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Proximate and Heavy Metal Concentrations of Locally Processed Cassava Food (Abacha) in Selected Markets in Yenagoa Bayelsa State

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ABSTRACT

This evaluation analyzed the proximate and heavy metal compositions of locally processed cassava food product (Abacha) in selected markets in Yenagoa. The Abacha used for this study was purchased from Tombia, Opolo, Swali, and Azikoro markets. Proximate and heavy metal were determined carried based on standard methods. The ash, moisture, rude lipid, crude fiber, and carbohydrate of Abacha obtained from Tombia market for week 3 were 2.01±0.15%, 3.16±0.11%, 3.82±0.03%, 3.51±0.023%, and 86.59±2.11% respectively The ash, moisture, rude lipid, crude fiber, and carbohydrate of Abacha obtained from Swali market were 3.71±0.10%, 3.31±1.03% 3.25±0.20%, 3.84±0.16%, and 85.08±0.59% respectively. The Pb, Cr, Cd, an Hg levels in Abacha purchased from Tombia market for week 3 were 2.10±0.10%, 2.05±0.02%, 2.07±0.02%, and 2.10±0.00% respectively. The Pb, Cr, Cd, an Hg levels in Abacha purchased from Swali market for week 3 were 2.14±0.02%, 2.17±0.21%, 2.11±0.30%, and 2.17±0.02% respectively. The carbohydrate content in Abacha purchased from Opolo market was highest followed by Swale market, Azikoro market while the least was Tombia market. The Pb, Cr, Cd, and Hg observed in Abacha from Tombia and Swali markets were within the reference daily intake values for both women and men. There should be profound control of inorganic mineral concentration of locally processed food in Yenagoa, Bayelsa from time to time in order to thwart the incidence of metal-induce toxicity, resulting from consumption of food loaded with pollutant by the public.

Keywords: Abacha, cassava product, processed food, proximate parameters, heavy metals, Yenagoa markets

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1. INTRODUCTION

Production of cassava in Africa emerged at 193.62 million metric tonnes in 2020, thus placing Africa as the world's largest cassava growing region [1]. Unarguably, Nigeria known as the highest manufacture of cassava globally is about 60 million metric tonnes in 2020. Cassava is a priggish principal food whose roots are highly substantial in carbohydrates, which is fundamental source of metabolic ATP. After sugarcane, cassava has the highest carbohydrate concentration amongst all crop plants [2]. Looking at the humongous instrumentality of Cassava when it comes to food sufficiency and foo crisis in Africa, it has been recognized and accepted as Africa's food security crop [3].

Food clarification has to do with the modification of its substances from its raw state into a finish end state by the application of varying techniques [4]. Food processing is vital since it ensures the improvement of shelf life of the products, reduce spoilage and increase the availability and accessibility of the food products to people [1]. Fresh cassava roots contain about 70 % moisture content thereby increasing its bulkiness and this poses serious transportation problems which may affect the availability of the food crop to users and he processed forms of cassava finds wide applications both as food and useful industrial products [1]. Tapioca, farina, garri, fufu, starch etc. are some of the product often gotten from processing of cassava tuber locally.

The different processed forms are the inexpensive source of principal food in Nigeria in particular. African countries consume almost all that it generate, notwithstanding the high level of cassava production [5, 6]. Traditionally, soaking, fermentation, cooking, steaming and chipping, frying, drying and roasting are the different processing steps employed in the processing of the cassava roots [7, 8].

Proximate composition is seen as the basic components of a food, including its moisture, protein, fat, fibre, ash, and carbohydrates. Efforts have been made over the years, towards characterizing the proximate composition of various species of cassava roots and derived products to unravel the effects of processing methods, environmental factors, and genetic diversity on their nutritional profiles [9-11].

Current breakthroughs in analytical methods and innovative research have presented very vital understanding into the proximate composition of processed cassava products. In 2020, noticeable contributions were made to this field, shedding light on the nutritional content and potential health benefits of cassava-based foods.

Meanwhile, the situation of land used for agricultural activities add principally to the condition of the farm products harvested on it [11]. This could be attributed water and nutrients from the soil which are absorbed by the roots of plants during growth. All of these processes have implications on the quality of farm produce [12]. Based on the delivery factor factor from soil to plants, the heavy metals mineral contents in the soil leave their signature on the produce from the farm. Anthropogenic activities [13] contributed to the loads of heavy metals in the soil on which farm products are cultivated [14].

Excess exposure to heavy metals especially when they are highly concentrated in foodstuff consumed or are contained in small proportion in food items popularly consumed by young and old can pose major health risk to consumers [15], hence the need to evaluate heavy metal contents in processed cassava product becomes imperative.

2. MATERIALS AND METHODS

2. 1. Collection of Sample

Locally processed cassava food (Abacha) was purchased from Swali, Azikoro, Opolo, and Tombia markets in Yenagoa. Processed cassava product (Abacha) was purchased from the four main markets in Yenagoa City namely: Opolo, Swale, Azikoro, and Tombia markets. Abacha was collected from week one to week eight for each of the selected markets. The samples were collected and transported directly to the Chemical Science laboratory, Faculty of Basic and Applied Science, University of Africa Toru-Orua, for analysis. The sample was treated based on standard laboratory methods and procedures.

2. 2. Preparation of Samples

Exactly, 50 g of the locally processed cassava product sample was put in tightly sealed aluminium foil and kept in field cellophane bags before analysis to prevent environmental contamination.

2. 3. Proximate Analysis

Proximate composition such as moisture, crude protein, crude fibre, crude fats, ash and carbohydrate contents in the of the sample was measured according to the standard methods as described in AOAC [16] and other standard techniques obtained from the literature.

2. 3. 1. Moisture determination (% MD)

The moisture content for sample for week 1-8 were characterized based on [16] method 925.10. In this method, 2 g of the sample was measured into a pre-labelled, preweighed beaker and was oven dried at 130 °C. The sample was raised at 1 h -30 min, 2 h, 2 h -30 min, and 3 h, and measured again until constant weight was reached. All sampling and analysis were in three data points [8]. The formula used for the calculation of moisture content and dry matter can be seen below:
Sample weight – moisture content = dry matter

$$\% \text{ moisture content} = \frac{\text{Dry matter}}{\text{Wt of sample}} \times 100 \qquad (1)$$

2. 3. 2. Ash (% Ash) Determination

The ash content of each sample for week 1-8 were evaluated following the AOAC [16] method 923.03. In this method, the sample was prepared and weighed into preweighed, porcelain crucible. The sample was transferred to a muffle furnace and ashed at 550 °C for 8 h. The crucible was allowed to cool in desiccators and then weighed. The formula that was used for the calculation of ash content can be seen below:

$$\% \text{ Ash} = \frac{\text{Wt of Ash}}{\text{Wt of sample}} \times 100 \qquad (2)$$

2. 3. 3. Fat (% Fat) Determination

The fat content of each sample for week 1-8 were evaluated based on the 920.39 of AOAC [16] method by dissolving 8 g of the sample into a 200 cm^3 beaker containing 8.4 cm^3 of hydrochloric acid and heated in a water bath for 1 h. After heating, the sample solution was allowed to cool and then extracted with petroleum ether in a separating funnel. After extraction, the sample solution were heated to dryness and the weight collected after cooling [16]. The formula that was used for the calculation of fat content can be seen below:

$$\%\ \text{fat} = \frac{\text{Wt loss of sample (extract)}}{\text{Wt of sample}} \times 100 \qquad (3)$$

2. 3. 4. Crude protein (% C.P) Determination

The crude protein content of each sample for week 1-8 were evaluated based on the method described by Nuwamanya *et al.* (2010) [19] using Dumas combustion method of nitrogen content analysis (Leco Truspec Model FP-528, St Joseph Mi, USA) by taking about 0.3 g of sample and using the conversion factor:

$$\%\ \text{protein} = \%\text{N} \times 6.25 \qquad (4)$$

2. 3. 5. Crude fibre content (% C.F)

The crude fibre content was analyzed based on 962.09 of AOAC method [16]. In this method, 0.5 g of the sample was boiled in 50 mL of 0.3 M H_2SO_4 under reflux for 30 min, followed by filtering through a 75 mm sieve under suction pressure. The residue was rinsed with deionnized water to remove the acid. The residue was then boiled in 100 mL, 0.25 M sodium hydroxide under reflux for 30 min and filtered under suction. The insoluble portion was washed with hot distilled water to free the alkaline. The insoluble portion was dried to the constant weight in the oven at 100 °C, for 2 h, then cooled in the desiccator. The dried sample was ashed in a muffle furnace to subtract the mass of ash from the fibre after then the % of fibre was determined [20].

2. 3. 6. Determination Heavy Metal Concentration

Sediment sample of Abacha collected from the selected markets were air dried and the dried sample was passed through a 2 mm sieve. The sieved sample was powdered and passed through a 500 m sieve. The mixture was stored in acid washed and deionized water rinsed glass bottles. For heavy metal content analysis, 1 g of dried sediment subsample was digested in teflon vessels with 10 ml HNO_3 (65%):HCl (37%) in a ration of 3:1. The mixture was heated using a heating mantle for 10-20 minutes inside a fume cupboard. After digestion, the sample solution was filtered through Whatmann filter paper into 100 ml standard flask, adjusted to a suitable volume with double deionized water. The sediment extract was analyzed for Pb, Hg, Cr, and Cd using Atomic absorption spectrometry (AAS) equipped with deuterium background correction. The AAS was calibrated daily and each of the metals whose specific gravity is ≥ 5 g/cm^3 were run using specific metallic standard.

2. 7. Data Analysis

Data was analyzed using a one-way analysis of variance (ANOVA). The mean differences were determined using the Tukey's Least Significance Difference test at 5% significant level. Values of $p \leq 0.05$ were considered statistically considerable. All data were expressed as the mean ± standard deviation (SD) of three observations. All calculations were done using the Minitab version 20 software.

3. RESULTS

Table 1-4 show the proximate composition of Abacha purchased from selected markets (Tombia, Opolo, Swali, and Azikoro) in Bayelsa State. Also, Table 5-8 indicate the heavy metal concentrations in Abacha purchased from selected markets (Tombia, Opolo, Swali, and Azikoro) in Bayelsa State.

Table 1. Proximate composition of Abacha purchased from selected markets in Yenagoa for Week one (n=3)

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
Tombia Abacha	0.76±00 ^{a}	2.87±0.01 ^{b}	1.02±0.00 ^{b}	2.01±0.12 ^{b}	0.91±0.03 ^{a}	92.43±1.21 ^{k}
Opolo Abacha	0.94±0.01 ^{a}	3.91±0.14 ^{d}	1.22±0.02 ^{b}	1.86±0.10 ^{a}	0.78±0.01 ^{a}	91.29±2.10 ^{d}
Swali Abacha	1.02±0.05^{b}	3.25±0.21 ^{d}	1.63±0.22 ^{b}	1.31±0.03 ^{a}	1.06±0.02 ^{b}	91.73±3.25 ^{d}
Azikoro Abacha	1.05±0.02 ^{b}	4.02±0.23 ^{k}	0.71±0.03^{a}	1.62±0.04 ^{a}	1.03±0.11 ^{b}	91.56±5.82 ^{d}

Results are mean ± Standard deviation (SD) of duplicate determinations. Means with different superscript letters along the same column are significantly (P < .05) different.

Table 2. Proximate composition of Abacha purchased from selected markets in Yenagoa for week Two (n=3)

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
Tombia Abacha	1.02±0.01^{b}	2.02±0.23 ^{b}	4.21±0.21 ^{k}	2.41±0.01 ^{b}	0.75±0.00 ^{a}	89.59±1.34 ^{k}
Opolo Abacha	1.71±0.04 ^{b}	3.83±0.25 ^{d}	4.01±0.23 ^{k}	3.15±1.02 ^{d}	0.28±0.00 ^{a}	87.02±3.02 ^{d}
Swali Abacha	1.25±0.03 ^{b}	3.08±0.34 ^{d}	3.81±0.21 ^{b}	3.24±0.25 ^{d}	0.92±0.01 ^{a}	87.70±2.50 ^{d}
Azikoro Abacha	1.81±0.03 ^{b}	4.81±0.12 ^{k}	4.11±0.26 ^{k}	2.81±0.02 ^{b}	0.36±0.12 ^{a}	86.10±3.01 ^{a}

Results are mean ± Standard deviation (SD) of duplicate determinations. Means with different superscript letters along the same column are significantly (P < .05) different.

Table 3. Proximate composition of Abacha purchased from selected markets in Yenagoa for week Two (n=3)

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
Tombia Abacha	1.02±0.01^{b}	2.02±0.23 ^{b}	4.21±0.21 ^{k}	2.41±0.01 ^{b}	0.75±0.00 ^{a}	89.59±1.34 ^{k}
Opolo Abacha	1.71±0.04 ^{b}	3.83±0.25 ^{d}	4.01±0.23 ^{k}	3.15±1.02 ^{d}	0.28±0.00 ^{a}	87.02±3.02 ^{d}
Swali Abacha	1.25±0.03 ^{b}	3.08±0.34 ^{d}	3.81±0.21 ^{b}	3.24±0.25 ^{d}	0.92±0.01 ^{a}	87.70±2.50 ^{d}
Azikoro Abacha	1.81±0.03 ^{b}	4.81±0.12 ^{k}	4.11±0.26 ^{k}	2.81±0.02 ^{b}	0.36±0.12 ^{a}	86.10±3.01 ^{a}

Results are mean ± Standard deviation (SD) of duplicate determinations. Means with different superscript letters along the same column are significantly (P < .05) different.

Table 4. Proximate composition of Abacha purchased from selected markets in Yenagoa for week Three (n=3)

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
Tombia Abacha	2.01±0.15 [a]	3.16±0.11 [b]	3.82±0.03 [b]	3.51±0.02 [b]	0.91±0.11 [a]	86.59±2.11 [b]
Opolo Abacha	2.52±0.03 [a]	3.51±1.00 [b]	3.71±0.14 [b]	3.91±0.01 [b]	0.82±0.15 [a]	85.53±0.16 [a]
Swali Abacha	3.05±0.15 [b]	3.18±0.21 [b]	3.41±0.03 [b]	3.62±0.11 [b]	0.51±0.51 [a]	86.23±2.00[b]
Azikoro Abacha	3.71±0.10 [b]	3.31±1.03 [b]	3.25±0.20 [b]	3.84±0.16 [b]	0.81±0.00 [a]	85.08±0.59[a]

Results are mean ± Standard deviation (SD) of duplicate determinations. Means with different superscript letters along the same column are significantly (P < .05) different.

Table 5. Proximate composition of Abacha purchased from selected markets in Yenagoa for week Four

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
Tombia Abacha	2.61±0.15[a]	3.91±0.10 [b]	4.04±0.16 [k]	4.16±0.00 [k]	0.82±0.01 [a]	84.46±2.01 [b]
Opolo Abacha	2.41±0.03 [a]	3.63±0.14 [b]	4.00±0.04 [k]	3.82±0.00 [b]	0.67±0.03 [a]	85.47±0.23[k]
Swali Abacha	3.18±0.01 [b]	3.74±0.18 [b]	3.91±0.10 [b]	3.61±0.10 [b]	0.74±0.01 [a]	84.82±0.16[a]
Azikoro Abacha	3.82±1.00 [b]	3.71±1.00 [b]	3.82±0.11 [b]	3.25±0.21 [b]	0.91±0.00 [a]	84.49±1.03[a]

Results are mean ± Standard deviation (SD) of duplicate determinations. Means with different superscript letters along the same column are significantly (P < .05) different.

Table 6. The mean heavy metal concentration in Abacha purchased from selected markets in Yenagoa for Week one (n=3)

Sample	Pb (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Hg (mg/kg)	FNB (2016) Reference intake for women (mg/day)	FNB (2016) Reference intake for Men (mg/day)
Tombia Abacha	2.11±0.01[a]	2.07±0.00 [a]	2.16±0.10 [a]	2.14±0.00 [a]	2.14-2.23	2.64-2.81
Opolo Abacha	1.09±0.01	1.11±0.00	1.11±0.01	1.17±0.01	2.14-2.23	2.64 -2.81
Swale Abacha	2.01±0.10 [a]	2.12±0.01 [a]	2.10±0.10 [a]	2.05±0.12 [a]	2.14-2.23	2.64 -2.81
Azikoro Abacha	1.04±0.04	1.09±0.15	1.09±0.14	1.20±0.05	2.14-2.23	2.64 -2.81

Data are reported in mean and standard deviation of mean (M±SD). Value bearing superscript ‘‘ a’’ were significantly higher than others down the group. Value bearing no superscript were statistically similar down the group.

Table 7. The mean heavy metal content in Abacha purchased from selected markets in Yenagoa for week Two

Sample	Pb (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Hg (mg/kg)	FNB (2016) Reference intake for women (mg/day)	FNB (2016) Reference intake for Men (mg/day)
Tombia Abacha	2.14±0.05[a]	2.17±0.11[a]	2.09±0.12[a]	2.03±0.00[a]	2.14-2.23	2.64-2.81
Opolo Abacha	1.51±0.21	1.73±0.03	1.74±0.01	1.84±0.11	2.14-2.23	2.64 -2.81
Swale Abacha	2.01±0.11[a]	2.05±0.20[a]	2.11±0.00[a]	2.08±0.02[a]	2.14-2.23	2.64 -2.81
Azikoro Abacha	1.63±0.06	1.72±0.04	1.82±0.11	1.52±0.00	2.14-2.23	2.64 -2.81

Data are reported in mean and standard deviation of mean (M±SD). Value bearing superscript ‘‘ a’’ were significantly higher than others down the group. Value bearing no superscript were statistically similar down the group.

Table 8. The mean heavy metal content in Abacha purchased from selected markets in Yenagoa for week Three (n=3)

Sample	Pb (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Hg (mg/kg)	FNB (2016) Reference intake for women (mg/day)	FNB (2016) Reference intake for Men (mg/day)
Tombia Abacha	2.10±0.10[a]	2.05±0.02[a]	2.07±0.02[a]	2.10±0.00[a]	2.14-2.23	2.64-2.81
Opolo Abacha	1.00±0.10[a]	1.98±0.07	1.92±0.02	1.23±0.07[a]	2.14-2.23	2.64 -2.81
Swale Abacha	2.14±0.02[a]	2.17±0.21[a]	2.11±0.30[a]	2.17±0.02[a]	2.14-2.23	2.64 -2.81
Azikoro Abacha	1.42±0.00	1.62±0.02	1.93±0.02	1.00±0.14[a]	2.14-2.23	2.64 -2.81

Data are reported in mean and standard deviation of mean (M±SD). Value bearing superscript ‘‘ a’’ were significantly higher than others down the group. Value bearing no superscript were statistically similar down the group.

4. DISCUSSION

Table 1 shows the proximate composition in Abacha purchased from selected markets in Yenagoa for week one. The moisture content in Abacha purchased from Azikoro market was highest followed by Swali, Tombia markets while the least was Opolo market. The moisture and rude fiber content in Abacha purchased from Tombia market were higher than that of Opolo market. The carbohydrate content of Abacha purchased from Opolo market was noticed to be highest followed by that of Tombia market, Swali market while the least was Azikoro market.

The percentage range of carbohydrate observed in this study was 91.29±2.10-92.43±1.21 % for Abacha purchased from the four selected markets which is higher than the range of carbohydrate percentage as presented by Idongesit *et al.* [1] in their study on comparative analysis on the proximate composition of processed cassava products obtained from January to March, 2023 in Lafia Town, Nigeria.

The ash content in Abacha purchased from Azikoro market was highest followed by Swali market, Opolo market while the least was Tombia. The moisture content in Abacha purchased from Azikoro market was highest followed by Opolo market, Swali market while the least was Tombia market. The crude lipid percentage in Abacha bought from Swali market was highest next to it was Opolo market, Tombia while the least was Azikoro market. The crude fiber amount in Abacha bought from Tombia has the highest value next to it was Opolo market, Azikoro market, while the least was Swali market. The crude protein level in Abacha purchased from Swali market was noticed to be highest next to it was Azikoro market, Tombia market while the least was Opolo market. Also, the carbohydrate level in Abacha bought from Tombia market was highest followed by Swali market, Azikoro market while the least was Opolo market (Table 1). The range of ash, crude fiber, and crude protein were 0.76±00-1.05±0.02 %, 1.31±0.03-2.01±0.12 %, 0.78±0.01-1.06±0.02 % were lower than those reported by Idongesit *et al.* [1].

Table 2 shows the proximate composition of Abacha purchased from selected markets in Yenagoa for week Two. The ash content in Abacha purchased from Azikoro market was highest followed by Opolo market, Swal market while the least was Tombia market (Table 2). The moisture percentage in Abacha purchased from Azikoro market was noticed to be highest followed by Opolo market, Swali market while the least was Tombi market. The crude lipid content in Abacha purchased from Tombia market was highest in followed by Azikoro market, Opolo market while the least was Swalei market (Table 2). The crude fiber content in Abacha purchased from Swali market was highest followed by Opolo market, Azikoro market while the least was Tombia market. The carbohydrate content in Abacha purchased from Tombia market was highest followed by Swali market, Opolo market while the least was Aikoro market (Table 2**).** The range of the ash, crude fiber, moisture, crude lipid, and crude protein were lower in percentage when compared to the range reported by Gregory et al. [22] except the carbohydrate content

Table 3 shows the proximate composition in Abacha purchased from selected markets in Yenagoa for week Three. The ash content in Abacha purchased from Azikoro market was highest followed by Swali market, Opolo market while the least was Tombia market (Table 3). The moisture percentage in Abacha purchased from Opolo market was noticed to be highest followed by Azikoro market, Swali market while the least was Tombia market. The crude lipid level in Abacha bought from Tombia market was seen to be highest next to it was Opolo market, Swali market while the least was Azikoro market. The crude fiber content in Abacha purchased from Opolo market was highest followed by Azikoro market, Swali market while the least was Tombia market. The crude protein level in Abacha bought from Tombia market was highest followed by Opolo market, Azikoro market while the leas was Swali market (Table 3). The carbohydrate content in Abacha purchased from Tombia market was highest followed by Swali market, Opolo market while the least was Azikoro market (Table 3**)**.

Table 4 shows the proximate composition in Abacha purchased from selected markets in Yenagoa for week Four. The ash content in Abacha purchased from Azikoro market was highest followed by Swali market, Tombia market while the least was Opolo market (Table 4).

The moisture percentage in Abacha purchased from Tombia market was noticed to be highest followed by Swali market, Azikoro market while the least was Opolo market. The crude lipid level in Abacha bought from Tombia market was seen to be highest next to it was Opolo market, Swali market while the least was Azikoro market. The crude fiber content in Abacha purchased from Tombia market was highest followed by Opolo market, Swali market while the least was Azikoro market. The crude protein level in Abacha bought from Azikoro market was highest followed by Tombia market, Swali market while the leas was Opolo market. The carbohydrate content in Abacha purchased from Opolo market was highest followed by Swale market, Azikoro market while the least was Tombia market (Table 4**).**

The moisture content of Abacha purchased from Tombia and Swali markets in this study were significantly high which points to the good quality of the product. According to Pirasath *et al*. [23], high moisture content enhances the digestion of food and glucose formation and its release into the blood.

The ash content of cassava products is the inorganic minerals found in cassava products. Tables 3 and 4 showed high level of these minerals found in cassava products and are comparable to 1.71% to 2.34%, as observed by Emmanuel *et al.* [24]. Although, they are usually lost at different stages of processing cassava roots into cassava-based products Onyenwoke and Simonyan [25].

Proteins are bodybuilding blocks that assist in repairing worn-out tissues and make enzymes, hormones, and other body chemicals. The proteins from this study (Table 1-4) confirmed the view that the protein content of locally processed cassava food (Abacha) is very low as against the range 1% to 3% on a dry matter basis reported by Emmanuel et al. [24] and Sulistyo et al. [26]. Cassava's protein has a more negligible effect on carbohydrate digestion and assimilation rate. Total carbohydrate content values in Abacha obtained in this present study were within the range of 84 % to 92% and agree with what has been reported [24].

The ash contents in Abacha obtained from Tombia, Opolo, Swali, and Azikoro for week 4 were highest and similar followed those of week 2 while the least was that of week 1. The moisture contents in Abacha obtained from Tombia, Opolo, Swali, and Azikoro for week 4 for week 1 and 2 were similar and were the least while those of week 3 and four were also similar and were highest. The crude lipid content in Abacha obtained from Tombia, Opolo, Swali, and Azikoro for week was highest followed by week 4 and 3 while least was that of week 1. The crude fiber percentage in Abacha purchase from Tombia, Opolo, Swali, and Azikoro for week 4 was highest next to it was week 3 and 2 while the least was week 1. The carbohydrate percentage in Abacha obtained from Tombia, Opolo, Swali, and Azikoro for week 1 was highest followed by week 2 and 3 while least was that of week 4 (Table 1-4). The variation in the proximate composition of Abacha obtained from Tombia, Opolo, Swali, and Azikoro from week 1-4 could be attributed to lack of standardized methods of local processing of Abacha in the Niger Delta regions and in the South-West and South-East where the product is widely accepted for meal. This is in agreement with the report of Fabrice *et al.* [27] on effect of different processing methods on the proximate composition, mineral content and functional properties of foods.

Heavy metals are toxic environmental substances which may bioaccumulate up a food chain and pose threat to the health of humans. Many of these metals, such as Cd, Pb and Cr, are carcinogens and are involved in several diseases, including Alzheimer's, Parkinson's, multiple sclerosis, osteoporosis, developmental disorders and failure of several organs (e.g., heart, kidney, lungs, immune system) (Duruibe *et al.*, 2007). Table 5 shows the mean heavy metal concentrations in Abacha purchased from selected markets in Yenagoa City for week One. The mean Pb level in Abacha was noticed to be highest in Tombia market followed by Swali market, Opolo market while the least was Azikoro market (Table 5). The Pb concentration in Abacha purchased from Opolo and Azikoro markets were lower than the reference daily intake values for both women and men. The Pb level in Abacha bought from Tombia and Swali markets were within the reference intake for both women and men (Table 5), hence regular intake of the food could be considered relatively safe. Wodaje [28] in his study on assessment of some heavy metals concentration in selected cereals collected from local markets of Ambo city, Ethiopia, reported similar heavy metals locally processed food.

Also, the mean Cr level in Abacha purchased from Swali market was highest next to it was Tombia market, Opolo market while the least was Azikoro markets. The mean Cr levels in Abacha obtained from Swali and Tombia markets were within the reference daily intake for both women and men while those of Opolo and Azikoro markets were below the reference daily intake values for both women and men (Table 5), hence consumption of the food might not pose any health risk. The significantly high levels of Cd observed in Abacha purchased from Tombia and Swali markets could be due to the increases in the burning of plastics and other activities within the market environment which do not occur in the Opolo and Azikoro marketplaces

More so, the mean Cd level in Abacha obtained from Tombia market was highest followed by Swali market, Opolo market while the least was Azikoro market. The mean Cd level in Abacha purchased from Tombia and Swali markets fell within the daily reference intake values for both women and men while those of Opolo and Azikoro markets were below the daily reference intake values for both women and men (Table 5), therefore, consumption of such food over a long period of time might not lead to toxicological consequences. The significantly high levels of Cd observed in Abacha purchased from Tombia and Swali markets could be due to the increases in the burning of plastics and other activities within the market environment which do not occur in the Opolo and Azikoro marketplaces.

The mean Hg concentration in Abacha bought from Tombia market was highest next to it was Swali market, Opolo market while the least was Azikoro market. The mean Hg levels in Abacha bought from Opolo and Azikoro markets were lower than the daily reference intake for both women and men while those of Tombia and Swali markets were within the range of the reference daily intake values for both women and men. The significantly increased Hg levels observed in Abacha purchased from Tombia and Swali markets when compared to those of Opolo and Azikoro markets could be attributed to the increased refuge incineration and other activities in connection to crude oil dealing around the market places.

Rapid and unorganised urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries including Nigeria [29]. In the Niger Delta region, due to the level of pollution as a result of oil exploration activities, there has been an increased level of toxic metals in air, water and agricultural soils with a resultant increased uptake and deposition on foods (including processed foods) such as cereals, rice, and vegetables thus posing serious health implications to the health of consumers [29]. Table 6 in this study, shows the mean heavy metal concentrations in Abacha purchased from selected markets in Yenagoa City for week Two. The mean Pb level in Abacha was noticed to be highest in Tombia market followed by Swale market, Azikoro market while the least was Opolo market (Table 6). The Pb concentration in Abacha purchased from Opolo and Azikoro markets were lower the reference daily intake values for both women and men.

The Pb level in Abacha bought from Tombia and Swale markets were within the reference intake for both women and men (Table 6), which could be attributed illegal burning of plastics and other waste products. However, regular intake of Abacha purchased from the selected markets may not cause any health challenge.

Also, the mean Cr level in Abacha purchased from Swale market was highest next to it was Tombia market, Opolo market while the least was Azikoro markets. The mean Cr levels in Abacha obtained from Swale and Tombia markets were within the reference daily intake for both women and men while those of Opolo and Azikoro markets were below the reference daily intake values for both women and men (Table 6). The significantly high levels of Cd observed in Abacha purchased from Tombia and Swale markets could be due to the increases in the burning of plastics and other activities within the market environment which do not occur in the Opolo and Azikoro marketplaces.

More so, the mean Cd level in Abacha obtained from Tombia market was highest followed by Swale market, Azikoro market while the least was Opolo market. The mean Cd level in Abacha purchased from Tombia and Swale markets fell within the range of the daily reference intake values for both women and men while those of Opolo and Azikoro markets were below the daily reference intake values for both women and men (Table 6). The significantly high levels of Cd observed in Abacha purchased from Tombia and Swale markets could be due to the increases in the burning of plastics and other activities within the market environment which do not occur in the Opolo and Azikoro marketplaces**.** The mean Hg concentration in Abacha bought from Tombia market was highest next to it was Swale market, Azikoro market while the least was Opolo market (Table 6). The mean Hg levels in Abacha bought from Opolo and Azikoro markets were lower than the daily reference intake for both women and men while those of Tombia and Swale markets were within the range of the reference daily intake values for both women and men (Table 6). The significantly increased Hg levels observed in Abacha purchased from Tombia and Swale markets when compared to those of Opolo and Azikoro markets could be attributed to the environmental contamination arising from constant burning of plastics, wastes, and others activities. The heavy metal levels in Abacha obtained selected Swali, Opolo, Tombia, and Azikoro for week 2 were lower than the values reported by Iniebiyo and Atieme [30] on assessment of heavy metals concentration in selected foods sold in markets within port-Harcourt city, Nigeria.

Table 7 shows the mean heavy metal concentrations in Abacha purchased from selected markets in Yenagoa City for week Three. The mean Pb level in Abacha was noticed to be highest in Swale market followed by Tombia market, Azikoro market while the least was Opolo market (Table 7). The Pb concentration in Abacha purchased from Opolo and Azikoro markets were lower the reference daily intake values for both women and men. The Pb level in Abacha bought from Tombia and Swale markets were within the range of the reference intake for both women and men (Table 7), which could be attributed illegal activities stated above. However, daily intake of Abacha purchased from the selected markets may pose threat to the general populace who patronize such locally processed cassava product.

Also, the mean Cr level in Abacha purchased from Swale market was highest next to it was Tombia market, Azikoro market while the least was Opolo markets. The mean Cr levels in Abacha obtained from Swale and Tombia markets were within the range of the reference daily intake values for both women and men while those of Opolo and Azikoro markets were below the reference daily intake values for both women and men (Table 7). The mean Cd level in Abacha obtained from Swale market was highest followed by Tombia market, Azikoro market while the least was Opolo market. The mean Cd level in Abacha purchased from Tombia and Swale markets fell within the range of the daily reference intake values for both women and men while those of Opolo and Azikoro markets were below the daily reference intake values for both women and men (Table 7). The significantly high levels of Cd observed in Abacha purchased from Tombia and Swale markets could be reported illegal activities around the market environment as reported by the government of Bayelsa State**.**

The mean Hg concentration in Abacha bought from Swale market was highest next to it was Tombia market, Azikoro market while the least was Opolo market (Table 7). The mean Hg levels in Abacha bought from Opolo and Azikoro markets were lower than the daily reference intake for both women and men while those of Tombia and Swale markets were within the range of the reference daily intake values for both women and men (Table 7). The significantly increased Hg levels observed in Abacha purchased from Tombia and Swale markets when compared to those of Opolo and Azikoro markets could be attributed the illegal activities stated above.

Table 8 shows the mean heavy metal concentrations in Abacha purchased from selected markets in Yenagoa City for week Four. The mean Pb level in Abacha was noticed to be highest in Tombia market followed by Swale market, Opolo market while the least was Azikoro market (Table 8). The Pb concentration in Abacha purchased from Opolo and Azikoro markets were lower the reference daily intake values for both women and men. The Pb level in Abacha bought from Tombia and Swale markets were within the range of the reference intake for both women and men (Table 8). However, daily intake of Abacha purchased from the selected markets may pose threat to the general populace who patronize such locally processed cassava product. Also, the mean Cr level in Abacha purchased from Swale market was highest next to it was Tombia market, Opolo market while the least was zikoro markets. The mean Cr levels in Abacha obtained from Swale and Tombia markets were within the range of the reference daily intake values for both women and men while those of Opolo and Azikoro markets were below the reference daily intake values for both women and men (Table 8).

More so, the mean Cd level in Abacha obtained from Swale market was highest followed by Tombia market, Azikoro market while the least was Opolo market. The mean Cd level in Abacha purchased from Tombia and Swale markets fell within the range of the daily reference intake values for both women and men while those of Opolo and Azikoro markets were below the daily reference intake values for both women and men (Table 8). The mean Hg concentration in Abacha bought from Swale market was highest next to it was Tombia market, Opolo market while the least was Azikoro market (Table 8). The mean Hg levels in Abacha bought from Opolo and Azikoro markets were lower than the daily reference intake for both women and men while those of Tombia and Swale markets were within the range of the reference daily intake values for both women and men (Table 8).

The need to evaluate the safety of processed and unprocessed food cannot be overemphasized as the safety of consumers' needs to be protected. According to the National Bureau of Statistics, a staggering 112 million of the Nigerian population live below $1 per day, thus majority of the populace depend on ready-made snacks and cheap food sold in major markets while overlooking safety concerns. Also, locally processed cassava food such as Abacha as is major source energy to the South-South and South-East region of Nigeria. Food materials including locally made Abacha sold within cities are exposed to a wide array of toxic metals from various sources. There is an increasing concern on environmental pollution which has a very significant contribution to food pollution.

The average consumers are unaware of the likely dangers of these heavy metals in the food they consume hence adequate and routine check is needed to ensure consumer safety. In this present study, the Pb, Cr, Cd, and Hg observed in Abacha obtained from Tombia and Swali markets fell within the range of the reference daily intake values for both women and men, hence consumption of Abacha for a long period of time may not pose health risk to the population of persons who consume it.

5. CONCLUSION

The locally processed cassava food (Abacha) showed more comparable results with each other based on the analyzed nutritional composition implying that the various methods of processing and genotypic nature of the raw forms of the cassava samples affected the nutritional contents of the products respectively. The carbohydrate contents of Abacha from week 1-4 were within acceptable ranges except. The Pb, Cr, Cd, and Hg observed in Abacha obtained from Tombia and Swali markets for week 3 and 4 fell within the range of the reference daily intake values for both women and men while those for week 1 and 2 were below the reference daily intake values hence consumption of Abacha for a long period of time may not pose health risk to the population of persons who consume it. Regulatory agencies should carefully monitor the heavy metals levels of locally processed food in circulation from time to time to ascertain and control incidence of heavy metal-induce toxicity.

NOTE

This research displayed the effectiveness of garbage enzyme mixture from fermented organic peel wastes in the decontamination of selected heavy metals in crude oil contaminated soil. This concept should be carefully investigated in the light of current pollutants remediation techniques so that they can be accepted as appropriate bioremediation tools.

References

[1] Idongesit, V. E., Timothy, M. A., Abel, U. A., Teghtegh, F. S., Ekponoudim, J. E., and Dumebi, D. N. 2023. Comparative Analysis on the Proximate Composition of Processed Cassava Products Obtained from January to March, 2023 in Lafia Town, Nigeria. *Chemical Science Journal*, 2-23; 32(4): 50-63

[2] Chandrasekara, A., Kumar, T.J. 2016. Roots and tuber crops as functional foods: a review on phytochemical constituents and their potential health benefits. International Journal of Food Science, 2016: 3631647. doi: 10.1155/2016/3631647

[3] Alamu, E.O., Ntawuruhunga, P., Chibwe, T., Mukuka, I., Chiona, M. 2019. Evaluation of cassava processing and utilization at household level in Zambia. *Food Security*, 11(1): 141-150

[4] Singla, M., Sit, N. 2021. Application of ultrasound in combination with other technologies in food processing: A review. *Ultrasonics Sonochemistry,* 73: 105506

[5] Isabirye, Z. 2021.The distribution and abundance of bondar's nesting whitefly (paraleyrodes bondari) on cassava in busukuma sub county, wakiso district, uganda (Doctoral dissertation, Makerere University).

[6] Ogunyinka, O., Oguntuase, A. 2020. Analysis of cassava production and processing by various groups in support of cassava value chain in the south west of Nigeria. *ISABB Journal of Food and Agricultural Sciences,* 9(1): 11-19

[7] Agiriga, A., Iwe, M. 2016. Optimization of Chemical Properties of Cassava Varieties Harvested at Different Times using Response Surface Methodology. *Am J Adv Food Sci Technol,* 4: 10–21

[8] Burns, A.E., Gleadow, R.M., Zacarias, A.M. 2012. Variations in the chemical composition of cassava (Manihot esculenta Crantz) leaves and roots as affected by genotypic and environmental variation. *J Agric Food Chem,* 60: 4946–4956

[9] Chisenga, S.M., Workneh, T.S., Bultosa, G., Laing, M. 2019. Proximate composition, cyanide contents, and particle size distribution of cassava flour from cassava varieties in Zambia. *AIMS Agriculture & Food,* 4(4)

[10] Okonkwo, C.E., Olaniran, A.F., Adeyi, O., Adeyi, A.J., Ojediran, J.O., Adewumi, A.D., Erinle, O.C. 2021. Drying characteristics of fermented-cooked cassava chips used in the production of complementary food: Mathematical and Gaussian process regression modeling approaches. *Journal of Food Process Engineering,* 44(7): e13715

[11] Nzuta, R.A., Elechi, J.O., Isa, I.S., Kittika'a, H.J., Thomas, C.T. Flour and Cassava (Manihot spp) Cultivars in Nigeria: Understanding their Chemical Functionalities and Acceptability in Food Systems. *Int. J. Sci. Res. in Chemical Sciences,* 9(2)

[12] Peterson, P.J. 1995. Assessment of exposure to chemical contaminants in water and food. *Sci Total Environ,* 168: 123–129

[13] Kwarteng, G. 2012. Environmental Impact of Mining and the Well-being of the People in Akwatia: a Case Study in Akwatia Town, Ghana. Master Thesis, Swedish University of Agricultural Science, Uppsala, Sweden.

[14] Junior, K.J.K., Matsui, K. The impact of environmental degradation by surface mining on sustainable agriculture in Ghana. *Int J Food Nutrition,* 106(1): 5.

[15] Banza, C.L.N., Nawrot, T.S., Haufroid, V., Decree, S., De Putter, T., Smolders, E., Kabyla, B.I., Lubova, O.N., Ilunga, A.N., Mtombo, A.M., Nemery, B. 2009. High human exposure to cobalt and other metals in Katanga, a mining area of the democratic republic of Congo. *Environ Res Lett,* 109: 745–752.

[16] Shams, M., Nezhad, T.N., Dehghan, A., Alidadi, H., Paydar, M., Mohammadi, A.A., Ahmad, Z. 2020. Heavy metals exposure, carcinogenic and non-carcinogenic human health risks assessment of groundwater around mines in Joghatai, Iran. *Int J Environ Anal Chem,* 100: 1–16

[17] Association of Analytical Chemistry (AOAC). Official Methods of Analysis of AOAC international. Gaithersburg, Maryland, USA: 19th edition, AOAC International.

[18] Kenneth, V.A.R. 2012. Evaluation of three cassava varieties for tuber quality and yield. Gladstone Road Agricultural Centrecrop Research Report, 4.

[19] Nuwamanya, E., Baguma, Y., Rubaihayo, P. 2010. Physicochemical and functional characteristics of cassava starch in Ugandan varieties and their progenies. *J Plant Breed Crop Sci*, 2: 001–011

[20] Manano, J., Ogwok, P., Byarugaba-Bazirake, G.W. 2017. Chemical composition of major cassava varieties in Uganda, targeted for industrialisation. *J Food Res*, 7: 1

[21] Burns, A.E., Gleadow, R.M., Zacarias, A.M. Variations in the chemical composition of cassava (*Manihot esculenta* Crantz) leaves and roots as affected by genotypic and environmental variation. *J Agric Food Chem*, 60: 4946–4956

[22] Gregory, N.N., Emmanuel, O. A., Rasaki, A. S., and Busie, M-D. 2023. Evaluation of improved cassava (Manihot esculenta Crantz) varieties and associated products for proximate, cyanogenic potential and glycemic indices. *CyTA Journal of Food* 11: 20-30

[23] Pirasath, S., Balakumar, B., & Arasaratnam, V. 2015. Glycaemic index of Sri Lankan meals. *Journal of Blood Disorders*, 6(254): 1–6

[24] Emmanuel, O. A., Clement, A., Agnes, S. B., Chiwona-Karltun, L., & Drinah, B. N. 2012. Chemical composition and cyanogenic potential of traditional and high yielding CMD resistant cassava (Manihot esculenta Crantz) varieties. *International Food Research Journal*, 19(1), 175–181

[25] Onyenwoke, C. A., & Simonyan, K. J. 2014. Cassava post-harvest processing and storage in Nigeria: A review. *African Journal of Agricultural Research*, 9(53): 3853–3863.

[26] Sulistyo, J., Shya, L. J., Mamat, H., & Wahab, N. A. 2016. Nutritional value of fortified cassava flour prepared from modified cassava flour and fermented protein hydrolysates. AIP Publishing LLC.

[27] Fabrice, T. Djikeng., Cecile, M. M. N., Eric, S.N., Bernard, T., Stephano, T. T., Aduni, U. A., Hilaire, M. W. 2022. Effect of different processing methods on the proximate composition, mineral content and functional properties of snail (Archachatina marginata) meat. *Journal of Agriculture and Food Research*, 8: 100298

[28] Wodaje, A. T. Assessment of some heavy metals concentration in selected cereals collected from local markets of Ambo city, Ethiopia. *Journal of Cerels and Oilseeds*, 6(2): 8-12

[29] Duruibe, J.O., Ogwuebu, M.O.C., Egwurugwu, J.N. Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, 2(5): 112-118

[30] Iniebiyo F., Atieme, J. O. 2018. Assessment of heavy metals concentration in selected foods sold in markets within port-Harcourt city, Nigeria. *Open Access Journal of Science*, 2(4): 233-236

[31] Galadima, A., Garba, Z.N. 2012. Heavy metals pollution in Nigeria:causes and consequences. *Elixir Pollution*, 45: 7917-7922