contributed by presence of solid wastes dumped at Jumbi. In this study, there was no significant difference of Mn level in the studied areas ($P = 4.78$, $P > 0.05$), and the concentrations are above the USDA limit.

3.1.6: Selenium (Se)

The level of selenium in this study ranged from 1.5 to 3.3 mg/kg, which is above the USDA permissible limit. Thus, in increasing order the level of Se was:

Jumbi > Ndijani > Mpigaduru > Masingini

Therefore, banana of Jumbi showed highest concentration of Se and that of Masingini have lowest concentration of Se. The highest level of Se might have been contributed by dumping of municipal solid wastes at Jumbi, and there was no significant difference of Se concentration in banana of selected areas (P =0.217, P > 0.05).

3.1.7: Lead (Pb)

The level of Pb in all banana samples of this study ranged from 0.3 to 210.9 mg/kg. In increasing order, the level of Pb was:

Masingini > Jumbi > Mpigaduru > Ndijani

Therefore, highest concentration of Pb was recorded from Masingini sample, whereby Mpigaduru showed lowest concentration of Pb.

Moreover, there was significance difference of Pb concentration in banana of different studied areas (P=0.010, P< 0.05). This may be due to the application and addition of municipal wastes in banana fields of selected areas as fertilizers. Also the concentration of Pb in this study is above the maximum permissible limit set by WHO, this is also showed by [6, 20] which were 1.106 mg/kg and 3.152 mg/kg in banana respectively.

4.1.8: Chromium (Cr)

The level of Cr in all banana samples ranged from 1.5 to 122.4 mg/kg, which is above the maximum permissible limit set by WHO. In increasing order the level of Cr was:

Masingini> Ndijani> Jumbi> Mpigaduru

The highest level of Cr might have been contributed by dumping of municipal solid wastes at Masingini. Also, there was significant difference of Cr concentraion in banana of different studied areas. (P=0.0001, P< 0.05). The reason might be due to the addition of wastes in selected banana fields as fertilizers. Hafez, *et al.* [20] also show this, which was 4.343 mg/kg.

3.1.9: Cadmium (Cd)

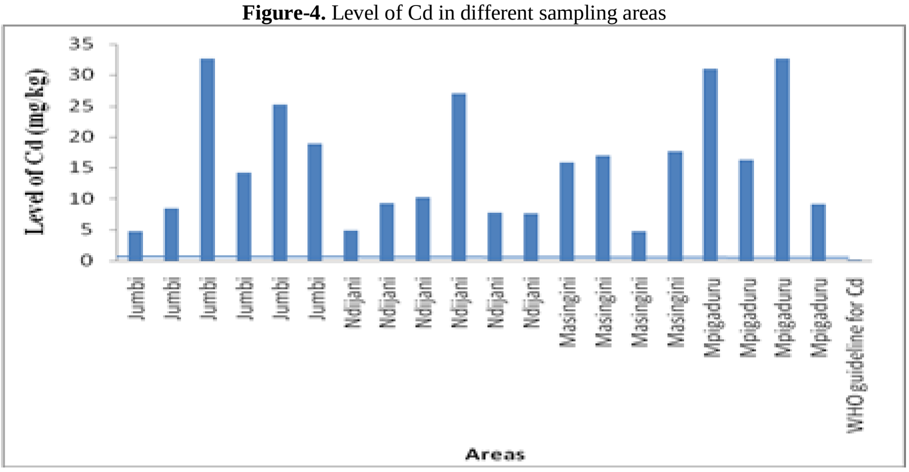
Level of Cd in all samples reported in this study varied between 0.2 to 32.7 mg/kg. The mean concentration of Cd in this study exceeds the WHO maximum limits.

Therefore, the level of Cd in inceasing order was:

Mpigaduru = Jumbi> Ndijani> Masingini (Figure 4)

Whereby the highest concentration of Cd in banana was in Mpigaduru which was also the same as that of Jumbi.

Figure-4. Level of Cd in different sampling areas



There was no significant difference of Cd concentraion in studied areas (P=0.148, P> 0.05). Available literatures have shown that, Radwan and Salama [22] have also reported Cd levels of 0.02 and 0.001 mg/kg in banana respectively, which are below the limit of WHO.

Therefore, the levels of Mn, Se,Na, K,Fe,Cr Cd, Zn and Pb in banana from different selected areas in Unguja-Zanzibar in increasing order are summarized as:

K > Na > Pb > Cr > Fe > Mn > Cd > Zn > Se

From One way Anova, the levels of Cr, Fe, Pb and Na in banana varied significantly in the studied areas (p < 0.05).

4. Conclusion

The highest level of analyzed parameters might have been contributed by disposal of municipal solid wastes dumped at the study areas. Remarkably, the present study reveals that the age of the dumping sites positively influence the levels of both NEs and NNEs found in the analyzed samples. Thus, these findings could be useful baseline information about the presence of nutritious and non-nutritious elements in banana grown in different areas of Unguja- Zanzibar. Moreover, this information could be a used as very important data for nutritional classification with the observance of the standard of identification to ensure that the products meet human consumption specification and safety.

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