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Research Article

Investigating Cassava Root Cortex Peels as a Potential Source of Toxic Contaminant

OO Adejumo[1]*, FA Balogun[2] and MO Dawodu[3]

[1]*Department of Physics and Solar Energy, Bowen University, Iwo, Nigeria*

[2]*Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria*

[3]*Department of Chemistry and Industrial Chemistry, Bowen University, Iwo, Nigeria*

***Corresponding Author:** OO Adejumo, Department of Physics and Solar Energy, Bowen University, Iwo, Nigeria.

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Abstract

Cassava, largely produced in Nigeria contains cyanide compounds which are distributed widely throughout the plant, with large amounts in the leaves and root cortex (skin layer) and generally smaller amounts in the root parenchyma (interior). In rural southern Nigeria, cattle are fed with peels of cassava. Ingestion of cyanogens in cassava peels by these cattle and its subsequent consumption by humans might lead to increased toxic levels in human population especially in the rural communities. In this work, the elemental composition of cassava root cortex was determined using atomic absorption spectrometry, AAS technique. Quantities of the cassava peels were collected and taken to the laboratory for analysis after sample preparation by digestion and filtration process. A PG-990 Atomic Absorption Spectrophotometer used in the flame configuration mode was used for the elemental composition analysis. Results of the AAS analysis showed that Manganese (62.780 ± 0.126 mg/kg), Zinc (11.080 ± 0.104 mg/kg), Iron (498.720 ± 0.226 mg/kg), Copper (7.670 ± 0.176 mg/kg), Lead (not detected) and Magnesium (258.850 ± 0.132 mg/kg) were present in the cassava root cortex peels. These high concentration values of Iron and Magnesium in cassava peels might be a source of increased toxicity levels in humans.

Keywords: *Cassava Root Cortex Peels; Iron; Magnesium*

Introduction

Cassava, which is also called *Manihot esculenta*, belongs to the family Euphorbiaceae is a perennial woody shrub grown in the tropical and sub-tropical regions of the world. Stephen in 1995 believed that it originated from Brazil and Paraguay [1]. Eke-Okoro and Njoku in 2012 reported that Muoneke and Njoku in 2008 opined that cassava was introduced into Nigeria by Portuguese traders and explorers from Fernando-Po to Warri in the then Mid-Western Nigeria in the late 18th Century [2]. Agboola, in his publication on the Agricultural Atlas of Nigeria in 1979, stated that cassava usage later spread to Lagos, Badagry, Abeokuta and Ijebu in the early 19th Century by slaves returning from Brazil, West Indies and Sierra Leone who settled in these towns, and imparted their knowledge of how to process the crop into food to these local people thereby popularizing the consumption of cassava in the local food economy. This eventually lead to the development of demand for processed forms of cassava like gari, fufu, lafun, bread flakes, flour etc (Agboola, 1979). Cassava and cassava products were later introduced into Eastern Nigeria along the Coast towns of Calabar and Yenagoa by traders from Western Nigeria [3]. Nigeria is presently acknowledged as the world's largest producer of cassava with yearly quantities of over 40 million metric tonnes according to the 2004 statistical bulletin of the Central Bank of Nigeria, CBN [4]. About 90% of cassava produced in Nigeria is used domestically for food, animal feed, industrial and pharmaceutical uses and unquantifiable quantities for export according to Eke-Okoro and Njoku in 2012 [2]. Information from Food and Agriculture Organization of the United Nations, FAO in 2016 indicate that the total 2013 world cassava production was 263,177,000 tonnes, with Nigeria, Thailand, Indonesia, Brazil and Democratic Republic of Congo producing the largest amounts. Nigeria, the highest producer, produced 47,407,000 tonnes that year [5]. Arinola and other workers in a publication in 2008, reported that fresh cassava roots and leaves contain cyanide compounds including linamarin or cyanogenic glucoside and hydrocyanic acid at levels that may be toxic. These cyanogens, he further opined, are distributed widely throughout the plant, with large amounts in the leaves and root cortex, also called the skin layer and generally smaller amounts in the root parenchyma or the interior [6]. The edible starchy root tuber, is a major food source and it is common practice in rural southern Nigeria to feed cattle with peels of this cassava root cortex. Ingestion of cyanogens in cassava peels and subsequent consumption of these cattle by humans might lead to increased toxic levels in human population especially in the rural communities. This suspicion has influenced this study. Atomic absorption spectroscopy, AAS, an analytical technique for the quantitative determination of chemical elements using the absorption of optical radiation by free atoms in the gaseous state was used in this study to determine the elements present in peels of the root cortex of cassava in this work. Quantities of cassava root cortex peels were collected and taken to the laboratory for analysis after sample preparation by digestion and filtration process. The line source PG-990 Atomic Absorption Spectrophotometer, LS AAS located at the Central Science Research Laboratory of the Bowen University, Iwo was used in the flame configuration mode for the elemental analysis.

Materials and Methods

Sample Preparation

Cassava root cortex peels were collected and prepared by digestion and filtration process in the laboratory for analysis. These samples were prepared by air-dried and acid digestion at the Chemistry Laboratory of the Bowen University, Iwo. One gram (1g) each of three replicate samples were measured and concentrated HNO_3 (5 ml) was added in a Teflon beaker and heated on a hot plate for about 10 min after which perchloric acid (1 ml) was added and then heated for about 30 - 45 minutes. The digested samples were allowed to cool to room temperature and filtered. The filtrate was then transferred into a 25 ml volumetric flask and made up to mark with distilled water. The samples were analysed with the PG 990 Atomic Absorption Spectrophotometer available at the Central Science Research Laboratory of Bowen University, Iwo.

Atomic absorption spectroscopy (AAS): Theory and instrumentation

Atomic Absorption Spectroscopy, AAS is a spectroscopic technique usually used in the determination of the concentrations of chemical elements present in a given sample. This is usually accomplished by measuring the absorbed radiation of the chemical element of interest from the spectra produced when the sample is excited by radiation. Here three main analytical techniques are used; flame, graphite and hydride. Depending on the analytical problems each have its advantages and disadvantages. The flame technique, which is the most common, usually determines trace elements in ppm for most analytical elements and is the most cost effective, for a lower level determination, (usually ppb) the graphite technique can be used, and for a number of elements that can form volatile hydrides, the hydride technique can be employed. The five major components of an atomic absorption spectrophotometer, that is; the light source, the burner assembly, optics, detector and signal processing are designed such that each component produces minimum disruption to the overall system and many design features are installed to keep the signal-to-noise ratio as low as possible. The Atomic Absorption Spectrophotometer used in this study is a fully automated intelligent instrument for flame and/or graphite furnace analysis developed by PG Instruments Ltd., a user-friendly instrument controlled from a personal computer with AAWin software. It incorporates two background correction systems; the deuterium lamp method and the self-reversal method. This allows the operator to make automatic setting or adjustment for wavelength scan, peak-search, slit width change-over, element lamp turret alignment, height/position parameter setting and adjustment of the atomizer. Other setting/adjustment allowances include, the fuel and supporting gas flow rate, lamp current and voltage of the photomultiplier. Configuration options of flame and graphite furnace analysis at the operator's discretion is available. For this analysis, the flame configuration option was used.

Atomic absorption spectrometer analysis

In this work, air was allowed to mix with acetylene gas from the gas cylinder in good proportion to ignite the burner of the Spectrophotometer. After ignition, the Spectrophotometer was calibrated using distilled water (as blank) and standard solution (as supplied with the Spectrophotometer). After calibration, the aerosol of the cassava root cortex solution was aspirated through the nebulizer into the flame for analysis and this was done at the particular wavelength specific to the element, using the Hollow Cathode Lamp, HCL of the element under investigation. The result is then displayed on the computer screen.

Results

Table 1 shows the mean concentrations of the elements Mn, Zn, Pb, Fe, Cu and Mg analysed. The results have been presented for triplicate measurements in each of the cases, and the mean concentration displayed. The daily dietary allowance for humans for each of the elements analysed as recommended by National Research Council, USA, is presented in table 2 (as obtained from the Recommended Dietary Allowances 10th Edition, 1989) [7].

Elements	Concentrations (mg/kg)
Manganese	62.780 ± 0.126
Zinc	11.080 ± 0.104
Lead	Not detected
Iron	498.720 ± 0.226
Copper	7.670 ± 0.176
Magnesium	258.850 ± 0.132

Table 1: *Mean values for determined elements in cassava root cortex samples.*

Elements	Recommended Dietary Allowances per day (mg)	
	Male	Female
Mn	2 - 5	2 - 5
Zn	15	12
Fe	10	10
Cu	2 - 3	2 - 3
Mg	320	320

Table 2: *Recommended dietary allowances per day of elements for humans.*
(Source: Recommended Dietary Allowances 10th Edition. National Academies Press, Washington, DC).

Discussions and Conclusion

The result of the determination of the elemental composition of cassava root cortex peels using atomic absorption spectrometry, AAS technique reveals the presence of Manganese, Zinc, Iron, Copper and Magnesium in the cassava root cortex peels. The reported non-detection of Lead in this study should not rule out its presence in cassava root cortex. This work has utilized the flame technique, which is the most common and cost effective, determining trace elements in ppm (mg/kg). If the graphite technique is used, a lower level determination (usually ppb) can be obtained, which may reveal the presence of Lead. The high concentration values of Iron, Magnesium and Magnesium in cassava peels is suggestive of the need for further work by health workers to determine the extent of increased (or otherwise) toxicity levels in humans who consume the cattle that feed on these cassava root cortex peels. According to Sadrzadeh and Saffari in 2004, accumulation of Iron in humans has been related to some neurologic disorders such as Alzheimer disease, Parkinson disease, etc [8], while Tan., *et al.* in 2006 reported that the exposure of Manganese is reported to have an adverse effect on CNS function and mood [9]. In a publication in 2004, Travers opined that Magnesium is useful for the body. It is essential for life and is a co-factor in numerous enzymes involved in phosphate transfer, muscle contractility and neuronal transmission. Deficiency of Mg can result in tetany and lead to calcium deficiency [10]. Comparing these concentration values of the elements analysed, with daily dietary allowance as recommended by National Research Council, USA (Table 2), we see that the iron content of 498.720 ± 0.226 mg/Kg far exceeds the recommended 10mg per day for humans. The concentration of 62.780 ± 0.126 mg/Kg obtained for Manganese is indicative of an intolerable level for consumption when compared with the daily dietary allowance as recommended by National Research Council, USA (Table 2). Results of these and similar studies, and its practical relevance for human nutrition especially with respect to the magnitude of the "iron effect" and "manganese exposure" need to be further investigated. Since metal toxicity depends upon the absorbed dose, the route and duration of exposure whether acute or chronic that can cause various disorders as stated in 2014 by Jaishankar., *et al.* [11]; it is necessary to set standards for the consumption of these cassava root peels by cattle and enforce compliance particularly in a country like Nigeria where the product is heavily consumed with a view to safeguarding public health.

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Conflicts of Interest

The authors declare no conflict of interest.

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