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BACTERIOLOGICAL QUALITY AND CYANIDE CONTENTS OF DIFFERENT CASSAVA PRODUCTS PROCESSED IN BENUE STATE FOR USE AS FOOD FOR MAN OR FEEDSTOCK FOR ANIMALS

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ABSTRACT

The bacteriological profiles of the different cassava products were investigated. Ground cassava samples, serially diluted with sterile normal saline were cultured in different sterile bacteriological media. Hydrogen cyanide content was determined by spectrometric method. Colonies isolated from the different locations were statistically the same for total viable bacterial counts (TVBC). Cassava peels had the highest values of TVBC (4.456 $\log_{10}$CFU/g) TCC (3.025 $\log_{10}$CFU/g) EC (1.663) and SA counts. Gari had the lowest values of TVBC (3.193) TCC (2.580) EC (not isolated) and SA counts. The traditionally processed cassava products showed no statistically significant differences ($p<0.05$) with the mechanically processed products except in fufu. The total viable bacterial count was highest in cassava products dried along the roadside (6.980 $\log_{10}$CFU/g) and lowest oven-dried cassava products (2.763 $\log_{10}$CFU/g). No *Salmonella* and *Shigella* spp. were isolated in most of the assayed cassava products. The identified storage places of the cassava products did not significantly impact any difference on the bacterial load. There was a progressive decrease in the cyanide contents from cassava peels to cassava chips to fufu and least in gari. The highest hydrogen cyanide concentration of 14.50 mg/kg was recorded in cassava peels and was higher than 10 mg of HCN/kg body weight recommended by WHO. Gari had the least content of 2.25 mg/kg. The study provides information on potential infections and toxicities due to the microorganisms and cyanide level.

Contribution/Originality: This study is one of the very few studies which have investigated bacteriological quality of different cassava products processed in Benue State for use as food for man or feedstock for animals.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a basic root crop that is utilized globally as food for humans and feed for animals. It serves as a major source of carbohydrates for millions of people especially the low income earners in the tropics and sub-tropical countries [1]. In terms of agricultural food security, it is the most robust and important food crop in Nigeria [2] and Nigeria is the world's largest producer for over a decade [3].

In Nigeria, cassava tubers are processed and consumed in different forms, namely: cassava chips which is processed for flour, gari and cassava peels used for feedstock for animals. Other economic uses of cassava include making *fufu*, confectionaries, glues, monosodium glutamate, sweeteners, pharmaceuticals and textiles [2]. However,

most indigenous low-income earners of the society use the cassava in the form of gari, fufu, chips and the peels are consciously or unconsciously served to ruminant animals as feedstock.

Microorganisms are ubiquitous and are found virtually everywhere. They have a wide range of carbon substrates for growth and cellular metabolism. In cassava production systems, many microorganisms have been associated with its contamination including fungi [4, 5] and bacteria [2, 5] rendering it a public health issue. Microbial quality/ public health issues relating to consumption of cassava products include the following.

Cassava contains cyanogenic glucoside which is made up of linamarin and lotaustrain [6]. The quantity of cyanogenic glucoside is dependent on the cassava variety [7]. Diseases arising from excessive consumption of cassava with high cyanide contents include but not limited to cretinism, goiter, neuropathy and tropical diabetics Nhassico, et al. [8]. WHO [9] stipulated the limits of cyanogenic glucoside in consumed food to which if exceeded, becomes adverse. The implication of consumption of cassava product with high cyanide content is well known. The present work investigated the bacteriological quality cyanide compositions of different cassava products sold in Benue State for use as food for man or feedstock for animals.

2. MATERIALS AND METHODS

2.1. Collection of Cassava Product Samples

Survey was carried out in Benue State in November 2018 in three local government areas of the state to assess the techniques deployed in cassava processing, drying and storage in the various places visited and in addition determine the microbial load. Multistage sampling involving purposive and random methods were used. Cassava producing communities in Benue State were selected and then random samples were collected from livelihoods in the selected communities.

2.2. Bacteriological Analysis

2.2.1. Preparation of the Cassava Sample

The different cassava samples were prepared by weighing one gram of each of the granulated cassava (ground in sterile mortar and pistil) product in 9 mL of peptone water. These were the stocks used for the inoculation of the different isolation media below. The stocks were appropriately diluted prior to use for inoculation.

2.2.2. Nutrient Agar

Nutrient Agar (NA) was used for the determination of Total Viable Bacterial Counts (TVBC). Nutrient Agar (HiMedia Laboratories Pvt. Ltd, India) was prepared by weighing 14.0 g of NA powder into a 500 mL conical flask and dissolving in distilled water. This was brought to 500 mL volume and was heated and shaken intermittently to mix. Thereafter, it was tightly plugged with quality cotton wool, and was covered with aluminum foil and sterilized by autoclaving at 121 °C for 15 minutes. This was allowed to cool to 40 - 50 °C before dispensing into Petri dishes. The medium was allowed to solidify on the plate. A 0.1 mL of appropriately diluted sample was introduced into the sterile medium and evenly spread using a sterile glass spreader. This was subsequently incubated at 37 °C for 24 h. Colonies that form on the incubated plates were counted using a digital colony counter and results recorded.

2.2.3. MacConkey Agar

Total Coliform Counts (TCC) was determined using MacConkey Agar (MA). MacConkey Agar (HiMedia Laboratories Pvt. Ltd, India) was prepared by dissolving 27.6 g of MA powder in 500 mL of distilled water until a homogenous mixture was achieved. This was possible through gentle heating with continuous shaking. The medium was sterilized by autoclaving at 121 °C for 15 minutes. Thereafter, the sterile MA was allowed to cool to 40 – 50 °C before dispensing to sterile Petri dishes. The medium was allowed to solidify and a 0.1 mL of

appropriately diluted sample was introduced into the sterile medium and evenly using a sterile glass spreader. This was subsequently incubated at 37 °C for 48 h. Colonies that form on the incubated plates were counted using a digital colony counter and results recorded.

2.2.4. Xylose Lysine Deoxycholate Agar (XLDA)

Confirmation and enumeration of *Salmonella* and *Shigella* spp were done on XLDA. Xylose Lysine Deoxycholate Agar (XLDA) was prepared according to the manufacturer's specifications. A 500 mL XLDA (27.7 g of powder) medium was sterilized in a 1 L Erlenmeyer flask by bringing to boil over a heater. This was allowed to cool to 40 – 50 °C before dispensing to Petri dishes. Prepared medium was inoculated with a 0.1 mL of appropriately diluted sample and was spread evenly on the plate. This was subsequently incubated at 37 °C for 24 h and emergent colonies were counted using a digital colony counter.

2.2.5. Eosin Methylene Blue Agar

The *Escherichia coli* content of the sample was determined using Eosin Methylene Blue Agar (EMBA). Eosin Methylene Blue Agar (TM Media, Titan Biotech Ltd, BHIWADI, Rajasthan, India) was prepared by dissolving 18.0 g of EMBA in 500 mL of distilled water. The dissolution was accompanied by gentle heating and was thereafter sterilized by autoclaving at 15 psi (121 °C) for 15 minutes. Upon cooling to 45 – 50 °C, the medium was dispensed into sterile Petri dishes. A 0.1 mL of appropriately diluted sample was introduced into the sterile medium and was evenly spread. This was subsequently incubated at 37 °C for 24 h. Colonies that form on the incubated plates were counted using a digital colony counter and results recorded.

2.2.6. Mannitol Salt Agar

Staphylococcus aureus (SA) was isolated in Mannitol Salt Agar (MSA). Mannitol Salt Agar (HiMedia Laboratories Pvt. Ltd, India) was prepared by suspending 55.6 g MSA in distilled water. It was homogenized with frequent heating and agitation until completely dissolved. The MSA was sterilized by autoclaving at 121 °C for 15 minutes. This was allowed to cool to 50 °C before pouring into sterile Petri dishes. A 0.1 mL of appropriately diluted sample was introduced into the sterile medium and evenly spread using a sterile glass spreader. This was subsequently incubated at 37 °C for 24 h. Colonies that form on the incubated plates were counted using a digital colony counter and results recorded.

2.3. Biochemical Identification of the Isolates

Triple sugar iron (TSI), urease test, oxidase, coagulase and catalase in addition to indole test, methyl red, Voges-Proskauer, and citrate utilization (IMVIC) were used to characterize the bacteria following the protocol documented by Cheesbrough [10].

2.4. Determination of Hydrogen Cyanide Concentration

Hydrogen cyanide concentration was determined by modifying the methods by Ezeh, et al. [11] and Sawyerr, et al. [12] as presented below. Two grams of the cassava powder was added to 20 mL of sterile distilled water in a conical flask, shaken to form a paste, stoppered and allowed to stand at room temperature (28±2 °C). The paste was filtered (Whatman No.1) after addition of further sterile distilled water. The filtrate was made up to 50 mL volume. This was kept in the refrigerator (4 °C) until used.

2.4.1. Alkaline Picarate Preparation

Alkaline picarate was prepared by dissolving 1 g of picric acid and 2 g of sodium trioxo carbonate in a small volume of minimally warm water. This was thereafter brought to a 100 mL volume and stored in an amber-colored bottle in the fridge (4 °C) until used.

To determine the cyanide content, 4 mL of alkaline picarate was added to a 5 mL quantity of the filtered cassava solution. This was warmed for 5 min in a water bath set at 5 °C for brown color development. Thereafter, this was allowed to cool and read against a blank at 490 nm (UV-Spectrophotometer). The blank was prepared by adding 1 mL water to 4 mL of alkaline picarate solution. The cyanide concentration expressed as mg/kg was extrapolated from a standard curve.

2.5. Statistical Analysis

Descriptive statistics and one-way analysis of variance (ANOVA) were performed using SPSS (version 16.0).

3. RESULTS

Results of the bacteriological profiles of the different cassava products are shown below. Cassava chips, fufu, garri and cassava peels had numerically different bacterial loads. Table 1 presents the levels of bacterial load with respect to locality from where the products were sourced. The Table reveals that Ikyose of Katsina-Ala (KA) and Mbahaya of Makurdi Local Government had the highest TBVC value of 4.326 $\log_{10}$CFU/g. The TVBC of 3.215 got from samples from Ehurekpe in Oju was the lowest. However, most of the TVBC values were statistically homogeneous. The mean total coliform count (TCC) was highest (2.763 $\log_{10}$CFU/g) in Katsina-Ala (KA) (Ikyose) and lowest in Adaka (1.806 $\log_{10}$CFU/g) of Makurdi Local Government. *Escherichia coli* count (ECC) used as indicators of food quality was highest (1.681 $\log_{10}$CFU/g) in samples from KA area of KA local Government but was not isolated in some areas of Makurdi and Oju. Cassava peel samples from Makurdi had *Salmonella* sp (1.00 $\log_{10}$CFU/g) as opposed to all other locations where *Salmonella* and *Shigella* were not isolated.

Table-1. Influence of location on the bacterial quality ($\log_{10}$CFU/g) of cassava peels.

Local Govt.	Locations	TVBC	TCC	SAL	SHI	EC	SA
Katsina-Ala	Katsina-Ala	3.729	2.335	-	-	1.681	1.556
	Agasoma	4.050	2.505	-	-	1.415	1.681
	Agoasu	4.269	2.620	-	-	1.531	1.556
	Ikyose	4.326	2.763	-	-	1.505	1.748
Makurdi	Tionsha	4.215	2.964	1.000	-	1.663	2.924
	Mbahaya	4.326	2.256	-	-	1.505	1.681
	Yagba	4.107	2.601	-	-	1.204	1.707
	Adaka	3.982	1.806	-	-	-	-
	Mbayo	4.065	2.579	-	-	1.342	-
Oju	Obolori	3.934	2.756	-	-	1.204	1.672
	Ihiejwo	4.256	2.556	-	-	1.326	2.819
	Ehurekpe	3.215	2.065	-	-	-	1.833

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*.

Table-2. Effect of location on the bacterial quality ($\log_{10}$CFU/g) of cassava chips.

Local Govt.	Locations	TVBC	TCC	SAL	SHI	EC	SA
Katsina-Ala	Katsina-Ala	3.729	2.193	-	-	1.301	1.204
	Agasoma	3.415	2.025	-	-	1.114	1.602
	Agoasu	3.672	2.305	-	-	1.079	1.477
	Ikyose	3.556	2.025	-	-	1.091	1.415
Makurdi	Tionsha	3.833	2.121	-	-	1.301	1.903
	Mbahaya	3.604	2.009	-	-	1.176	1.204
	Yagba	3.215	2.220	-	-	1.146	1.326
	Adaka	3.782	1.968	-	-	-	-
	Mbayo	3.256	2.204	-	-	1.231	0.954

Oju	Obolori	3.672	2.093	-	-	1.114	1.699
	Ihiejwo	3.156	2.162	-	-	1.301	1.778
	Ehurekpe	3.065	2.215	-	-	-	1.231

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*.

Effect of location on the bacterial quality (log_{10}CFU/g) of cassava chips is presented in Table 2. The TVBC was highest (3.833) in cassava chips from Tionsha in Makurdi Local Government Area and least (3.065) in samples from Ehurekpe in Oju. The TCC values obtained from cassava chips was highest (2.305) from Agossu in KA and lowest (1.968) in samples from Adaka in Makurdi. *Salmonella* and *Shigella* spp. were not isolated from the cassava chips from the locations at the time of the study. The three locations had similarly the highest (1.301) EC contaminations. *Escherichia coli* was not isolated in cassava chips from Adaka and Ehurekpe. *Staphylococcus aureus* was highest (1.903) in MA area of MA local Government Area.

Effect of location on the bacterial quality log_{10}CFU/g of gari is shown in Table 3. The Table shows that the TVBC was highest (3.655) in gari from Agoasu district of KA local Government and lowest (3.070) in Ihejiwo in Oju locality. The TCC (log_{10}CFU/g) was highest (2.361) in Agoasu district of KA local Government and lowest (1.903) isolated from Adaka area of Makurdi Locality. *Salmonella* and *Shigella* spp were not isolated. The Table also shows EC count to be highest at 1.397 log_{10}CFU/g from samples isolated from KA in KA Local Government Area. Some localities had no *E. coli* whereas *Staphylococcus aureus* was highest (1.778og_{10}CFU/g) in Tionsha area of Makurdi.

Mean bacterial load (log_{10}CFU/g) of the cassava products irrespective of location is presented in Table 4. The Table shows that cassava peels used for animal feeds was the highest values of TVBC (4.456) TCC (3.025) EC (1.663) and SA counts. Gari had correspondingly the lowest values of TVBC (3.193) TCC (2.580) EC (not isolated) and SA counts. *Salmonella* sp. and *Shigella* sp. were not isolated (Table 3) from any of the cassava food product. The *E. coli* counts ranged from not isolated to 1.663 log_{10} CFU/g. Table 4 also presents the SA counts ranging from 1.505 log_{10}CFU/g to 1.806 log_{10} CFU/g.

Table-3. Effect of location on the bacterial quality (log_{10}CFU/g) of gari.

Local Govt.	Locations	TVBC	TCC	SAL	SHI	EC	SA
Katsina-Ala	Katsina-Ala	3.602	2.146	-	-	1.397	1.301
	Agasoma	3.301	2.000	-	-	1.079	1.161
	Agoasu	3.653	2.361	-	-	1.079	1.342
	Ikyose	3.344	2.079	-	-	1.000	1.301
Makurdi	Tionsha	3.778	2.113	-	-	1.000	1.778
	Mbahaya	3.544	2.000	-	-	-	1.000
	Yagba	3.176	2.161	-	-	1.176	1.113
	Adaka	3.778	1.903	-	-	-	-
	Mbayo	3.204	2.204	-	-	-	0.778
Oju	Obolori	3.602	2.113	-	-	1.100	1.477
	Ihiejwo	3.070	2.113	-	-	1.204	1.402
	Ehurekpe	3.079	2.161	-	-	-	1.000

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*.

Table-4. Mean bacterial load (log_{10}CFU/g) of the Cassava products irrespective of location.

Process Products	TVBC	TCC	SAL	SHI	EC	SA
Cassava peels	4.456	3.025	-	-	1.663	1.806
Cassava chips	4.310	2.623	-	-	1.415	1.579
Fufu	4.334	2.806	-	-	1.447	1.643
Gari	3.193*	2.580	-	-	-	1.505

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*, * = significant difference along the column.

The influence of the methods of processing on the mean bacterial load (log_{10}CFU/g) of the different cassava products is presented in Table 5. Whereas the TVBC values of the traditionally processed cassava peels, cassava

chips and gari did not show any statistically significant differences ($p<0.05$) with the mechanically processed foods, traditional processed fufu significantly had higher TVBC value than mechanically processed ones. Comparison between the traditionally and mechanically processed cassava products for TCC, the difference for each value did not vary significantly. *Salmonella* and *Shigella* spp. were not isolated, whereas the range of *E. coli* and *S. aureus* not isolated to 1.857 and not isolated to 2. 819 (log_{10}CFU/g) respectively.

Table-5. Influence of the methods of processing on the mean bacterial load (log_{10}CFU/g) of the different Cassava products.

Processing method	Cassava product	TVBC	TCC	SAL	SHI	EC	SA
Traditional	Cassava peels	4.220	3.049	-	-	1.681	2.556
	Cassava chips	3.025*	2.681	-	-	1.362	2.716
	Fufu	4.158	3.025	-	-	1.857	2.819
	Gari	2.833*	2.079*	-	-	-	2.447
Mechanical	Cassava peels	4.107	2.982	-	-	1.505	2.362
	Cassava chips	3.009*	2.806	-	-	1.415	2.681
	Fufu	3.121	2.991	-	-	1.623	2.748
	Gari	2.819*	2.415*	-	-	-	-

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*, * = significant difference along the column.

The mean bacterial profile (log_{10}CFU/g) of the cassava chips following different drying methods is shown in Table 6. The total viable bacterial count was highest in cassava chips dried along the roadside (6.98), followed by chips dried at the roofs of houses. Oven-dried cassava chips had the lowest TVBC (2.763). Even though coliform was not isolated from cassava chips dried in the oven and at the roof of houses, roadside drying accounted for the highest TCC (4.486 log_{10}CFU). *Salmonella* and *Shigella* spp. were not isolated from the cassava chips irrespective of the drying method. Similar to TVBC and TCC records, roadside drying presented the highest EC and SA isolates.

Table-6. Mean bacterial profile (log_{10}CFU/g) of the cassava chips following different drying methods.

Drying Method	TVBC	TCC	SAL	SHI	EC	SA
Concrete slab	5.162	2.806*	-	-	2.204	2.914
Mats	5.220	4.025	-	-	2.362	2.914
Oven	2.763*	-	-	-	-	1.204*
Roof of house	4.093**	-	-	-	-	1.623*
Road side	6.968***	4.486	-	-	2.580	3.318

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*, * = significant difference along the column.

Table 7 presents the mean bacterial profile (log_{10}CFU/g) of cassava product used in making fufu following different drying methods. Total viable bacterial count ranged from 2.826 to 5.982 log_{10}CFU. The highest TVBC was recorded in roadside drying followed by drying on concrete slab. The lowest TVBC was recorded oven-dried fufu product. Total coliform count was highest (3.623) in samples dried along roadside and lowest (1.301) in oven-dried fufu samples. In all the parameters assessed, roadside drying gave the highest level of fufu contaminants whereas oven-dried fufu presented the least bacterial load, followed by drying at the roof of houses. No *Salmonella* and *Shigella* spp. were isolated outside roadside drying. The range of *E. coli* and SA were from not isolated to 2.354 and from 1.041 to 1.623 log_{10} CFU/g respectively.

Table-7. Mean bacterial profile (log_{10}CFU/g) of fufu following different drying methods.

Drying Method	TVBC	TCC	SAL	SHI	EC	SA
Concrete slab	4.459	2.215	-	-	1.690	2.025
Mats	4.380	2.250	-	-	1.415	1.982
Oven	2.826*	1.301*	-	-	-	1.021*
Roof of house	3.892	2.361	-	-	0.602*	1.041*
Road side	5.982**	3.623**	1.301	1.00	2.354	1.623

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*, * = significant difference along the column.

The mean bacterial load (log_{10}CFU/g) of gari samples following the different storage places is as shown in Table 8. Total viable bacterial counts and TCC were maximum (4. 350 and 2. 806 log_{10} CFU/g respectively) when the gari was stored in the kitchen and lowest when the storage was in drums (3.982 and 2.380 log_{10} CFU/g respectively). *Salmonella* and *Shigella* spp. were not isolated from the stored gari irrespective of the storage type. *Escherichia coli* isolates ranged from not isolated to 1.556 log_{10} CFU/g. *Staphylococcus aureus* was highest (1.732 log_{10} CFU/g) when the gari was stored in the kitchen and lowest as the gari was stored in drums.

Table-8. Mean bacterial profile (log_{10}CFU/g) of the gari following different storage methods.

Storage Method	TVBC	TCC	SAL	SHI	EC	SA
Kitchen	4.350	2.806	-	-	1.415	1.732
Bags	4.107	2.447	-	-	1.556	1.556
Clay pots	4.065	2.748	-	-	-	1.204
Baskets	4.158	2.505	-	-	1.447	1.681
Head pans	4.033	2.556	-	-	-	1.556
Drums	3.982	2.380	-	-	-	1.681

Note: TVBC = Total Viable Bacterial Counts, TCC = Total Coliform Counts, SAL = *Salmonella* sp. SHI = *Shigella* sp. EC = *E. coli*, SA = *S. aureus*, * = significant difference along the column.

Table-9. Cyanide (HCN) concentration (mg/kg) of the different cassava products.

S/No.	Sample	Mean	Minimum	Maximum
1	Cassava peels	10.75****	7.00**	14.50**
2	Cassava chips	5.35***	2.00*	11.25
3	Fufu	3.78**	0.75	9.40
4	Gari	1.70*	0.85	2.25*

Note: * = significant difference along the column.

The hydrogen cyanide (HCN) content (mg/kg) determined spectrometrically from the different cassava products varied amongst themselves Table 9. The mean, minimum and maximum cyanide (HCN) concentration (mg/kg) of the different cassava products as presented in Table 9 shows there is a progressive decrease in the cyanide contents from cassava peels to cassava chips to fufu and least in gari. The highest hydrogen cyanide content (14.50 mg/kg) was recorded in cassava peels whereas gari had the least hydrogen cyanide (2.25 mg/kg). The hydrogen cyanide of cassava peels was significantly higher than the load of gari.

4. DISCUSSION

Bacteriological quality of the different cassava products processed in the study area was not remarkably differentiated in the line of location, processing, drying or storage even though numerical differences existed. They were differentiated along product lines. The total viable bacterial count is used as a quantitative measure of the level of contamination of food. Even though the different products presented varying TVBC, in the present study, the TBVC obtained were within the recommended limit since the contamination level were not $\geq 10^6$ CFU/g. Cassava products consumed as food and feed are being produced in manners that they are not standardized, bringing queries to the quality and safety indices and most importantly hiking public health concerns [13]. Handling of cassava products with bare hands, drying on bare cement floors, mats or basins, display on open containers during storage and sales, and carriage over a long distance in inappropriate containers and the handling during the process are the major route of transmission of bacteria. Long storage could worsen the food and feed value and demand more public health concerns. All the above listed were observed during the survey in the present study.

The mode of storage calls for concern. From the survey done, the cassava processors were not having conscious efforts to store the products in a way that microbial multiplication is prevented. The increase in relative humidity which is largely responsible for the spoilage of most stored agricultural produce is not put to check. Food safety demands food free of pathogens and spoilage organisms. In industrialized nations, efforts are being made to reduce if not completely eradicate possible food-borne disease outbreak owing to handling. In developing countries, such

handling consciousness is most especially lacking in addition to the non-specialized and non-standardized protocol. These are possible routes of contamination [14].

The study shows the presence of coliforms (TCC) and *Escherichia coli* (EC) within the range of not debatable to 4.486 CFU/g and not debatable to 2.580 CFU/g respectively. Coliforms are surrogate organisms used to indicate quality in addition to some specific indicators like *Escherichia coli*. The presence of these organisms could mean possible material contact with fecal matter. This is not impossible because of the processing and storage operations discussed above. Specific pathogens *Salmonella* and *Shigella* spp were almost not found in predominantly all the cassava samples assayed. The presence of *Staphylococcus aureus* in the products is not surprising since the organism is a normal flora of a human body. The processors could shed the organism unknowingly to the products.

All the gari and fufu samples of the present study had hydrogen cyanide contents lower than the recommended limit of 10 mg/kg [9, 15]. However, some of the cassava peels and cassava chips had cyanide contents higher than the acceptable limit. Consumers of such products are therefore at risk since the toxicity of cyanide to humans even at sub-lethal doses has been well established [1].

The hydrogen cyanide contents of the cassava products of the present study showed significant variation amongst products. Nambisan [7] noted that the cyanide content of cassava largely depends on the variety which is an intrinsic genetic attribute of the plant. Traditional methods of processing of cassava including boiling, drying, parboiling and baking, steaming, frying and preparation to flour reduce cyanide in a range of 25% to 98% [7]. The variation could therefore be attributed to either the difference in the varieties or on the processing protocol used. Cassava peels and chips are not fermented which could account for the higher cyanide contents.

5. CONCLUSIONS

The total viable bacterial counts in the cassava products were high but not higher than the recommended levels. *Salmonella* and *Shigella* spp. were sparingly found in the samples whereas coliform and *Escherichia coli* indicative of poor hygienic status were found. There was a progressive decrease in the cyanide contents from cassava peels to cassava chips to fufu and least in gari. The highest hydrogen cyanide concentration of 14.50 mg/kg recorded in cassava peels was higher than 10 mg of HCN/kg body weight recommended by WHO and therefore poses danger to consumers.

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