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Comparative Evaluation of the Cyanide and Heavy Metal Levels in Traditionally Processed Cassava Meal Products Sold Within Enugu Metropolis

Ezeh E[1]*, Okeke O[2], Aburu CM[3] and Anya OU[4]

[1]*Chemical Engineering Department, Nnamdi Azikiwe University, Awka*

[2]*Plastic Production Unit, Scientific Equipment Development Institute, Enugu*

[3]*Machine Shop Unit, Scientific Equipment Development Institute, Enugu*

[4]*Plastic Recycling Unit, Scientific Equipment Development Institute, Enugu*

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***Corresponding author:** Okeke O, Chemical Engineering Department, NnamdiAzikiwe University, Awka Tel: 08160080576; Email: onyekaokeke207@yahoo.com

Abstract

Studies were carried out to comparatively evaluate the cyanide and heavy metal levels in traditionally processed cassava meal products (abacha, akpu and garri) sold within Enugu Metropolis using relevant analytical procedures and instrumentation. The mean levels of cyanide in the abacha, akpu and garri samples sold within Enugu metropolis were, 11.07, 6.84 and 9.22ppm respectively. Only the mean cyanide levels in abacha samples sold within the metropolis was above the maximum safe intake limits of 10ppm in cyanide containing food/feed for human and animals. The levels of cyanide in the samples were statistically significant ($p < 0.05$). Cd, Zn, Cu, Pb and Fe were all detected at non-toxic levels in the traditionally processed cassava meal product sold within Enugu metropolis. The mean levels of the metals in akpu were significantly higher than in the other studied samples sold within the metropolis ($p < 0.05$). Varying periods of fermentation, soil chemistry and ecology was attributed to be responsible for the varying levels of cyanide in the samples. Contamination during processing and in the soil where the cassava were harvested could have significantly influenced the levels of the studied heavy metals in the samples.

Keywords: Heavy Metal; Cyanide; Akpu; Garri; Abacha

Theoretical Basis and Methodology

Cassava (*Manihot esculentacrantz*) is a tuberous root belonging to the surphorbiaceae family. Due to its high adaptability to a variety of environmental conditions, cassava is considered an important nutritive source [1-30]. It is the third largest source of carbohydrates after rice and maize, being an important dietary component for populations worldwide [16]. Cassava is an all season crop of the tropics and ranks among the top ten food crops in the world [15]. Today, Africa is the largest producer of cassava referred to as the bread of the tropics, with Nigeria leading with nineteen percent of global market share [10]. It holds the position as a primary food security crop in Africa due to its resistance to drought and disease, flexible planting, harvest cycles and tolerance of low-quality soils [17]. Cassava is a tuber crop that is propagated by stem and matures between 6-12 months of planting depending on the variety [22]. It supplies about 70% of the daily calorie of over 50 million people in Nigeria [8]. Edible part of fresh cassava root contains 32-35% carbohydrate, 2-3% protein, 75-80% moisture content, 0.1% fat, 1.0% fibre and 0.70-2.50% ash [29-31].

According to [14] fresh cassava roots cannot be stored for long because they rot within days of harvest since they are bulky with about 75% moisture content with the roots and leaves containing varying amounts of cyanide which is toxic to humans. Therefore, cassava must be processed into various forms in order to increase the shelf-life of the products, facilitate transportation and marketing, reduce cyanide content and improve palatability [32-36]. Cassava can be processed into a number of products both traditionally and industrially [13]. Depending on the product, the methods involved in processing cassava include, peeling, cutting, and submerged fermentation, dewatering, sieving, frying, washing, frying, cooking and pounding [34]. Some commonly processed cassava meals include chips, abacha, fufu, lio-lio, tapioca, cassava flour and garri [21]. For instance, abacha is a traditionally processed by first harvesting and peeling the cassava and was quickly followed by cooking the tubers to soften for a period of time. The cooked cassava will be sliced and soaked in water over night. After about 12hours of soaking, the cooked and sliced cassava will be washed thoroughly with water until it become edible [21]. According to 33, the cassava product called akpu is usually prepared by harvesting and pealing cassava tubers and then washing them into a container where it will be fermented with water for atleast seven days to ten days. It is then removed from the fermented water and mashed in a sieve bag that drains out water when compressed/swizzed. The mashed cassava in the sieve bag can be cooked and pounded into gelatinized pastes called fufu [30]. Stated that the traditional production of garri involves peeling of the cassava tubers and grating it into fine pulp. Next the pulp is transferred into lessian sacks and compressed to drain and ferment for days. The fermented and relatively dewatered pulp will be sieved to remove fibrous materials and palm oil could be added according to preference. Roasting is carried out in large frying pan to yield gelatinized granules of reduced moisture content which can be stored for relatively long-time. Palm oil is added to cassava mash to give the garri an aesthetic value and source of vitamin A.

Though cassava mealed products such as fufu, cassava and abacha contain a list of mineral elements in trace amounts which are of good use to the body, May also contain a number of heavy metals. These heavy metals sometimes are accumulated in the cassava through the soil. Heavy metals are environmental contaminants with the capability of finding their way into the food we eat and causing human health problems. They are given special attention throughout the world due to their ubiquitous nature and toxic effects even at low concentrations [11]. Heavy metals contamination of the environment and food materials are major source of concern. In humans, heavy metals are taken up through consumption of heavy metal laden food, water and inhalation of heavy metal contamination of heavy metal contaminated air [24]. Heavy metals such as Cu and Zn are essential for normal plant growth and development since they are constituents of many enzymes and other proteins [36]. Elevated concentrations of both essential and non-essential metals in the soil can lead to toxicity symptoms and accumulation in parts of plants [18]. Plants growing within the heavy metals contaminated areas usually take up heavy metals by absorbing minute deposits on the parts exposes to the air in the polluted environments and during uptake of contaminated soils [37-39]. Analysis of processed cassava flour has revealed the presence of poisonous metals such as lead, arsenic and cadmium [5].

Cadmium, chromium and nickel are carcinogenic [28]. Lead causes neurological impairment and central nervous system damage by its ability to mimic and inhibit the actions of calcium in its neurotransmission function [26]. Some heavy metals such as cobalt, copper, iron, manganese and zinc are essential macro elements for living things however; they are toxic at high concentrations [4]. Cassava contains the cyanogenic glucosides, linamarin and lotaustralin which are hydrolyzed after tissue damage by the endogenous enzyme, linamarase to the corresponding cyanolydrin and further to hydrogen cyanide (HCN) [9]. The hydrogen cyanide is responsible for the chronic toxicity when inadequately processed cassava products are consumed by humans and animals for prolonged periods [8]. During processing, cassava tubers are disrupted and cyanogenic glucosides is brought in contact with p – glucosisases and a-hydroxynitrile lyases, engendering and hydrolysis of cycinogenic glucosides into cyanolydrins, hydrogen cyanides and ketones [8]. Based on the wide consumption of cassava products as everyday diet in many Nigerian homes, studies were carried out to comparatively evaluate the cyanide and heavy metal levels in traditionally processed cassava meal products (garri, akpu and abacha) sold within Enugu metropolis.

Materials and Method

Sample Collection

Samples of abacha, akpu and garri were obtained at various market outlets within Enugu metropolis.

Elemental Analysis

The samples were oven-dried at 100oC for 3hrs. Thereafter, the samples were ground into a fine powder and 0.5g each was weighed into a 100ml volumetric flask. Thirty mililitres (30ml) of mixed concentrated acid (650ml nitric acid + 80mlperchloric acid+20ml suphuric acid) were added and the mixture heated at 150oC until dense white fumes of nitric acid escaped. Thereafter, it was cooled and brought to a volume of 50ml using de-ionized water in a 50ml volumetric flask. The resulting solution was analyzed with atomic absorption spectrometer (AAS model Pa 990). The spectrometer was standardized using standard solutions of the elements analyzed and distilled water was acidified and aspirated to zero using air acetylene for Cu, Cd, Zn, Pb and Fe. The absorption radiation of the elements produced from the metals at various wavelengths was measured using the atomic absorption spectrometer.

Statistical Analysis

All data were expressed in mean and standard deviation. The data was subjected to one way analysis of variance (ANOVA) using SPSS version 18.0 at 5% level of confidence.

Hydrogen Cyanide Determination

This was carried out using the method adopted by [31]. 2g each of the samples were made into paste in 20ml of distilled water in a corked conical flask overnight after which extraction took place. The extract was filtered and the filtrate was used for the analysis. 1ml of this was put in a test-tube, followed by the addition of 4ml alkaline picrate solution. This was heated in water at 90oC for 5min. After the colour development, the absorbance value of each sample was determined at 490nm using spectrophotometer (AAS 6200 SHIMADZU). The actual amount of cyanide was extrapolated from the standard cyanide was extrapolated from the standard cyanide curve. A blank reagent from 4ml picrate solution and 1ml distilled water were also prepared to standardize the spectrophotometer before measuring the absorbance. Table 1 shows that the mean levels of cyanide in abacha, akpu, and garri sold within Enugu metropolis

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were, 11.07, 6.84 and 9.22ppm respectively. These cassava meal products (akpu, garri and abacha) were traditionally processed using different methods, with the sole aim of reducing the cyanide level, improve storability, convenience and palatability of the meal products. The order of decrease of cyanide levels in the sample were, abacha>garri>akpu as shown in Figure 1. The mean levels of cyanide in the abacha samples sold within Enugu metropolis was above the maximum safe limit of 10ppm in cyanide contaminating food/feed for humans and animals [38]. Abacha is a ready-to-eat cassava meal product widely consumed in many Nigerian homes, so to have found the cyanide level above the recommended limit in this edible food/snack is of public health concern. According to [29], fermentation of cassava tubers is a major determining factor in achieving a significant reduction in cyanide content in cassava meal products [33]. Stated that the disparity in cyanide content in cassava meal products is as a result of difference in ecological factors and soil chemistry in the various places were the cassava is grown [8]. Stated that key component of soil such as potassium, calcium and magnesium adversely affected the biosynthesis and translocation of cyanide to storage organs, which invariably contributed to inconsistencies in cyanide content in the plant tissues.

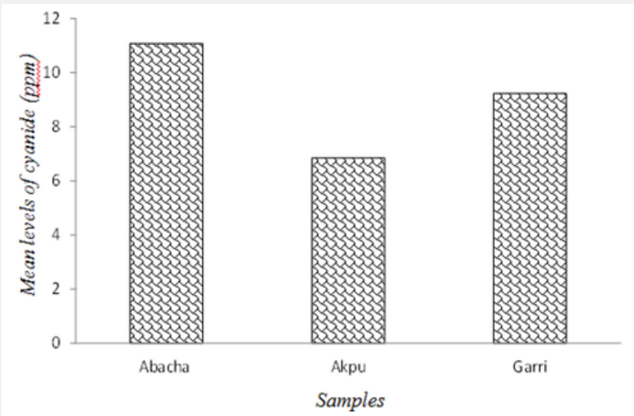

Figure 1: Bar chart representation of mean levels of cyanide in the cassava meal products sold within Enugu metropolis (ppm).

Table 1: Mean levels of cyanide in the cassava meal products sold within Enugu metropolis (ppm).

Sample	Cyanide content (ppm)
Abacha	11.07 ± 0.96
Akpu	6.84 ± 0.33
Garri	9.22 ± 0.46

WHO STD-10.00ppm

Another reason that can be attributed to the high level of cyanide in the abacha and garri samples sold within Enugu metropolis can be attributed to the short period of fermentation employed by the processors. According to [12], HCN is responsible for tissue hypoxia. Chronic exposure to HCN causes neurological, respiratory, cardiovascular and thyroid defects. Symptoms of this may be seen less than one minute following ingestion of cyanide [19].

Cadmium

Table 2 shows that the mean levels of cadmium in the abacha, akpu and garri sold within Enugu metropolis were, 0.084, 0.206 and 0.135ppm respectively. The order of decrease of the metal in the samples were,akpu>garri>abacha (Figure 2) Statistical analysis of cadmium levels in the samples shows significant difference at $p < 0.05$. According to [39], plants growing within heavy metal contaminated areas usually take-up heavy metals by absorbing minute deposits on the parts exposed to air in the polluted environments and during uptake from contaminated soils.

The difference in soil chemistry from which the cassava tubers were processed into the sample products were grown, heavy metal contamination levels of such soils, contamination from water used during the fermentation process and general processing environment could have significantly influenced the levels of cadmium and other metals in the samples. The mean concentrations of cadmium in the samples were within recommended permissible limits for a solid food product [38] Chronic exposure to cadmium could cause nephrotoxicity in humans, mainly due to abnormalities of tubular re-absorption [27,28]. Higher values of 0.55 ± 0.002mg/kg, for cadmium in cassava tubers sold in major markets in Benue State, Nigeria, than obtained in this research [13]. Did not detect cadmium in cassava flour sold in Anyigba market, Kogi State, Nigeria.

Zinc

Table 2 shows that the mean levels of zinc in abacha, akpu and garri sold within Enugu metropolis were, 4.82, 6.76 and 5.49ppm respectively. The mean concentration of zinc in the cassava meal samples were statistically significant ($p < 0.05$) and within the established recommended maximum safe limits. The order of decrease of zinc in the sample were, akpu>garri>abacha. The mean values of zinc obtained for the cassava meal products in the research compared very well with 5.66±0.31mg/kg reported by [24] for the metal in garri sold in some major markets in Yenegoa metropolis, Nigeria. Zinc is one of the major essential elements required by the human system [23]. Zinc plays several functions in the human body, such as wound healing, blood clotting, and proper thyroid function, maintenance of vision, bone mineralization, fetal growth, sperm production and cell growth. High concentrations of zinc in the body induce several health effects such as vomiting, gastro-intestinal irritation, weakness, anaemia and loss of hair [2].

Copper

Table 2 shows that the mean levels of copper in abacha, akpu and garri sold within Enugu metropolis were, 1.34, 2.81 and 1.65ppm respectively. The order of decrease in mean levels of cooper in the samples were,akpu>garri>abacha as shown in Figure 2. The mean levels of copper in the cassava meal

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samples were found to be statistically significant and equally within the maximum permissible limit [38]. Higher mean values of 3.72±0.87mg/kg was obtained for Cu by [24] in garri sold in some major markets in Yenegoa metropolis, Nigeria, than reported in this study [6].

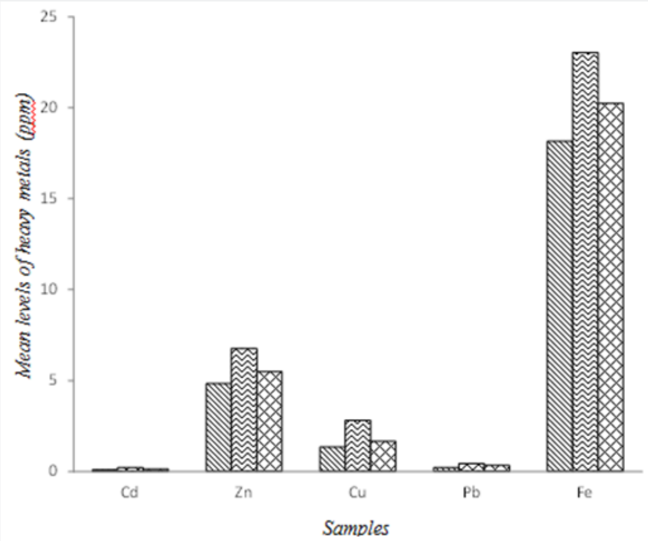

Figure 2: Bar chart representation of mean levels of heavy metals in the cassava meal products sold within Enugu metropolis (ppm).

Table 2: Mean levels of heavy metals in the cassava meal products sold within Enugu metropolis.

Metal	Abacha(ppm)	Akpu(ppm)	Garri(ppm)	F-test	WHO STD
Cd	0.084 ± 0.02	0.206 ± 0.06	0.135 ± 0.05	0.02	0.5
Zn	4.82 ± 0.41	6.76 ± 0.53	5.49 ± 0.38	0.04	350
Cu	1.34 ± 0.08	2.81 ± 0.21	1.65 ± 0.40	0.03	300
Pb	0.203 ± 0.05	0.431 ± 0.04	0.323 ± 0.07	0.03	0.5
Fe	18.16 ±1.71	23.04 ± 0.98	20.25 ± 0.64	0.02	300

A higher mean value of 10.18±0.73mg/g for copper in cassava flour processed by road side drying along Abuja Lokoja highway, Nigeria, than what was obtained for the metal in the studied cassava meal products in this research. The plant uptake of heavy metals is dependent upon a number of factors. These factors include; physical processes such as root intrusion, water and ion fluxes and their relationship to the kinetics of metals solubilization in soils, biological parameters, including kinetics of membrane transport, ion interactions and metabolic fate of absorbed ions, soil acidity and the ability of the plants to adapt metabolically to charging stresses in the environment [7].

Although, copper is an essential element of life, it causes adverse effects on health by acute or chronic intoxications or even death of animals, when it is introduced in excess in the body. The biological functions of copper include cell metabolism, normal iron metabolism, red blood cell synthesis, connective tissue metabolism and bone development [35,3]. Chronic exposure to high concentration of copper causes irritation of nasal mucosa, vomiting, nausea, diarrhea, kidney and liver damage.

Lead

The mean levels of lead in abacha, akpu and garri samples sold within Enugu metropolis were, 0.203, 0.431 and 0.323ppm respectively. The mean levels of the metal in the cassava meal samples decreased in the following order; akpu>garri>abacha and shown in Figure 2. The mean concentration of lead was found to be statistically significant ($p < 0.05$) in the cassava product samples. Lead was present at non-toxic levels in the analyzed samples. Dietary intake of many heavy metals through consumption of plants has long term detrimental effects on human health [37]. Heavy metal polluted food can severely reduce some vital nutrients in the body that are accountable for declining immunological defenses, growth delay, reduced psychological abilities and gastro-intestinal cancer [23]. High level of lead in adults' body can generate heart diseases, cancer and infertility. For children the disease caused by lead can lead to antisocial behaviour, low intelligence or hyperactivity [3,28]. Obtained a higher mean value of 0.889mg/kg for lead in garri sold in two major garri markets in Benue State, Nigeria, than reported for the metal in cassava meal samples in this research.

Iron

Iron plays an essential role in living organisms such as the formation of heamoglobin, transferrin, ferritin and bone iron – containing enzymes, transport, deoxyribonucleic acid synthesis, and electron transport chain, regulation of cell growth and differentiation and cytochromes [25].

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Table 2 shows that the mean concentrations of iron in abacha, akpu and garri samples sold within Enugu metropolis were, 18.16, 23.04 and 20.25ppm respectively. The concentrations of iron in the traditionally processed cassava meal products were statistically significant ($p < 0.05$) and within the recommended maximum safe limits for an edible solid food. The order of decrease of the mean levels of iron in the samples were, akpu>garri>abacha [13] obtained a lower mean value of 1.27mg.g for iron in cassava flour sold in Anyigba market, Kogi State, Nigeria, than reported for the metal in cassava meal products studies in the research.

Conclusion

Cyanide was found present in abacha, akpu and garri samples sold within Enugu metropolis. The mean levels of cyanide in abacha samples sold within the metropolis were detected at above the maximum safe intake in cyanide containing food/ feed for humans and animals. The least concentration of cyanide was detected in akpu samples. The concentrations of cyanide in the traditionally processed cassava meal products (abacha, akpu and garri) sold within Enugu metropolis were statistically significant at $p < 0.05$. The varying duration of fermentation of the samples, soil chemistry and ecology of where the cassava were grown could have significantly influence the cyanide levels in the studied samples.

The studied heavy metals (Cd, Zn, Cu, Pb and Fe) were detected at non-toxic levels in abacha, akpu and garri samples sold within Enugu metropolis. The levels of the analyzed metals in the samples were statistically significant ($p < 0.05$). Higher levels of heavy metals were found present in akpu samples than in the other studied cassava meal samples.

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