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Proximate Analysis, Hydrogen Cyanide and Some Essential Mineral Content of Sweet Cassava Variety (*Manihot utilisima*) and Bitter Cassava Variety (*Manihot palmata*) Cultivated in Kachia Local Government Area of Kaduna State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author OBI designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the literature searches. Authors JMN and CIA managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the proximate composition and the hydrogen cyanide content of two different cassava species, bitter cassava and sweet cassava species *(Manihot esculenta Crantz)* harvested from Kachia Local Government Area of Kaduna State, Nigeria. The proximate composition analysis were determined using standard methods and the hydrogen cyanide content of the cassava samples were determined using fermentation and titration methods. The mean result of proximate analysis of both species showed that the fresh samples of sweet cassava variety had chloride content value of 0.0024±0.0002 mg/L, ash content: 0.87±0.44%, moisture content: 41.05±2.26%, dry matter: 58.9±0.14% and fat content: 0.57±0.42%. The bitter cassava variety had chloride content value of 0.0028±0.0000 mg/L, ash content: 0.94±0.06%, moisture content: 38.2±2.69%, dry matter: 61.7±2.69% and fat content: 0.49±0.42%. These values were within the Food and

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Agricultural Organization and World Health Organization (FAO/WHO) standards for proximate composition in cassava except for the high moisture content of both species which was above the permissible limit. The mean total HCN content in bitter cassava was 89.60 mg/Kg, while the sweet cassava had an HCN content value of 80.60 mg/Kg. The yeast fermentation procedures was employed and the mean extracted hydrogen cyanide content obtained was as follows: 69.33±2.80 HCN mg/Kg for the sweet cassava and 85.33±4.61 HCN mg/Kg content in the bitter cassava species; the remaining free HCN in both cassava varieties were within recommended consumption limit. The mineral concentration in both cassava varieties were however lower than the recommended mineral values as stated by *United States Department of Agriculture* USDA, 2016.

Keywords: Cassava; mineral concentration; hydrogen cyanide; proximate analysis.

1. INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions [1]. Latest statistics show that Nigeria is amongst the world largest producer of cassava roots with an annual production of about 45 million metric tonnes [2]. This quick spread of cassava development was because of its simplicity of cultivation and minimal effort of production in cost. It develops on poor and ineffectively prepared soils, it can stand extreme drought and insects attack, and the roots can remain underground for a considerable length of time without deterioration, even after its leaves have fallen [3]. It is rich in carbohydrates, calcium, vitamin B and C and essential minerals. However, nutrient composition differs according to variety, age of the harvested crop, soil conditions, climate and other environmental conditions during cultivation [4]. Besides satisfying the dietary needs of the greater part of the population of Nigeria, there is a huge demand for the roots as raw material for the manufacture of live stock feed, bio fuel, pharmaceutical and textile industries [5].

Cassava cultivars can be classified into two major types, which are the bitter and sweet variety [6]. Sweet cassava roots contain less than 50 mg per kg HCN on fresh weight basis, whereas that of bitter variety may contain up to 400 mg per kg HCN [7]. However, the rate of cyanide in the cassava roots can be reduced with different processing and fermentation methods [8,9]. Hydrocyanic or prussic acid (HCN) is produced in cassava, when two major cyanogenic glucosides (linamarin and lotaustralin) are hydrolysed and the acid released when the cassava roots is ruptured [10]. Therefore making it very toxic for consumers to eat the cassava root and leaves raw [11]. Several cases of cassava poisoning have been recorded in Nigeria, all resulting to improper fermentation and processing of cassava [12].

[13] Reported that workers exposed to HCN for more than 5 years showed an increase in symptoms such as headache, weakness, changes in taste and smell, irritation of throat, vomiting, lacrimation, abdominal colic, pericardial pain and nervous instability. Acute intoxication, with symptoms of dizziness, nausea, diarrhoea and sometimes death were observed in humans as a result of poor processing cassava products [14,15] reported that an increase in the triglyceride and Atherogenic index of plasma (AIP) in the blood of cassava workers.While it was reported that tropical ataxic neuropathy (TAN) or similar degenerative neuropathies that causes poor vision occur in Nigeria mainly amongst older people who have consumed cyanide mainly from garri over a long period of years [16,17].

Kaduna State in the North West region of Nigeria produces 2 million tonnes of cassava a year, which is comparable in output to many of the states in the southern regions which produce less than 6 million tonnes of cassava [18]. With increasing farming activities in the cultivation of cassava in Kaduna State, more interest should be employed on the quality of the cassava products grown in the soils. Kachia Local Government in Kaduna state is home to large cassava, ginger and maize cultivation [19]. This study was to evaluate the proximate analysis and the use of yeasts fermentation process to reduce the amount of HCN content in the sweet and bitter cassava variety grown on Kachia soil.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Cassava tubers (Sweet and Bitter) *(Mannihot esculenta Crantz)* were collected from farmlands located in Kachia Local Government Area of Kaduna State Nigeria. The cassava samples were mixed together and representative samples were picked at random. The two species sweet and biter cassava were clean with water and rinsed with distilled water to avoid surface contamination, peeled and stored in a plastic container for fermentation, mineral content analysis and proximate content respectively. Analyses on the cassava samples were prepared in duplicate for proximate content, mineral concentrations and triplicate for fermentation and hydrogen cyanide content determination [20].

2.2 Sample Methods of Analysis

2.2.1 Proximate analysis

2.2.1.1 Moisture/Dry matter

The sliced cassava samples of 2 g were accurately weighed into pre-labelled, pre-weighed beaker and transferred to vacuum dry oven to dry at a temperature of 130°C. The samples were heated within a time range of 1 hr, 1 hr -30 min, 2 hrs, 2 hrs -30 min, 3 hrs respectively and weighed till a constant Weight was achieved. All sampling and analysis were done in duplicate [21]. The formula used for the calculation of moisture content and dry matter can be seen below:

$$sampleweight - moisturecontent = drymatter$$

$$\% = \frac{drymatter}{weightofsample} \times 100$$

2.2.1.2 Ash

Prepared samples were weighed into pre-weighed, porcelain crucibles. The samples were transferred to a muffle furnace and ash at 550°C for 8 hours. The crucibles were allowed to cool in desiccators and then weighed [21]. The formula used for the calculation of ash content can be seen below:

$$\% = \frac{WtofAsh}{weightofsample} \times 100$$

2.2.1.3 Fat

The fat content sample was determine by dissolving 8 g of the cassava sample in a 200 cm^3 beaker containing 8.4 cm^3 of hydrochloride acid and heated in a water bath for 1 h after heating the sample solution were allowed to cool and extracted with petroleum ether in a separating funnel. After extraction, the sample solution was then heated to dryness and the weight collected after cooling [21]. The formula used for the calculation of fat content can be seen below:

$$\% fat = \frac{weightlossofsample\ (Extract)}{weightofsample} \times 100$$

2.2.1.4 Chloride

The ash of the cassava samples weighing 0.064 g was dissolved in a 250 cm^3 beakers with 50 cm^3 of 0.1 M silver nitrate ($AgNO_3$) and 20 cm^3 HNO_3 was added into the wet ash. The mixture was transferred to conical flask and titrated with 0.1 M KSCN, and 0.1 M $FeNH_4(SO_4)_2$ were used as indicator. The appearance of brown reddish precipitate marked the end point which was noted. All sampling and analysis were done in duplicate. The chloride concentration (mg/L) was thus calculated [21].

2.2.2 Determination of mineral content (Ca, Fe, Mg, k, Na)

Cassava samples of 2 g was washed and transferred into a 250 cm^3 beaker containing 5cm^3 of aqua and heated for 10 minutes. After digestion, the sample solution was allowed to cool, then filtered and transferred into a 100 cm^3 volumetric flasks. The solution was made up to the mark with deionised water and transferred to a 100 cm^3 sterile plastic container which was then carried to the Atomic Absorption Spectrophotometer for determination of hydrogen cyanide content and Flame Emission Spectrophotometer for determination of mineral concentration [21].

2.2.3 Method of fermentation

2.2.3.1 Procedure: fermentation of samples using baker's yeast

The sample was washed with tap water and after with distilled water respectively. The technique employed involved the addition of 0.5 g of hydrated bakes yeast was cultured into a volumetric flask containing 200 cm^3 of distilled water. Thereafter the fermented yeast was transferred to already weigh 20 g of the sample

and the retting time was 60 hours. The mixture was then filtered using filter paper and the filtrate was analyzed using UV- Spectroscopy analysis. All sampling and analysis was done in duplicate [22].

2.2.4 Preparation of calibration stock solution

This was prepared by dissolving 69 gK_2CO_3 0.5 M in a 100 cm^3 beaker and transferred to 500 cm^3 volumetric flask and made up to the mark with distilled water. standard solution KCN 0.1 M of 0.25 g of potassium cyanide was added to 10 cm^3 of 0.5 M K_2CO_3 solution in a beaker, transferred to a 100 cm^3 volumetric flask and made up to the mark with distilled water. Working standards of concentration 2, 4, 6, 8 and 10 part per million (ppm) were prepared by serial dilution and taken to the UV-spectrophotometer. The calibration curve for the cyanide determination was obtained by plotting absorbance against concentration of the standard cyanide solutions. Then the graph factor obtained from the plot was then used for the calculation of the cyanide content in the cassava samples [23].

2.2.5 Determination of total cyanide content in cassava samples using titrimetric distillation method

Twenty (20) grams of the cassava sample (bitter and sweet cassava) was weighted and transferred into a 1000 cm^3 beaker containing 100 cm^3 of distilled water, 200 cm^3 of phosphate buffer (pH 6.0) and 10 cm^3 of 2% mercuric chloride solution and left overnight. The sample was then transferred to 500 cm^3 round bottom flask and 5.0 g of hydrated stannous chloride was added to the sample and steam distillation method was used to separate the hydrocyanic acid from the prepared sample. After the mixture was heated by steam distillation, the released hydrogen cyanide was collected in a conical flask containing 50 cm^3 of 1% Alcoholic sodium hydroxyl (NaOH) solution until the volume of the distillate was 200 cm^3. The distillate was then titrated against 0.02 M $AgNO_3$ using 1 cm^3 of freshly prepared 0.5% w/v dithizone in ethanol as indicator and the amount of cyanide in the sample was determined. The end point of the titration was accommodated with a colour change of the indicator from red to purple [24,25].

Chemical equation of the reaction:

$$HCN_{(aq)} + AgNO_{3_{(aq)}} \rightarrow HNO_{3_{(aq)}} + AgCN_{(aq)}$$

1 ml of 0.02 m $AgNO_3$=0.5 $mgCN^-$

$$Concentration of CN^- = \frac{Titre value \times 0.52 \times 1000}{Weight of the sample taken}$$

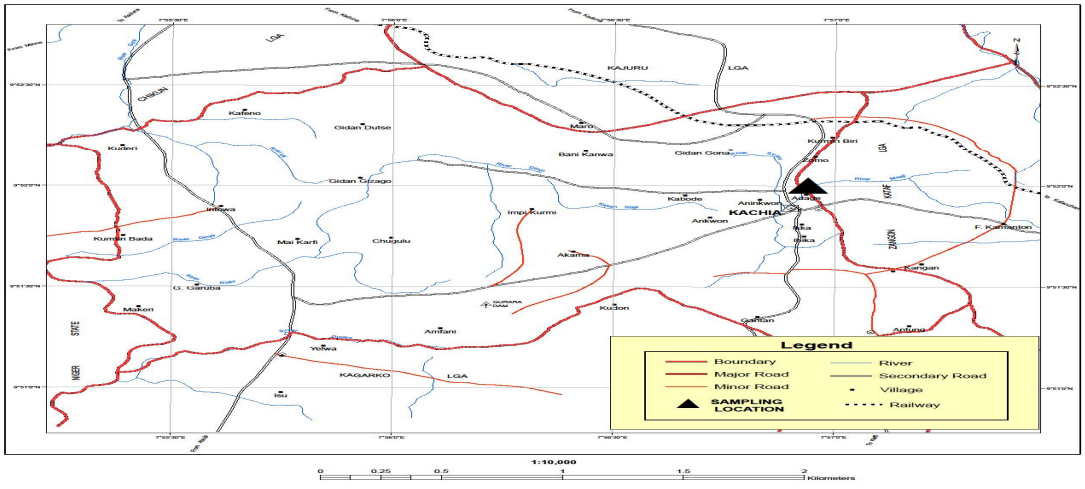

Fig. 1. Map of Kachia local government area showing sampling location (Source: Nigerian Defence Academy (NDA) Geography Department, Kaduna State)

3. RESULTS AND DISCUSSION

The following results displayed in the Tables 1–4 were obtained as a result of the analysis done on the determination of the proximate analysis on the cassava samples, their hydrogen cyanide content and mineral concentrations.

3.1 Discussion

3.1.1 Proximate analysis

3.1.1.1 Chloride content

The bitter cassava variety had higher chloride content than the sweet cassava variety as harvested in Kachia LGA, Kaduna State. The values as shown in Table 1 were within the WHO/FAO permissible limits. Several researchers have reviewed chloride content to be higher than the reported values. As such as seen in [26] reported a chloride content values ranging from 46.8± 14.8 - 48.8±27.3 mg/L with some cassava varieties having no chloride content in them. [27] reported a zero presence of chloride content in cassava samples analysed in Ebonyi State, Nigeria. [28] stated that chloride is acidic and when taken in high concentration can alter the acid-base load of the body and obviously manifest as net acid load, if the diet source does not provide enough basic cations (K, Ca and Mg) to balance it. [29] stated that chloride plays a major role in plants as they are required for water-splitting step of photosynthesis, functions in water balance, role in root, shoot growth, plays a role in photolysis and deficiency of them leads to wilting, chlorosis, death of some plants leaves.

Table 1. The proximate analysis results of the cassava samples

Cassava sample varieties	Chloride content (mg/L)	Ash content (%)	Moisture content (%)	Dry matter (%)	Fat content (%)
Kachia bitter cassava sample 1	0.0028	1.02	40.10	59.80	0.78
Kachia bitter cassava sample 2	0.0028	0.93	36.30	63.60	0.20
Mean Result	0.0028±0.0000	0.94±0.06	38.20±2.69	61.7±2.69	0.49±0.42
Kachia sweet cassava sample 1	0.0022	1.18	41.20	58.80	0.86
Kachia sweet cassava sample 2	0.0025	0.55	42.80	59.00	0.27
Mean Result	0.0024±0.0002	0.87±0.44	41.05±2.26	58.9±0.14	0.57±0.42
Permissible limit FAO/WHO	250mg/L	3.0%	13%		

Table 2. Extracted HCN (mg/Kg) content in the yeast fermented cassava samples (Triplicate analysis)

Treatment	Kachia sweet cassava (mg/Kg)	Kachia bitter cassava (mg/Kg)
Cassava sample 1	66.00	88.00
Cassava sample 2	71.00	80.00
Cassava sample 3	71.00	88.00
Mean Results	69.33	85.33
WHO/FAO Permissible limit	10 mg/Kg HCN	

Note: KCS: Kachia Sweet Cassava Variety; KCB: Kachia Bitter Cassava Variety

Table 3. Result of HCN content, free cyanide content, total cyanide content and permissible limits

Cassava sample varieties	Total cyanide content (mg/Kg)	Extracted HCN content (mg/Kg)	Free cyanide (mg/Kg)	Permissible limit (mg/Kg)	Above / below limits
Kachia sweet cassava sample 1	80.60	66.00	14.60	10.00	BPL
Kachia sweet cassava sample 2	80.60	71.00	9.60	10.00	BPL
Kachia sweet cassava sample 3	80.60	71.00	9.60	10.00	BPL
Kachia bitter cassava sample 1	89.60	88.00	1.60	10.00	BPL
Kachia bitter cassava sample 2	89.60	80.00	9.60	10.00	BPL
Kachia bitter cassava sample 3	89.60	88.00	1.60	10.00	BPL

Note: APL: Above Permissible Limit, BPL: Below Permissible Limit

Table 4. The mineral concentration results of the cassava samples

Cassava sample varieties	Calcium (mg/L)	Potassium (mg/L)	Iron (mg/L)	Sodium (mg/L)	Magnesium (mg/L)
Kachia bitter cassava sample	42.5	39.04	2.25	31.59	27.47
Kachia sweet cassava sample	32.5	34.57	4.00	32.52	34.37
USDA Recommended Value (mg/100 g)	16	271	0.27	14	21

3.1.1.2 Ash content

It was observed that the bitter cassava variety had a higher ash content percentage value of 0.94±0.06% than the sweet cassava variety which had a value of 0.87±0.06%. These values were however within the recommended limits as shown in Table 1. However, the percentage ash content values were lower than some reviewed literature studies in Nigeria, as [11] reported an ash content in six cassava cultivars in Ghana ranging from 1.71±0.32% – 2.34± 0.15%. [30] reported an ash content value ranging from 1.44±0.52 – 2.35±0.35% from 6 yellow and white cassava variety cultivated in Umudike, Abia State, Nigeria. Ash content represents the total mineral content in food after it has been burned at a very high temperature. The variance in the ash content values of the cassava in study and the reviewed cassava could be as a result of environmental factors and location of harvesting.

3.1.1.3 Moisture content

The sweet cassava variety had a moisture content value of 41.05 ±2.26%, which was higher than the bitter cassava variety which had a value of 38.20±2.69%. These values were however higher than the recommended moisture content limits as shown in Table 1. The consequence of having higher moisture content is that the cassava samples can't be stored for a long

period of time. [31] reported a higher moisture content value of 71.53% and 72.07% for sweet and bitter cassava cultivated in Abia State, Nigeria. [32] reported an ash content value of 52.70±0.52% for cassava flesh and 58.88±0.25% for cassava peel in a CARI-555 cassava variety in Gannoruwa, Sri-Lanka. These variations in moisture content values as shown above could be as a result of cassava variety, locations of planting and time of harvesting.

3.1.1.4 Dry matter

The bitter cassava variety had high dry matter content value of 61.7±2.69% as compared to the sweet cassava variety, which had a value of 58.9±0.14%. These values are very good as Nigerian cassava have been reported to have higher dry matter percentage in cassava varieties. [33] reported a dry matter value of 92.50% for cassava roots and 90.90% for cassava leaves which is been used for livestock feeds. Dry matter determination in different genotypes of cassava is important since nutrition and energy calculation is based on magnitude and nature of dry matter content. Higher dry matter content naturally would provide greater yield [34].

3.1.1.5 Fat

The bitter cassava variety had high fat content with a value of 0.31±0.02%, while the sweet cassava variety had a value of 0.25±0.05%. These values were within the recommended limit for fat as shown in Table 1. The low fat content however corresponds with [35] value of 0.42% for fresh cassava peels. [36] reported percentage fat content of 1.2% and [31] also reported a similar low fat content value of 0.33% for cassava cultivars cultivated from Umudike, Abia State.

3.1.2 Total extracted cyanide content

The total extracted hydrogen cyanide results as shown in Table 2 shows that the bitter cassava variety had the highest extracted HCN content with a value of 85.33±4.61 mg/Kg, than the sweet cassava variety with a value of 69.33±2.80 mg/Kg. It can also be seen that the fermentation method using yeast agent was able to detoxify a large amount of hydrogen cyanide from both cassava variety as shown in Table 3 as reported by [37,38]. The fermentation process made the cassava edible for consumption, as it was able to remove the higher HCN level to the recommended permissible level. This is possible because it is one of the natural floras involved in cassava fermentation during processing [39]. [40] reported HCN value of 11.78±2.02mg/Kg and 15.30±3.10 mg/Kg for Garri processed in Ado-Ekiti and Egbira in Ekiti State, Nigeria. [41] reported a HCN value ranging from 10.51±0.13 mg/Kg – 16.02±0.12 mg/Kg for Garri processed in Ogun and Oyo State, Nigeria and attributed it to the short period of fermentation sometimes employed by the processors. Symptoms of acute cyanide intoxication appear four or more hours after ingesting raw or poorly processed cassava such as vertigo, vomiting, and collapse. In some cases, death may result within one or two hours. It can be treated easily with an injection of thiosulfate, which makes sulphur available for the patient's body to detoxify by converting the poisonous cyanide into thiocyanate [42].

3.1.3 Total hydrogen cyanide

The total hydrogen cyanide present in the cassava samples as shown in Table 3 shows that the bitter cassava variety had more hydrogen cyanide with a mean value of 89.60 mg/Kg, while the sweet cassava variety had a value of 80.60 mg/Kg. This supports the fact that the bitter cassava variety has a higher HCN content than the sweet cassava variety. The result also shows why it is harmful for people to eat cassava raw without any fermentation and processing method, in other to detoxify the cassava product [43]. Reports have shown that age, variety and environmental conditions influence the occurrence and concentration of hydrogen cyanide in various parts of the cassava plant and at different stages of development respectively [44]. This means that some varieties generally considered sweet (low cyanide content) can have a high cyanogenic potential under certain conditions [45]. [46] reported that in Amazonia (the original source of cassava) and in Africa different varieties have a range of total cyanide contents in the parenchyma from very low to very high (1–1550 ppm). Classical examples of variations in HCN content in cassava varieties can be seen as [47] reported an HCN value of different varieties with Nigerian origin harvested in Senegal, Soya cassava variety had a value of 231.2±10.2 mg/Kg, Kombo cassava variety had 104.2±3.9 mg/Kg, Gniargui cassava variety had 270.8±120 mg/Kg and TMS 30572 cassava variety had 171.6±5.4 mg/Kg. [48] reported an improved cassava variety HCN value with 10, 13 and 16 months of harvesting with TMS 98/0505 having a value of 43.68±33

mg/Kg, 44.34±4.92 mg/Kg and 47.85±4.92 mg/Kg; TMS 30752 had 42.80±0.00 mg/Kg, 42.68±45 mg/Kg and 46.44±3.25 mg/Kg; and TME 419 had value of 41.75±28 mg/Kg, 40.92±1.91 mg/Kg and 44.85±6.15 mg/Kg.

3.1.4 Mineral concentration

The mineral (Ca, K, Fe, Na and Mg) were present in the bitter and sweet cassava variety but however lower than the recommended amount of minerals in raw cassava as stated by [49] in Table 4. Calcium supplies the strength to bones that support locomotion, but it also serves as a reservoir to maintain serum calcium levels [50]. Although the requirement for Calcium varies according to age, the range is between 1000 and 1500 mg/day [51]. Since Nigeria is the highest producer of cassava and it is one of the main staple foods for the large population of Nigerian, the low calcium content observed shows an urgent input of calcium in the agricultural soils, if deficiency is to be avoided. Calcium insufficiency manifests as decreased bone mass and osteoporotic fracture. In the rapidly growing child, calcium deficiency causes rickets. Low levels of intestinal calcium resulting from low dietary intakes have also been associated with increased risk of kidney stones and colon cancer [52]. The same trend of extremely low amount mineral can be found in iron where the bitter cassava had a value of 2.25 mg/L and 4.00 mg/L for the sweet cassava. Iron exists in the blood mainly as haemoglobin in the erythrocytes and as transferrin in the plasma. It is transported as transferrin; stored as ferritin or hemosiderin and it is lost in sloughed cells and by bleeding [53]. The average adult stores about 1-3 g of iron in his or her body. A fine balance between dietary uptake and loss maintains this balance [54]. The most significant and common cause of anaemia is iron deficiency. If iron intake is limited or inadequate due to poor dietary intake, anaemia may occur as a result. This is called iron deficiency anaemia [55].

Magnesium is the fourth most abundant mineral and the second most abundant intracellular divalent cation in the body. It is a required mineral that is involved in more than 300 metabolic reactions in the body. Magnesium helps maintain normal nerve and muscle function, heart rhythm (cardiac excitability), vasomotor tone, blood pressure, immune system, bone integrity, and blood glucose levels and promotes calcium absorption [56]. [57] reported that magnesium enhances exercise performance via increasing glucose availability in the blood, muscle, and brain during exercise. The total body magnesium content of an average adult is 25 g, or 1000 mmol. Approximately 60% of the body's magnesium is present in bone, 20% is in muscle, and another 20% is in soft tissue and the liver. Approximately 99% of total body magnesium is intracellular or bone-deposited, with only 1% present in the extracellular space [58].

Magnesium was however low in both cassava varieties when compared to USDA, [49] and as such could not reach up the necessary dietary needs for human maximum utilization. [59] reported that patients with diagnoses of depression, epilepsy, diabetes mellitus, tremor, parkinsonism, arrhythmias, circulatory disturbances (stroke, cardiac infarction, arteriosclerosis), hypertension, migraine, cluster head- ache, cramps, neuro-vegetative disorders, abdominal pain, osteoporosis, asthma, stress dependent disorders, tinnitus, ataxia, confusion, preeclampsia, weakness, might also be consequences of the magnesium deficiency syndrome. Potassium and sodium content in the cassava were not enough to meet the necessary recommended value as needed by the human system. Potassium is the main intracellular cation in the body and is principally involved in membrane potential and electrical excitation of both nerve and muscle cells and acid-base regulation [60]. [61] reported that increased potassium intake has been shown to lower blood pressure (BP) even in the presence of high sodium consumption. Low levels of magnesium have been associated with a number of chronic diseases, such as Alzheimer’s disease, insulin resistance and type-2 diabetes mellitus, hypertension, cardiovascular disease (e.g., stroke), migraine headaches, and attention deficit hyperactivity disorder (ADHD) [62]. Sodium is the pincipal cation in extracellular fluids [29]. Sodium is an essential nutrient involved in the maintenance of normal cellular homeostasis and in the regulation of fluid and electrolyte balance and blood pressure (BP). Its role is crucial for maintaining extracellular fluids volume because of its important osmotic action and is equally important for the excitability of muscle and nerve cells and for the transport of nutrients and substrates through plasma membranes [63]. However deficiency of sodium is unlikely despite its low concentration in cassava and other foods. Instead its overconsumption of sodium and its salts that has the major health effects [64].

4. CONCLUSION AND RECOMMENDATION

In view on the status of cassava is to the economy and how it is a major tool in alleviating worldwide hunger. Special emphasis must be employed on the varieties of cassava harvested in the country and their HCN and mineral concentration. The cassava variety cultivated in Kachia LGA of Kaduna State show that they can't be stored for a long period of times, as a result of their high moisture content. Also observed in the study, is the low mineral values of Ca, Na, K, Mg and Fe in both cassava varieties, which encourages mineral supplements during diets to meet up with required daily dietary mineral use for humans. Geological locations, environmental factors, soil types, fertilizer applications and mode of cultivation also play a major role in the concentration of minerals and HCN in cassava. The study also shows the high amount of HCN in both cassava variety, this discourage the consumption of raw cassava without processing as toxicity is paramount.

With increasing awareness on the toxicity of HCN in cassava and the emancipation of different techniques in HCN detoxification, the yeast fermentation method could be employed, as it effectively detoxified large HCN content to a permissible acceptable limit. It is recommended that the Government of Kaduna State increase efforts on HCN toxicity in cassava awareness to farmers and consumers and the need for improved processing sites, where farmers can processes their cassava before it is been sold to the general public. A more comprehensive data on HCN content on various cassava varieties should be created for effective monitoring of cassava HCN values, soil location and its nature and mode of plantation and how more genetically improved cassava varieties with low HCN content could be grown in the State.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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