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Analysis of Cyanide and Essential Mineral Contents in Raw and Processed Cassava from Minna, Nigeria

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Authors' contributions

This work was carried out in collaboration between authors AIA, YBP, JOJ, MMN and JD. While author AIA designed the study and wrote the protocol and the first draft. Author YBP performed the statistical analysis. Authors JOJ and MMN managed the analysis of the study and author JD managed the literature search. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the cyanide and mineral content of raw cassava, white and yellow processed cassava obtained from cassava processing centre located at Gwadabe area of Minna, Niger state. The cyanide content was analysed using the alkaline picrate method while the minerals were analysed using atomic absorption spectrophotometer. The result obtained for the cyanide content ranged from 3.86- 6.84 mg/kg with the raw cassava having the highest cyanide concentration (6.84 mg/kg) and yellow processed cassava, the least (3.86 mg/kg). These values were below the WHO permissible limit of 10 mg/kg cyanide. The result of mineral analysis in the cassava samples ranged 26.6 – 40.96 mg/100 g Ca, 4.15 – 5.14 mg/100 g Cu, 4.30 – 11.50 mg/100 g Mg, 11.92 – 25.53 mg/100 g K, 19.98 – 29.90 mg/100 g Na, 4.34 – 6.10 mg/100 g Fe, 3.93 – 5.10 mg/100 g Mn and 1.94 – 3.18 mg/100 g Zn respectively. Generally, the value obtained was within the permissible level that will not be toxic to health.

Keywords: Minerals; cassava; processed; cyanide; permissible; analyzed; spectrophotometer.

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1. INTRODUCTION

Cassava (*Manihot esculenta crantz)* is a significant root crop in Africa, South America, Asia and India, which provides energy to about 500 million people [1,2]. In the last 35 years, there has been stable increase in the worldwide cassava production. Thus, world production has double [3]. The production of cassava for human consumption has been approximated to be 65% of cassava products, while 25% is for industrial use, mostly as starch (6%) or animal feed (19%) and 10% lost as waste [4,5].

Cassava roots contain 20-25% starch and low amounts of proteins, fats, vitamins and minerals. Substantial quantity of anti-nutrient factor cyanogenic glucoside, linamarine and a small amount of lotaustralin are also present in cassava which interferes with digestion and uptake of nutrients [6]. Additionally, the roots contain considerable quantities of the anti nutrient factor Such as cyanide. Cyanide occurs in two form in cassava; cyanogenic glycosides, linamarin and lotaustralin [7].

The linamarin and lotaustralin undergo a sequential enzymatic breakdown yielding toxic free cyanide. The sum of these two forms is called Cyanogenic glycosides. Cyanogenic glycosides act as effective defense agents against generalist herbivores [8], including humans. Cassava can be consumed either boiled or in a variety of processed forms depending on local customs and preferences and are known by different names. Cassava can be processed into different forms and act as the cheapest source of staple food in Africa and Nigeria in particular. Nigeria consumes nearly all that she produces, regardless of the high level of cassava production [9]. In Nigeria, cassava root tubers are processed in several ways that vary from region to region, leading to many different products like gari, fufu, lafun, flour, etc. Processing steps of cassava include soaking, fermentation, cooking, steaming and chipping, frying, drying and roasting.

Cyanide toxicity in cassava and its effect in human is well documented [10]. Cyanogens content in cassava tubers widely varies, depending on species, nature of soil in which it is cultivated and processing method. Processing cassava into dry form helps to reduce the high moisture content, makes it more transportable, reduces volume, ensures stability, reduces the level of cyanide content, makes it more palatable and increase the quality of products. Bradbury [11] proposed that processing is the suitable strategy to reduce cyanide in cassava products. The cyanogenic glycoside levels of cassava can be reduced to acceptable levels that would not cause hazard to the consumer when the cassava roots are processed adequately [12].

Most varieties contain 10 to more than 500mg HCN per kg fresh weight [13]. Cassava products are considered harmless at cyanide levels of less than 50 mg/kg. In whatever way, chronic toxicity results when cassava is consumed over a long period of time [14]. Inadequately processed cassava tubers are associated with several diseases such as tropic ataxic, neuropathy, endemic goiter, spastic paraparesis and konzo. Sub lethal doses of cyanogenic compounds are usually detoxified by the body to the low metabolite thiocyanate, which is excreted in the urine. A chronic overload of thiocyanate in conjunction with low iodine intake leads to goiter and cretinism in children [10].

Processing cassava tubers with different methods have one common goal, to have a safe food by reducing cyanogenic compounds. The methods help in the releasing of hydrogen cyanide (HCN) by allowing the enzyme linamarase to interact with the cyanogenic compounds. Then hydrogen cyanide either dissolves in water or escapes into the atmosphere.

The determination of mineral and cyanogens content of cassava products is fundamental to the theoretical and applied investigation in food science and technology. The concentration of the hydrocyanic acid that is safe for human body is small and the lists of mineral elements which are of good use to the body are in trace amount. Therefore, based on the high dependent on cassava products by the citizen, this study is sought to investigate the mineral and cyanide content in raw, white and yellow processed cassava.

2. SAMPLE COLLECTION / PRETREATMENT

Raw cassava, white and yellow processed cassava samples were obtained from cassava processing center located at Gwadabe market in Minna, Niger State for the analysis. Raw cassava was peeled, washed and then dried in a room temperature. The dried samples were grounded into powder using pestle and mortal and stored for further analysis.

2.1 Determination of Cyanide Content

The cyanide level of white, yellow processed cassava and raw cassava was determined using the alkaline picrate method as reported by Onwuka [15]. This method involved weighing 5g of the sample and dissolving it in 50 cm^3 distilled water and allowing it to stay overnight. This was then filtered and the filtrate was used for the cyanide determination. 1 cm^3 of the aqueous extract was then measured and poured into a test tube, and then 4 cm^3 of alkaline picrate was added and incubated in a water bath for 5 to 10 minutes. After the formation of a dark red color the absorbance value was read using a UV-Visible spectrophotometer at 490 nm against a reagent blank containing 4 cm^3 of alkaline picrate solution and 1 cm^3 of distilled water. A series of serial dilutions were made from potassium cyanide (KCN) by dissolving 50 mg of KCN in 100 cm^3 distilled water in a 500 cm^3 conical flask, followed by the addition of 25 cm^3 of 1M HCl. Then 0.1, 0.2, 0.3, 0.4 and 0.5 cm^3 of the solution were pipette and placed into test tubes. The resulting solution was further diluted with 10 cm^3 of distilled water to give a final concentration of 0.01, 0.02, 0.03, 0.04 and 0.05 ug/ cm^3 and the cyanide content of the samples was extrapolated from the standard. The cyanide content was calculated from the equation: Y = 4.3 + 0.215 x 10 where 4.3 = slope of the graph, 0.215 = intercept and 10 = dilution factor.

2.2 Determination of Mineral Content

1 g of dried samples was weigh and placed in 100 cm^3 beaker and then digested with HNO_3 and $HClO_4$ in a 3:1 ratio in a hot plate until a transparent solution was obtained [9]. The digests were filtered and diluted to 100 cm^3 with distilled water and stored for AAS analysis.

Atomic Absorption Spectrophotometer (Shimadzu AA650) was used to determine mineral elements concentration while Flame Photometer (Varian AA240FS)) was used to determine potassium, sodium and calcium after digestion.

3. RESULTS AND DISCUSSION

The hydrogen cyanide content in the raw cassava, white and yellow processed cassava samples determined are shown in Table 1. The result showed that the cyanide content ranged from 3.86 to 6.84 mg/kg with the raw sample having the highest concentration of 6.84 mg/kg while the yellow processed cassava had the lowest concentration. The raw sample value was within the permissible limit recommended by FAO/WHO of 10 mg/kg [16]. The hydrogen cyanide concentration of white and yellow processed cassava samples were 4.47 and 3.86 mg/kg respectively and were within the permissible level recommended by FAO/WHO of 10 mg/kg for cassava [16]. The low cyanide content in yellow processed cassava compared to the raw and white processed samples can be attributed to the application of palm oil which helps to deplete the cyanide content. Onabolu et al. [17] reported that there is loss of cyanohydrin and linamarin in cassava during short-term storage and when cassava is made into eba which reduces dietary cyanide load in consumers. The low level of HCN in white and yellow processed cassava samples signifies that proper fermentation took place during processing, thus has no health risk and good for consumption.

Table 1. Cyanide content of different cassava samples (mg/kg)

Samples	Total cyanide content
Raw cassava	$6.84{\pm}0.13^c$
White processed cassava	$4.47{\pm}0.11^b$
Yellow processed cassava	$3.86{\pm}0.09^a$

Values are mean of duplicate determinations and means with different superscripts across the rows are significantly different from each other at P<0.05, while those with same superscripts, a or b or c across rows are not significantly different from each other at P< 0.05

The concentrations of minerals in different cassava samples analyzed are presented in Table 2. Calcium content ranged from 26.66 to 40.96 mg/100 g with raw cassava being the highest and white processed cassava, the lowest. The concentration of Ca obtained from the raw cassava sample in this study was higher than that reported by Buitrago of 10 mg/100 g fresh weight [18] and 20 mg/100 g fresh weight as reported by Bradbury and Holloway [19]. Also, the value of raw sample was higher compare to the value obtained by Adepoju et al. of 25 mg/100 g [20]. The values obtained for white and yellow processed cassava (26.66 and 31.64 mg/100 g) were a little bit higher than the reported value of 21.8 mg/100 g by Adepoju et al. [20]. Calcium plays a major role in the increase of the cell membrane permeability and in the transmission of nerve impulses. 800 g of calcium is recommended per day for an adult person [21].

Magnesium ranged from 4.30 to 11.50 mg/100 g with raw cassava being the highest. However, all the samples were not significantly different ($p>0.05$) in their Mg contents except for raw cassava. Raw sample values obtained for magnesium content was lower as compared to reported value of 30 mg/100 g per fresh weight [18] and 43 mg/100 g per dry weight [22], but agrees with that obtained by Adepoju et al. [20] of 12.5 mg/100 g. Magnesium content in cassava and fermentable foods reduces with fermentation period [23]. The value of white and yellow processed cassava was lower than the reported value of 13.7 mg/100 g [20]. The recommended dietary allowance (RDA) per day for magnesium is 240 mg.

Potassium (K) ranged from 11.92 to 25.53 mg/100 g with yellow processed cassava being the highest while white processed cassava was lowest. The result showed that all the samples were not significantly different ($p<0.05$) in their K content except for yellow processed cassava. The results of white and yellow processed cassava are not in consonant with the reported value of 309.4 mg/100 g [20]. The result obtained from the raw sample was lower than that reported by Charles et al. [22] of 324 to 554 mg /100 g per dry weight. The recommended dietary allowance (RDA) per day for potassium is 4500 mg.

Sodium ranged from 19.9 to 29.9 mg/100 g with yellow processed cassava being highest. The samples were not significantly different at $p<0.05$ except for yellow processed cassava. The daily sodium dietary requirement per adult is 1500 mg. The sodium content obtained for raw cassava of 20.06 mg/100 g was higher than that reported by of 7.6 mg/100 g fresh weight [18] and lower than 50 mg/100 g as reported by Charles et al. [22]. The value of white and yellow processed cassava was lower when compared to that reported of 309.4 mg/100 g [20].

Cu ranged from 4.15 to 5.14 mg/100 g with white and yellow processed cassava samples not significantly different. The Cu content of white and yellow processed cassava was higher when compared with that obtained by of 0.06 mg/100 g [24]. The iron content ranged from 4.34 to 6.10 mg/100 g, with the raw cassava having higher concentration of (6.10 mg/100 g) which is still lower than that reported of between 29 to 40 mg/100 g [22], but higher than that reported by Okigbo of 0.7 mg/100 g [25] and 1.7 mg/100 g by Buitrago [18]. Iron is required due to its role in the synthesis of hemoglobin and myoglobin, which are oxygen carriers in the blood and muscle. The daily requirement for men and non-menstruating and pregnant women is 18 mg/100 g [21].

Manganese values ranged from 3.93 to 5.10 mg/100 g. All the samples showed significant differences at $p<0.05$. Charles et al. [22] reported 0.31 to 3.54 mg/100 g for cassava flours, while Buitrago reported 0.3 mg/100 g for Mn content of cassava root tubers [18]. 1.9 mg/day is recommended for adequate intake of manganese.

Zinc content ranged from 1.94 to 3.18 mg/100g. All samples were significantly different at $p < 0.05$. The reported value of Zn of 2.1 mg/100 g for raw cassava was higher compare to the obtained value of 1.94 mg/100 g [20]. The value of white and yellow processed cassava obtained in this study agreed with the reported value of 3.2 mg/100 g [20] and 2.72 mg/100 g [24]. The recommended dietary allowance (RDA) per day for Zn is 8mg. Buitrago reported 1.4 mg/100 g for Zn in cassava root tubers [18]. Charles et al. [22] also reported 13 to 19 mg/100 g for Zn from

Table 2. Mineral composition of different cassava samples (mg/100 g)

Minerals	Raw cassava	White cassava	Yellow cassava
Ca	40.96 ± 0.99^{c}	26.66 ± 1.03^{a}	31.64 ± 0.73^{b}
Mg	11.50 ± 0.11^{b}	4.30 ± 0.06^{a}	4.60 ± 0.12^{a}
K	11.96 ± 0.06^{a}	11.92 ± 0.11^{a}	25.53 ± 0.67^{b}
Na	20.06 ± 0.09^{a}	19.98 ± 0.03^{a}	29.90 ± 0.19^{b}
Cu	4.15 ± 0.01^{a}	5.13 ± 0.004^{b}	5.14 ± 0.006^{b}
Fe	6.10 ± 0.03^{c}	4.34 ± 0.03^{a}	4.61 ± 0.03^{b}
Mn	5.10 ± 0.007^{c}	3.93 ± 0.01^{a}	4.73 ± 0.01^{b}
Zn	1.94 ± 0.005^{a}	3.18 ± 0.01^{c}	2.67 ± 0.01^{b}

Values are mean of duplicate determinations and means with different superscripts across the rows are significantly different from each other at P<0.05, while those with same superscripts, a or b or c across rows are not significantly different from each other at P< 0.05 cassava flours. From Table 2, the concentration of metals in raw cassava is higher than those of processed white and yellow cassava because some of the metal ions in the white and red cassava may have been lost during the course of processing while the raw cassava was not processed. Similar trend can also be observed from Table 1 with the cyanide content being higher in the raw cassava compared to processed white and red cassava. It is therefore recommended that cassava should be well processed in order to reduce its cyanide content but care should be taken to ensure that the essential metals ions that are necessary for vital body metabolism are not lost in the process. Thus, processing of cassava in one way or the other increases or reduces the amount of minerals in the cassava samples. Generally, the minerals analyzed in the samples are within the limit that will not be toxic to health and hence making the products suitable for consumption.

4. CONCLUSION

The hydrogen cyanide concentration of white and yellow processed cassava obtained from cassava processing centre in Gwadabe area of Minna, Niger State were within permissive level that will not be deleterious to health as recommended by FAO/WHO (1991). The samples studied also contain some minerals that could be essential for growth and development. These minerals though present in small quantity could still play their vital roles in the body metabolic activities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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