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Studies on Cyanide and Trace Metals Contents of *Manihot esculenta* of Agbonchia and Umuechem in Rivers State, Nigeria

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Abstract The concentrations of cyanide and trace metals: nickel, zinc, copper, lead, iron in the unprocessed and processed Manihot esculenta (cassava) from farmlands of Agbonchia and Umuechem in Rivers State were determined. Samples were collected, prepared and digested following standard procedures. Powder Pillow method was employed to determine the cyanide content, while trace metals analysis was carried out using atomic absorption spectrophotometry.Cyanide was found in all the samples since all carried the cyanogenic glucoside as its precursor and it ranged from 0.0012-0.034 mg/Kg HCN. The results of detectable concentrations (mg/Kg) of trace metals of Agbonchia, ranged from BDL-3.310, while in Umuechem, it was BDL-0.890 for both the unprocessed cassava and the processed foods. Both the cyanide and trace metals contents were below international standards and this was attributed probably to lower activities than those that could have enriched the food with cyanide and metals in the studied areas at the time of the study. Nevertheless, the two studied areas revealed significant ($p<0.05$) variations in the metals concentrations, suggesting anthropogenic enrichment. The metal pollution index, PI was also less than unity in all cases, indicating that the cassava species studied may not yet have been polluted. The study is however of the opinion that, continuous consumption of these foods without monitoring their cyanide and metal status from time to time, may lead to bioaccumulation of some of the metals that are reportedly toxic.
BDL: Below Detection Limit

Keywords Cyanide, trace metals, *Manihot esculenta*, Agbonchia, Umuechem

Introduction

Cassava (*Manihot esculenta*) is a perennial crop that is native to tropical America [1-2]. It originated actually from Brazil and was introduced to Africa by Portuguese traders in the 16th century [3]. The plant parts used are the storage root (tuber) and leaves [4]. It belongs to the dicotyledon family, *Euphorbiaceae*. The *Manihot* genus is reported to have about 100 species, among which the only commercially cultivated one is *Manihot esculenta*. Cassava constitutes one of the major staple foods for an estimated 500 million people in the tropical world and 700 million people worldwide, many of whom are very poor [5].

The leaves and roots of the plant contain the cyanogenic glucosides (Linamarin and a small amount of lotaustralin) [6-7]. The Linamarin is readily hydrolysed to glucose and acetone cyanohydrin in the presence of the enzyme Linamarase, which is also produced by the plant [8-9]. The acetone cyanohydrin decomposes rapidly in neutral or alkaline conditions liberating hydrogen cyanide and acetone. The sum of the amounts (HCN equivalent) of Linamarin, acetone cyanohydrin, hydrogen cyanides and cyanide ion equals the cyanogenic potential of the cassava sample [9-10]. It is one of the most perishable tuber crops with a high postharvest loss [11].

Trace metal contamination levels in agricultural soil are considered significant because of their toxicological potentials if allowed to accumulate in soil for a long period of time [12]. Cultivation of crops for human or livestock consumption on contaminated soil can potentially lead to the uptake and accumulation of trace metals in the edible plant parts around industrial areas with a resulting risk to human and animal health [13-14]. Trace metals are elements such as chromium, copper, iron, magnesium, selenium, copper, nickel and zinc that occur at a low concentration in the environment. Organisms need very little amount of these trace metals which are toxic at high amount. The environmental burden with heavy metal are that they are non-degradable and most of them have toxic effect on living organisms when they exceeded a certain concentration level either in water, soil or food substances [15].

Excessive accumulation of heavy metals in agricultural soils may result not only in soil contamination but also affect food quality and public health safety issues. Evidence of heavy metal contamination/pollution of agricultural soils and uptake of the heavy metals in vegetables and fruits/crops in Romania and Brazil have been reported by Lacatusu [16] and Guerra *et al* [17] who further added that the toxic effects of some heavy metals in vegetables like Cu and Pb focus on several human body organs such as liver, kidneys, spleen and lungs cause a variety of biochemical defects.

Traditional methods, which have been extensively studied and widely reported in literatures, were used to process the various cassava based foods [18]. Cassava can be consumed either in natural (i.e. boiled) or in a variety of industrially- ortraditionally-processed forms, known under various names depending on the preferences and local customs. Cassava flour is one of these products, as well as chips and starch. The root flour is gaining recognition as a suitable wheat flour substitute in biscuits and the fast food industries. Indeed, although cassava flour has a low nutritional value, it remains an important food in several parts of the world, as it is less expensive than wheat and can be used to produce a variety of food products. In Nigeria, we have many products which include fufu, garri, tapioca, flour, bread and biscuit.

It is therefore important to express concerns on the state of the soils as reported in literature, and how that may affect the quality of processed and unprocessed *Manihot esculenta* (cassava) with respect to some trace metals and its cyanide contents as well as provide information on possible risk factor.

Materials and Methods

Sample Collection and Preparation

Fresh cassava tubers were harvested on permission from local farms in Agbonchia, in Eleme Local Government Area and Umuechem, in Etche Local Government Area of Rivers state, twice a month from the months of October-December, 2019. The two LGAs are in the Niger Delta region of Nigeria, covering an area of about 7500 km^2 [19] where crude oil prospecting and allied activities take place.

The fresh tubers were separated into four parts for garri, fufu, tapioca and the raw (unprocessed).The tubers for the unprocessed sample were peeled and washed thoroughly with fresh water. The peeled tubers were then sliced and rinsed again to remove impurities and sun dried. The dried samples were then pulverized into powder using mortar and pistle and sieved into obtain uniform particle of 2mm diameter.

Preparation of the Garri from Raw Cassava Tuber

The outer skin cover of the fresh tubers for garri were peeled and washed with clean water, taken to the cassava processing plant where it was ground, packed into a sack bag and then pressed to remove the water content. This process was allowed for 24 hours for all the water content to dry up. Thereafter it was sieved and fried in an oven to obtain the garri granules. The dried garri was later reduced to 2mm particle size with the help of a sieve.

Preparation of Tapioca from Raw Cassava Tuber

The fresh tuber after peeling and thorough washing with water and boiled in water for 20 minutes, was allowed to cool, and then sliced for soaking overnight to effect detoxification (extraction of cyanide content). The sample was then sun-dried, ground and sieved to a diameter of 2mm size.

Preparation of Fufu from fresh Tuber

The fresh tubers were peeled and washed, soaked in water for four days to ferment. Thereafter it was brought out of the water and filtered with clean water using a sieve. This helps to remove the shaft. The filtrate was then poured into a bag and the water in it was allowed to drain. It was later oven dried to obtain fufu. The fufu was later dried then homogenized with a grinding machine and sieved to 2mm diameter size. It should be noted that the services of people who do business of processing these foods were employed to process the food by their local methods before the laboratory processes were applied on them for analysis.

Determination of Cyanide in Cassava

To the well-ground air dry powdered cassava sample and its products, (about 15g) in a digestion vessel was added 30 ml of distilled water. They were allowed to stand for duration of 45 to 60 minutes and thereafter filtered into graduated cylinders. To each of the filtrate in the graduated cylinders, a round sample cell with 10 ml of the sample was filtered; the content of concentrated cyanide Ver3 cyanide reagent powdered pillow cap was added (This is the prepared sample). The sample cell was then shaken for 30 seconds and left undisturbed for 30 seconds. The contents of cyanide Ver4 cyanide reagent powdered pillow and cap was added to the sample. The sample was shaken for 10 seconds to set the stage for heating. Note that delay in addition of the cyanide Ver5 cyanide will yield low result. The contents of the concentrated cyanide Ver5 cyanide reagent powder pillow reagent cap was added to the sample cell and shaken vigorously. The presence of cyanide was indicated by a formation of a pink solution. The ok button was pressed allowing 30 minutes reaction, which turned the solution from pink to blue and consequently the timer beeped. Another round of sample cell was filtered (the blank) and placed into the cell reader and the result in Mg/Kg HCN was recorded.

Samples Digestion for Trace Metals Analysis

A measured weight (2g) each of the processed, cassava samples (garri, tapioca and fufu) and the unprocessed tuber from each of the two study areas were digested in 12 mL of aqua regia HNO_3/ HCl (1:3) on a hot plate for 3 hours at 110^{o}C until the brown fumes disappeared. Heating was then continued until the brown fumes turned to white. 20ml of distilled water was added and heated until a colourless solution was obtained. The solution was allowed to cool and filtered into a standard volumetric flask (100 ml) through Whatman No. 42 filter paper and the volume was made up to the mark with distilled water [20-21]. The concentrations of the heavy metals Lead (Pb), Copper (Cu), Nickel (Ni), Cadmium (Cd), Zinc (Zn), Magnesium (Mg), Manganese (Mn) and Iron (Fe)) in the various samples were determined using atomic absorption spectrophotometer.

Calculation of Pollution Index of Trace Metals

The pollution index (PI) is the ratio of metal concentration in a biotic or abiotic medium to that of the regulatory Standard of International bodies such as World Health Organisation (WHO), United States Environmental Protection Agency (USEPA), Federal Environmental Protection Agency (FEPA) of Nigeria etc [22]. Values of PI <1 value indicate that the soil or plant material is not yet contaminated whereas PI >1 indicates pollution. On the other hand, PI=1 reveals a critical state which makes the involved plant useful for environmental monitoring [23].

Mathematically, Pollution Index is expressed as

$$\mathbf{PI = Cplant / C_{USEPA/WHO\text{-}standard}} \quad \text{(i)}$$

Where PI is the individual pollution index of study metal; Cplant is the Concentration of the metal in plant. $C_{USEPA}/_{WHO\text{-}standard}$ is the value of the regulatory limit of the heavy metal by USEPA [24].

Results and Discussion

The levels of cyanide in the samples Agbonchia, Eleme were 0.019 mg/kg, 0.0071 mg/kg, 0.0012 mg/kg and 0.0013 mg/kg for the fresh tuber, garri, tapioca and fufu respectively. The results follow the order: tuber>garri>fufu>tapioca. The cyanide levels though appreciable, were lower than the limits set by Food and Agricultural Organisation [5, 25] at 10 mg HCN equivalent mg/kg. The levels were also lower than those obtained by Ubwa *et al.,* [26], in their work on three sweet cassavas around three Local Governments areas of Benue State. The research held that the cyanide content was due to the presence of a significantly high amount of the cyanogenic glucosides, linamarin contained in cassava tuber which is the major source [27]. The lower cyanide content from this study may therefore be attributed to the variety of the cassava that may be low in cyanogenic glucoside. The bitter cassava is known to be of high cyanide content; the variety used however for this study was of the sweet variety.

The results of Umuechem, Etche as shown in table 1 were 0.034 mg/kg, 0.0024 mg/kg, 0.0031 mg/kg and 0.0052 mg/kg for the fresh tuber, garri, tapioca and fufu respectively. Clearly, the processed foods from the fresh tuber as also observed with results obtained in Agbonchia, were of less cyanide content than the fresh tuber itself. This may suggest that most of the cyanide concentration might have been lost during the process of processing. It has reported that activities such as boiling/heating that may be involved in producing all the foods under investigation reduce the toxicant [28]. The cyanide levels in the cassava products in Umuechem also falls within the acceptable limit of 10 mg HCN equivalent/Kg dry weight recommended [29] for safe cassava products.

Cyanide levels (mg/kg) in Cassava samples of Agbonchia, Eleme and Umuechem, Etche are presented in table 1.

Table 1: Levels of cyanide (mg/kg HCN equivalent) in cassava samples of Agbonchia and Umuechem

Sample Identity	Tuber	Garri	Tapioca	Fufu
Abuchi, Eleme	0.089	0.0071	0.0012	0.0013
Umuechem, Etche	0.074	0.0024	0.0031	0.0052

The above findings may imply that the local cassava farmers within Eleme and Etche communities may have been observing the best practices in cassava cultivation, and that the final consumers may not be at risk in consuming the finished products of the cassava. The cyanide level is significantly lower than the lethal dose of cyanide intoxication of human which has been reported as 200 to 300 mg/kg [30] and the oral toxicity standard of 50 to 90 mg HCN equivalent/Kg body weight [25].

This study shows a lower cyanide level when compared to works in the eastern and western parts of Nigeria where the cyanide level was far above the acceptable limit and there have been reported cases of occasional deaths from cassava food consumption [31-33].

Although the cyanide concentrations in the samples used for this work are lower than the acceptable level recommended by WHO/FAO [29], studies on diseases have also shown that exposure to little doses can accumulate over a long period of time, and this may result in increased blood cyanide levels and could lead to the following symptoms: dizziness, headache, nausea and vomiting, rapid breathing, restlessness, weakness and even in severe cases paralysis, nerve lesions, hypothyroidism and miscarriage [34].

Trace Metals Contents of Cassava

Trace metals levels (mg/kg) in cassava tuber samples of Agbonchia, Eleme were; lead (0.014±0.003), copper (3.31±0.504), zinc (0.110±0.026), magnesium (0.860±0.249) andiron (1.45±0.065). Nickel, cadmium and manganese were not detected; lead was also below detection limit in the processed forms (Table 2). The concentrations of the different metals were far below the prescribed limit set by WHO [25]. Table 2 also showed that lead, nickel, cadmium and manganese were absent in all the processed foods. Copper, Zinc, Magnesium and Iron as well as those that were detected in the processed foods as shown were also below limits set by World Health Organisation for these metals in food.

Concentrations of trace metals in cassava samples of Agbonchia are shown in Table 2

Table 2: Mean Concentration (mg/kg) of Trace metals (mg/kg) in cassava samples of Agbonchia, Eleme (n-6)

Trace metals	Fresh Tubers	Garri	Tapioca	Fufu	WHO
Lead	0.014±0.003	BDL	BDL	BDL	0.3
Copper	3.310±0.0504	0.008±0.004	0.012±0.005	0.002±0.000	73
Nickel	BDL	BDL	BDL	BDL	67
Cadmium	BDL	BDL	BDL	BDL	0.1
Zinc	0.110±0.026	0.022±0.005	0.070±0.043	0.053±0.001	100
Magnesium	0.860±0.249	0.720±0.067	0.074±0.092	0.670±0.057	-
Manganese	BDL	BDL	BDL	BDL	500
Iron	1.450±0.65	0.200±0.082	0.380±0.050	0.190±0.016	48

BDL: Below Detectable Limit ±: Mean and standard deviation

The absence of lead except for the unprocessed cassava tubers, which was lower than that reported by Addo *et al.* [35] on Cassava, with 0.86 μg/g could be attributed to the processing methods used in preparing those products [36]. Copper was detected in all the cassava samples of Agbonchia, Eleme. These results, as expected, showed that the unprocessed samples had higher concentrations than what obtained in the processed food samples. Copper was highest in tapioca, followed by fufu and then garri. These variations especially in garri could be from the method used in processing the garri which required more heat [37].

Zinc was detected in all cases. Although it's a minor element in the class of heavy metals, it is extremely toxic even at low concentration. It causes learning disabilities and hyperactivity in children [38]. The low level could also bioaccumulate in tissues and cause harm to consumers of such products [38].

The mean concentrations of magnesium and iron were below the set limit for food by WHO [25]. The values obtained in this study however, are lower than those of similar studies by Ugulu *et al* [39] around Murat Mountain, Turkey, where iron concentration was in the range of 0.60 to 5.98 μg/g. The sources for accumulation of some trace elements have been explained by various researchers. For example, natural occurrences are the main causes of Pb and Zn according to Alfani *et al.*, [40], Blok [41] and Oliva and Rautio [42]. Activities from Coal and Oil mining aids in production of Cu, Ni and Pb, steel works and cement industry are major anthropogenic sources of Ni [43]. The trace metals followed the following order in terms of concentrations Cu>Fe>Mg>Zn>Pb>Ni>Cd>Mn. The highest trace metal concentration was from Copper followed by magnesium and iron. The least were manganese, nickel and cadmium which were in fact, below detection limit.

The mean concentrations (mg/kg) of trace metals in the fresh tubers of Umuechem, Etche, were as follows: copper (0.066±0.004), Nickel (0.023±0.00), Cadmium (0.013±0.004), Zinc(0.170±0.008), magnesium (0.890±0.070) and iron (0.990±0.002). Manganese and lead were not detected. These values were below the limit set by WHO [25] for trace metals in similar foods. The results of the concentration of trace metals in Cassava samples of Umuechem, Etche are presented in Table 3.

Table 3: Mean Concentration (mg/kg) of Trace metals in cassava samples of Umuechem, Etche (n-6)

Trace metals	Fresh Tubers	Garri	Tapioca	Fufu	WHO
Lead(Pb)	BDL	BDL	BDL	BDL	0.3
Copper (Cu)	0.066±0.004	0.037±0.002	0.019±0.003	0.015±0.001	73
Nickel (Ni)	0.023±0.000	0.021±0.001	0.019±0.000	BDL	67
Cadmium (Cd)	0.013±0.004	0.006±0.004	0.006±0.000	0.007±0.000	0.1
Zinc (Zn)	0.170±0.008	0.120±0.008	0.120±0.008	0.100±0.008	100
Magnesium (Mg)	0.890±0.070	0.510±0.016	0.600±0.041	0.710±0.036	-
Manganese (Mn)	BDL	BDL	BDL	BDL	500
Iron (Fe)	0.990±0.008	0.530±0.008	0.750±0.037	0.290±0.000	48

BDL=Below Detectable Limit ±: Mean and standard deviation

The results in garri were: copper (0.037±0.002 mg/kg), Nickel (0.021±0.001 mg/kg), cadmium (0.006±0.004 mg/kg), zinc (0.120±0.008 mg/kg), magnesium (0.510±0.016 mg/kg) and iron (0.530±0.008 mg/kg). These values were all below the limits for trace metals consumption in food (Table 3). The concentrations of Copper, Nickel, Cadmium, Zinc, Magnesium and Iron in tapioca were : 0.019±0.003 mg/kg, 0.019±0.000 mg/kg, 0.006±0.000 mg/kg, 0.120±0.008 mg/kg, 0.600±0.041 mg/kg and 0.750±0.037 mg/kg respectively.

The concentrations of copper, cadmium, zinc, magnesium and iron in fufu were : 0.015±0.001 mg/kg, 0.007±0.000mg/kg, 0.100±0.008 mg/kg, 0.710±0.036 mg/kg and 0.290±0.000 mg/kg respectively. These mean concentrations indicate that lead, nickel and manganese were below detectable limit. The results obtained from Umuechem generally showed that copper in the processed food varied significantly from one another with garri having the highest concentration of the metal. These results are far below those reported by Enemugwem *et al* [44] on Cassava tubers from Elele prison farm in Rivers State, who obtained 2.77 mg/kg for copper, and which also is below WHO limit for Cu in food items and vegetables. The low value may be attributed to low activities that could lead to introduction of copper to the environment [45].

Nickel also followed the same trend as that of the unprocessed food, that is, higher value than that of the processed one, but the garri product had the highest among the processed food. These results are lower than that reported by Ekmekyapar *et al* [46] on wheat around the Corlu-Cerkezkoy Highway in Thrace Region.

Though these values are low, even lower than recommended standard by WHO [25], accumulation can be very harmful to consumers of these products. Cadmium was found in all the products though as expected, the unprocessed food had higher concentrations. The values were however lower than the standard set for cadmium on food which is 0.1 mg/kg. The variations in concentrations in the produced food items from the unprocessed clearly showed that the processing methods had significant effect on the levels of these metals on the samples [18]. The Zinc levels were considerably low compared to that of WHO standard which is 100 mg/kg. These levels however, are in good agreement with the work of Opaluwa *et al* [47] on crops around Lafia.

Variations in the concentrations of metals between the two studied areas were assessed on the platform of independent sample *t*-test in various samples of the unprocessed cassava of Agbonchia and Umuechem. Table 4 shows that there were significant ($p<0.05$) differences for lead, copper, cadmium and iron for the unprocessed tuber samples, suggesting that these metal concentrations were different at both areas, while zinc and magnesium showed no significant ($p>0.05$) differences. Nickel and Manganese were not captured by the independent sample *t*-test, due to their very low concentration. The results of similar test of significance on the processed foods are shown in tables 5, 6 and 7.

Table 4: Test of Significance for the unprocessed cassava samples

Trace Metal	N	Mean	Std	t-test	Df	Sig	Decision
Pb	3	0.014	0.004	5.629*	4	0.005	Sig
Cu	3	3.310	0.617	9.101*	4	0.001	Sig
Ni	3	0.001	0.000	-	-	-	-
Cd	3	0.013	0.046	-4..768*	4	0.009	Sig
Zn	3	0.143	0.032	-1.372	4	0.242	NS
Mg	3	0.860	0.305	-0.164	4	0.878	NS
Mn	3	0.001	0.000	-	-	-	-
Fe	3	1.450	0.132	6.066*	4	0.004	Sig

0.05 level of Significance, Sig. = Significance, * = Significance, NS – No significance, df = degree of freedom.

Table 5: Test of Significance for the processed garri samples

Trace Metal	N	Mean	Std	t-test	Df	Sig	Decision
Pb	3	0.001	0.000	-	-	-	-
Cu	3	0.008	0.001	-23.852*	4	0.000	Sig
Ni	3	0.001	0.000	-34.641*	4	0.000	Sig
Cd	3	0.001	0.000	-8.660*	4	0.001	Sig
Zn	3	0.022	0.006	-14.502*	4	0.001	Sig
Mg	3	0.720	0.082	4.317*	4	0.012	Sig
Mn	3	0.001	0.000	-	-	-	-
Fe	3	0.200	0.100	-5.475*	4	0.005	Sig

0.05 level of Significance, Sig. = Significance, * = Significance, NS – No significance, df = degree of freedom.

The *t*-test for the metals in the processed garri also revealed significant($p<0.05$) differences with respect to the two areas for copper, nickel, cadmium, zinc, magnesium and iron, while lead and manganese were not picked due to low concentration.

Table 6: Test of Significance for the processed tapioca samples

Trace Metal	N	Mean	Std	t-test	Df	Sig	Decision
Pb	3	0.001	0.000	-	-	-	-
Cu	3	0.120	0.072	-1.630	4	0.178	NS
Ni	3	0.001	0.000	-	-	-	-
Cd	3	0.001	0.000	-	-	-	-
Zn	3	0.070	0.052	-1.632	4	0.178	NS
Mg	3	0.740	0.113	1.967	4	0.121	NS
Mn	3	0.001	0.000	-	-	-	-
Fe	3	0.380	0.0.061	-8.415*	4	0.001	Sig

0.05 level of Significance, Sig. = Significance, * = Significance, NS – No significance, df = degree of freedom.

Only iron had significant ($p<0.05$) difference for both areas as values for all other metals were either too low or below detection limit.

Table 7: Test of Significance for the processed fufu samples

Trace Metal	N	Mean	Std	t-test	Df	Sig	Decision
Pb	3	0.001	0.000	-	-	-	-
Cu	3	0.002	0.000	-22.517*	4	0.000	Sig
Ni	3	0.001	0.000	-	-	-	-
Cd	3	0.001	0.000	-	-	-	-
Zn	3	0.053	0.001	-8.100*	4	0.001	Sig
Mg	3	0.670	0.070	-0.840	4	0.448	NS
Mn	3	0.001	0.000	-	-	-	-
Fe	3	0.190	0.020	-8.660*	4	0.001	Sig

0.05 level of Significance, Sig. = Significance, * = Significance, NS – No significance, df = degree of freedom.

Significant ($p<0.05$) differences were also observed with copper, zinc and iron only in fufu. The concentrations of other metal were either too low or below detection limit, and so were not captured for the analysis.

Pollution Index of the Trace Metals

The pollution index (PI) of the metals was calculated and are presented in Tables 8 and 9 for samples of Agbonchia and Umuechem respectively. Only the fresh tuber of Agbonchia had appreciable but less than 1 PI for lead, copper and iron. The general trend of PI from the unprocessed cassava tuber to the processed food products revealed a very low pollution index. The PI values for the samples of Etche were also very low (<1) as in the case Agbonchia samples, with only iron in the fresh tuber, cadmium in the processed garri, tapioca and fufu showing appreciable levels. The implication of PI value <1 is that the consumption of eitherthe fresh tuber or the processed forms of it does not portend health risk at the moment

Table 8: Pollution index (PI) of the Trace metals of Samples of Agbonchia, Eleme

Metal	Pb	Cu	Ni	Cd	Zn	Mg	Mn	Fe
Tuber	0.047	0.040	-	-	0.001	-	-	0.021
Garri	-	0.0001	-	-	0.002	-	-	0.011
Tapioca	-	0.0002	-	-	0.001	-	-	0.016
Fufu	-	0.0001	-	-	0.001	-	-	0.006

Table 9: Pollution index (PI) of the trace metals of Samples of Umuechem, Etche

Metal	Pb	Cu	Ni	Cd	Zn	Mg	Mn	Fe
Tuber	-	0.001	0.0003	0.13	0.002	-	-	0.021
Garri	-	0.001	0.0003	0.060	0.001	-	-	0.011
Tapioca	-	0.0003	0.0003	0.060	0.001	-	-	0.016
Fufu	-	0.0002	-	0.070	0.001	-	-	0.006

Conclusion

The cyanide levels in the samples of cassava from the two studied areas were lower than the recommended 5 to 10 ppm range which is relatively very safe and within the acceptable limit of 10 mg HCN equivalent/Kg body weight recommended by FAO. Among the different samples tested for cyanide, the fresh tuber had the highest cyanide concentration for Agbonchia and Umuechem but this varied in the processed foods. The study of the opinion that variation in cyanide levels in the three products may probably be due perhaps to changing logistics and differences in processing techniques for each of the products.

Secondly, trace metals determined were found to be within limits of WHO/FAO for metals in food. The concentrations of trace metals determined were in sequence Cu > Mg > Fe > Zn > Ni > Pb > Cd> Mn and Mg > Fe > Mn > Zn > Ni > Cd > Pb for cassava samples from Eleme and Etche respectively. With PI<1 for all the metal at the two studied areas, the cassava and foods processed from it are safe for consumption at the moment.

Conscious efforts should therefore be made by the relevant agencies of the government in Nigeria such as National Agency for Food and Drug Administration Control (NAFDAC) to educate the peasant cassava processors on modern techniques of cassava processing and the health risk posed to the consumers when short-cut processing techniques adopted. Also, there should be routine monitoring of cyanide levels in cassava products among millers to avoid sharp practices.

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