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EFFECT OF WATER FROM DIFFERENT SOURCES ON THE MINERAL AND ANTI-NUTRIENT CONTENT OF CASSAVA TUBERS FERMENTED FOR FUFU PRODUCTION

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Abstract: In these research, the mineral and antinutrient content of cassava tubers (Manihot esculenta crantz) steeped in water from different sources for fufu production was investigated. It involved fermentation which was done by steeping peeled cassava tuber in water from five different sources (well, boiled, distilled, stream, tap) for five days. There were variations in the mineral content of both the fermented tuber, the mash and the fufu made from the different water sources with respect to the following minerals iron, sodium, zinc and magnesium, The mineral analysis shows a decrease in the mineral content of the fermented cassava tubers compared with the fresh cassava tuber with the magnesium content of the fresh cassava tuber which reduced from 428.53ppm to 309.21ppm for tubers fermented with stream water, 230ppm for tubers fermented with tap water, 288.46ppm for tubers fermented with boiled water, 228.52ppm for tubers fermented with distilled water. The antinutrient content decreased after fermentation with the tubers fermented with tap, stream and boiled having the lowest cyanide content reducing from $4.07^{b}\pm0.16$ to (2.44Mg) while fufu made with tap water had the lowest cyanide content(1.90Mg), cassava tubers fermented with tap water had the lowest phytate content of $2.476^{ab}\pm0.00$. Sensory evaluation was conducted on the fufu with regards to the following parameters Taste, Aroma, Texture, Appearance, and it was observed that the fufu prepared with well, distilled and tap water were most preferred, with regards to taste, appearance and textures respectively while the fufu made with boiled water had the highest numbers of dislike with regards to appearance, taste, texture and aroma.Cassava tuber steeped in tap water retained more of the nutrients with minimal antinutrient content and is therefore recommended for fermentation of cassava tubers for fufu production.

Keywords: Mineral, Antinutrient, Water, Cassava, Fermentation, Fufu

1. INTRODUCTION

Cassava (Manihot esculenta crantz) is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world. Cassava, which has its origin from tropical America, is now a dietary staple in most of tropical African countries (EI-Sharkawy, 2004). Nigeria is the world's largest producer of cassava and one of the major exporters of cassava to other countries and continents.

Like other roots and tubers, cassava contains anti-nutritional factors and toxins. It must be properly prepared before consumption. Improper preparation of cassava can leave enough residual cyanide to cause acute cyanide intoxication and goiters, and may even cause ataxia or partial paralysis (Aregheore and Agunbiade, 1991). To these end, cassava tubers are subjected to fermentation process before consumption (Nweke et al., 2002). This process is necessary in other for carbohydrate foods to be broken down to alcohol and acids anaerobically, during which toxic chemicals are reduced or eliminated. (Onabolu et al., 2002).

Inspite of some factors that tend to limit human and animal consumption of cassava (Kakes, 1990; Babu and Chatterjee, 1999), fufu remains a favourite cassava-based entree popular in many parts of West Africa. One major product of cassava is the fufe. The effect of some processing variables like length of fermentation time on the fermentation of cassava tubers to fufu have been well documented (Oyewole and Odunfa, 1992, Blanshard, et al, 1994).

There is however, little or no information on the effect of water used for fermentation on the nutritional value of fermented cassava and fufu. With the rising mortality rate due to water borne diseases and food poisoning, it is of great need to identify a source of water that reduces health risk while increasing health benefits and nutritional value of fufu. This research is thus, focused at understudying and evaluating the effect of water from different sources used in the fermentation of cassava tuber on the mineral and antinutrient content of both the fermented tubers and the fufu produced.

2. MATERIALS AND METHOD

— Materials

Materials – Plastic buckets, Jericans, Knife, Cassava tubers, Water from different sources (tap, well, distilled, boiled, stream), Syringes, Test tubes, Alumillium foil, Test tube rack. Tap water, stream water and well water were collected from Akure, Nigeria. Distilled water was collected from Crop soil and pest laboratory, Akure, Nigeria. The cassava tubers were obtained from Ilara-mokin, Nigeria.

— Experimental Procedure

Prior to the processing of the obtained cassava, the well water was heated to boiling point of 100°C in other to make it sterile devoid of any microorganism and allowed to cool to obtain boiled water sample. Cassava tuber (800g) were weighed separately into five portions, peeled in other to remove the cassava tuber peel, washed with water to remove the dirts on the peeled cassava tubers and steeped into five different plastic buckets containing 4liters of water from the different sources (well, stream, distilled, boiled and tap) and allowed to ferment for five days. The retted cassava was mashed by passing it through sieve of 200µm mesh size and then cooked to produce "fufu" (Oyetayo, 2006). Figure 1 shows the flowsheet for the production of fufu from cassava.

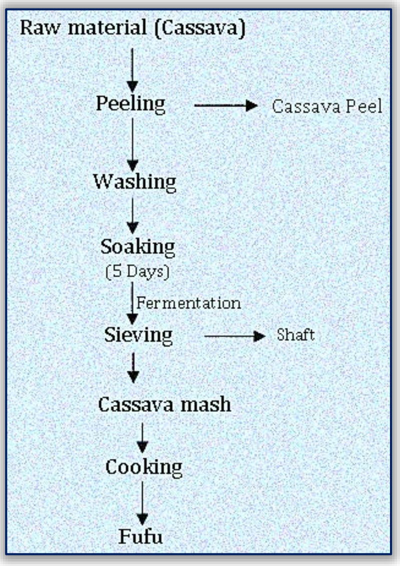

Figure 1: Step by step preparation of fufu

— Mineral analysis of cassava and fermented cassava products

The minerals were analyzed from the solution obtained by first dry-ashing. Samples of the ashed fresh cassava tuber and fermented cassava tubers (1g) each were placed in a crucible and placed in a muffle furnace at 550°C for 5hrs to ash. It was further transferred into desiccators to cool. The cooled ash was dissolved in 10% HCl and filtered into a clean graduated sample bottles, the solution was made up to 50ml with distilled water. The solution was aspirated into the atomic absorption spectrophotometer to obtain the mineral concentrations.

— Anti-nutritional analysis of fresh and fermented cassava tuber

≡ Phytate Content

The phytic acid in the samples (fresh cassava tuber, fermented cassava tuber and fufu) were precipitated with excess $FeCl_3$ after extraction of 10g of each sample with 100ml 0.5N HCl. The precipitate was converted to sodium phytate using 2ml of 2% NaOH before digestion with an acid mixture containing equal portions (1ml) of conc. H_2SO_4 and 65% $HClO_4$. The liberated phosphorus was measured calorimetrically at 620nm after colour development with molybdate solution. The amount of phytate in each sample was estimated from the equation:

$$\text{Mg/g Phylate} = Vt \times 8.24 \qquad \text{where } t = \text{titre value}$$

≡ Oxalate Content

Five grams of the sample (fresh cassava tuber, fermented cassava tuber and fufu) were weighed into a 100ml beaker, 20ml of 0.30N HCl was added and warmed to (40 – 50°C) using magnetic hot plate and stirred for one hour. It was extracted three times with 20ml of 0.30N HCl and filtered into a 100ml volumetric flask. The combined extract was diluted to 100ml mark of the volumetric flask.

The oxalate was estimated by pipetting 5ml of the extract into a conical flask and made alkaline with 1.0ml of 5N NH_4OH. A little indicator paper was placed in the conical flask to enable us know the alkaline regions. It was also made acid to phenolphthalein (2 or 3 drops of this indicator added, excess acid decolourizes solution) by drop-wise addition of glacial acetic acid. 1.0ml of 5% $CaCl_2$ was then added and the mixture allowed to stand for 3hrs after which it was then centrifuged at 3000rpm for 15min.

The supernatants were discarded and the precipitates washed 3 times with hot water with thorough mixing and centrifuging each time. 2 ml of 3N H_2SO_4 was added to each tube and the precipitate dissolved by warming in a bath (70- 80°C). The content of all the tubes was carefully poured into a clean conical flask and titrated with freshly prepared 0.01N $KMnO_4$ at room temperature until the first pink colour appeared throughout the solution. It was allowed to stand until the solution became colourless. The solution was then warmed to 70 – 80°C and titrated until a permanent pink colour that persisted for at least 30 seconds was attained. The amount of oxalate in each sample was estimated from the equation:

$$\text{Mg/g}_{\text{Oxolate}} = Vt \times 0.9004 \qquad \text{where } t = \text{titre value.}$$

≡ Tannin Content Determination

Finely ground sample of fresh cassava tuber, fermented cassava tuber and fufu (0.2g) were weighed into a 50ml sample bottle. 10ml of 70% aqueous acetone was added and properly covered. The bottle were put in an ice bath shaker and shaken for 2hours at 30°C. Each solution was then centrifuge and the supernatant store in ice. Each solution (0.2ml) was pipetted into the test tube and 0.8ml of distilled water was added. Standard tannin acid solutions were prepared from a 0.5mg/ml of the stock and the solution made up to 1ml with distilled water. Folinciocateau reagent (0.5ml) was added to both sample and standard followed by 2.5ml of

20% Na_2CO_3 the solution were then vortexed and allow to incubate for 40minutes at room temperature, its absorbance was read at 725nm against a reagent blank concentration of the same solution from a standard tannic acid curve was prepared (Makkar and Goodchild. 1996).

≡ Cyanide Content Determination

An enzymatic assay was used for the cyanide content determination of cassava tubers, fermented tubers and fufu. The food samples were first homogenised in orthophosphoric acid; filtered through glass-fibre paper and aliquots of the filtrate are neutralised and incubated with exogenous linamarase for 15 min. The cyanogenic glucosides present were hydrolysed to free cyanide which is estimated spectrophotometrically. The acid extraction solution inactivates endogenous linamarase, and assay of aliquots without enzyme treatment gives the free (non-glycosidic) cyanide contents of the extracts.

≡ Sensory analysis

A semi-trained panel of fifteen students (undergraduate and post graduate) of the Federal University of Technology Akure, who are familiar with cassava fufu were used to examine the texture, aroma, taste and appearance of cooked fufu produced with different water sources. The test was based on a scale which ranged from "like extremely having 3 points" to "dislike having 1 point". After which the average score of all the panelist for the four attributes (taste, aroma, texture and appearance) of all the samples were determined.

3. RESULTS

— Mineral content of the cassava tubers and various treaments

The mineral content of the water samples before and after being used for fermentation of the cassava tubers is shown in Figureure 1. Minerals such as iron,zinc,magnesium,sodium and calcium carbonate were observeed to be present in the fermented product. The sodium, iron,magnesium,calcium carbonate and zinc content of both fresh cassava tubers and the products of the tubers processed with different water sources are shown on Figures 2 to 6 respectively. Cassava tubers in stream water had the highest sodium content while tubers fermented with distilled water had the lowest sodium content, for magnesium tubers fermented with well water had the highest magnesium content while tubers in stream water had the lowest though there was a general decrease in the mineral content of the tubers after fermentation but the rate varied considerably among the water sources used for the fermentation of the cassava tubers.

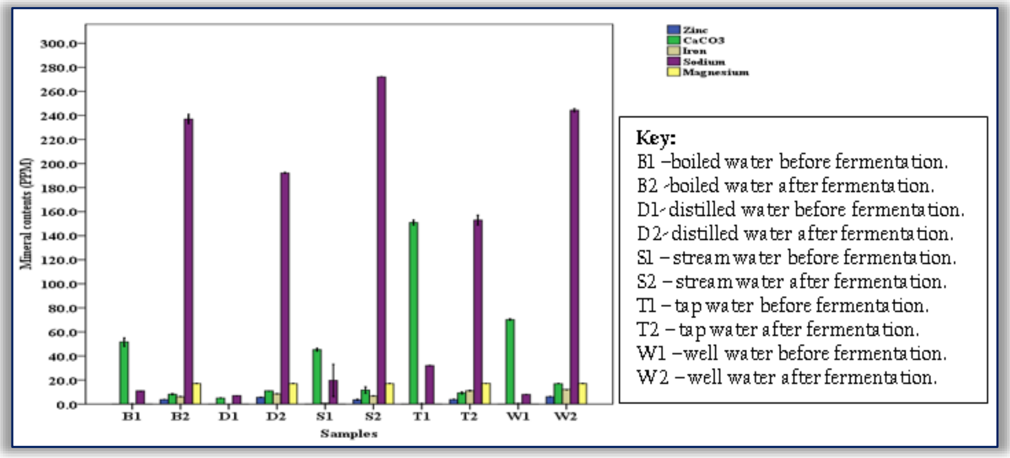

Figure 1: Mineral content of water samples before and after fermentation of cassava tubers

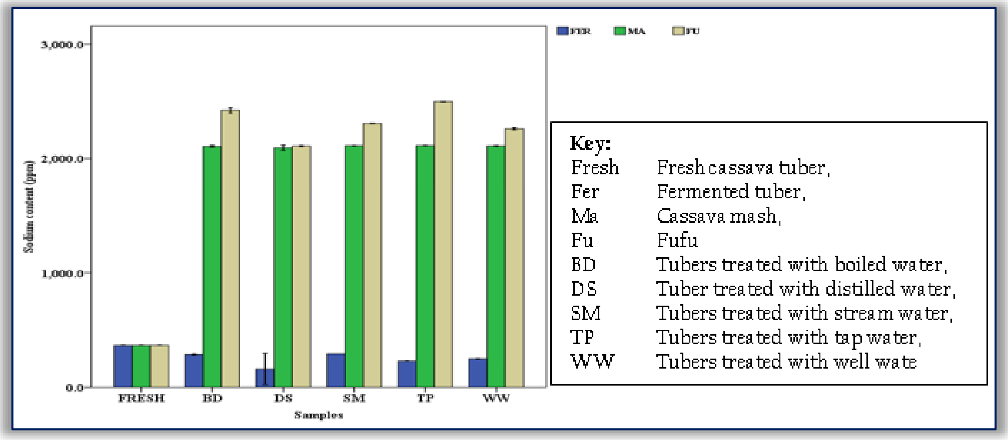

Figure 2: Sodium content of fermented cassava tubers and processed cassava products

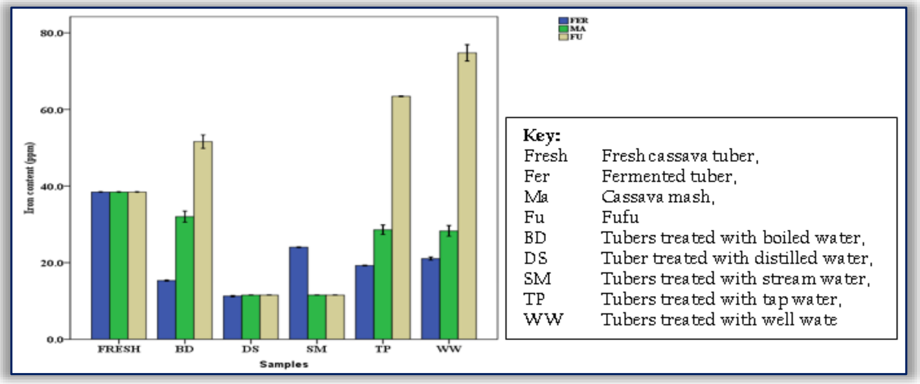

Figure 3: Iron content of fermented cassava tubers and processed cassava products

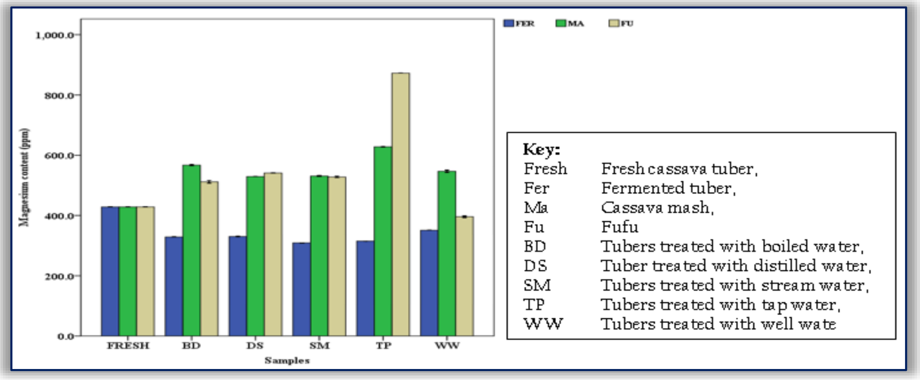

Figure 4: Magnesium content of fermented cassava tubers and processed cassava products

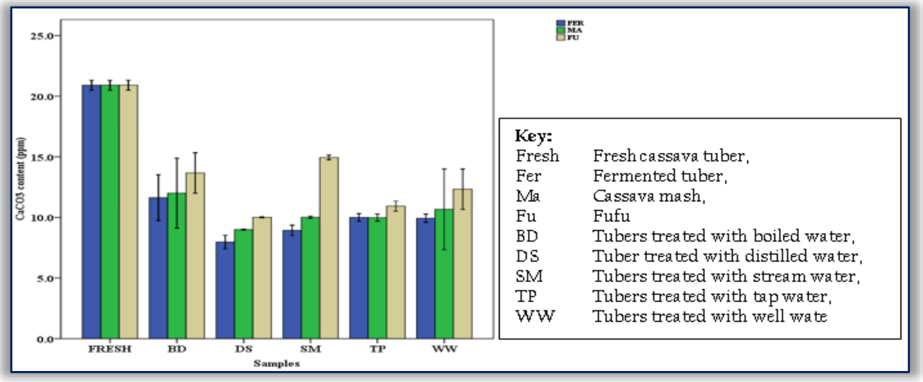

Figure 5: Calcium carbonate content of fermented cassava tubers and processed cassava products

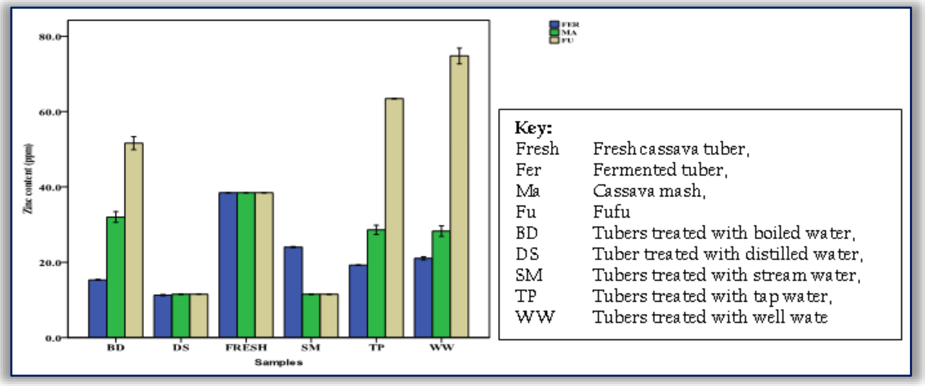

Figure 6: Zinc content of fermented cassava tubers and processed cassava products

- **Sensory evaluation of fufu made with different water sources**.

The cumulative average scores of all the fifteen judges for the sensory evaluation of fufu made with different water sources is shown in Table 5. It was observed that fufu made with distilled, well and tap water were most preferred based on the taste, aroma. Texture and appearance while fufu made with boiled water was least preferred in terms of its texture and appearance.

Table 1: cyanide content of fermented cassava tubers and processed cassava products

Samples	FER	FU
FRESH	$4.07^{b}\pm0.16$	$4.07^{b}\pm0.16$
TP	$2.44^{a}\pm0.16$	$1.90^{a}\pm0.16$
WW	$2.72^{a}\pm0.01$	$2.18^{a}\pm0.01$
SM	$2.44^{a}\pm0.16$	$2.17^{a}\pm0.00$
BD	$2.44^{a}\pm0.16$	$2.16^{a}\pm0.01$
DS	$2.71^{a}\pm0.00$	$2.17^{a}\pm0.00$

a-e Means in the same column not sharing a common letter are significantly different at P= 0.05 by duncan's multiple range test.
Mean value followed by similar alphabet along same column are not significantly different at P=0.05

Table 2: tannin content of fermented cassava tubers and processed cassava products

Samples	FER	FU
FRES	$0.67^{b}\pm0.01$	$0.670^{b}\pm0.01$
TP	$0.06^{a}\pm0.00$	$1.895^{b}\pm0.16$
WW	$0.03^{a}\pm0.00$	$0.026^{a}\pm0.00$
SM	$0.06^{a}\pm0.00$	$0.026^{a}\pm0.00$
BD	$0.06^{a}\pm0.00$	$0.053^{a}\pm0.00$
DS	$0.03^{a}\pm0.00$	$0.027^{a}\pm0.00$

a-e Means in the same column not sharing a common letter are significantly different at P= 0.05 by duncan's multiple range test.
Mean value followed by similar alphabet along same column are not significantly different at P=0.05

Table 3: phytate content of fermented cassava tubers and processed cassava products

Samples	FER	FU
FRES	$3.708^{b}\pm0.24$	$3.708^{c}\pm0.24$
TP	$2.476^{ab}\pm0.00$	$2.477^{b}\pm0.00$
WW	$2.886^{ab}\pm0.24$	$2.062^{ab}\pm0.24$
SM	$2.886^{ab}\pm0.24$	$2.062^{ab}\pm0.24$
BD	$2.886^{ab}\pm0.24$	$1.649^{ab}\pm0.00$
DS	$2.886^{a}\pm0.24$	$1.648^{a}\pm0.00$

a-e Means in the same column not sharing a common letter are significantly different at P= 0.05 by duncan's multiple range test.
Mean value followed by similar alphabet along same column are not significantly different at P=0.05

Table 4: oxalic acid content of fermented cassava tubers and processed cassava products

Samples	FER	FU
FRESH	$0.405^{b}\pm0.03$	$0.405^{ab}\pm0.03$
TP	$0.182^{a}\pm0.00$	$0.092^{a}\pm0.00$
WW	$0.180^{a}\pm0.00$	$0.180^{ab}\pm0.00$
SM	$0.138^{a}\pm0.03$	$0.540^{b}\pm0.21$
BD	$0.183^{a}\pm0.00$	$0.540^{b}\pm0.54$
DS	$0.186^{a}\pm0.00$	$0.135^{ab}\pm0.03$

a-e Means in the same column not sharing a common letter are significantly different at P= 0.05 by duncan's multiple range test.
Mean value followed by similar alphabet along same column are not significantly different at P=0.05

Table 5:culmulative average score for the sensory evaluation of fufu produced using different water sources

Sample	Taste	Aroma	Texture	Appearance
A	3	3	3	3
B	3	3	3	3
C	3	3	3	3
D	2	2	2	2
E	2	2	1	1

Key:
A= Fufu made with tap water
B= Fufu made with well water
C= Fufu made with distilled water
D= Fufu made with stream water
E= Fufu made with boiled water

4. DISCUSSIONS

In this study, it was observed that the mineral content of both fermented cassava tubers, and different water sources used for the fermentation changed after fermentation, such change is due to leaching. Oluwole et al., 2004 reported that soaking fresh cassava tubers for days result in significant reduction in mineral content of prepared diets due to leaching. There was a general increase in the sodium content of the water after fermentation with the stream water infusion and the tubers fermented with stream water having the highest sodium content, this could be due to high sodium content in the stream water before being used for fermenting the cassava (Figure 2). It was also observed that heating or cooking might increase the sodium content of the fufu during preparation since there was an increase in the sodium content of the fufu with fufu made with tap water having the highest sodium content, though this could also be due to the concentration of the cassava mash used in the fufu preparation, also the elimination of water could also lead to such increase in the sodium content.

The magnesium content of the fresh cassava tuber decreased after fermentation with tubers steeped in well water having the highest magnesium content while fufu prepared with tap water had the highest magnesium content (Figure 4). This may be as a result of high magnesium content in well and tap water. Being aware of the health benefits of magnesium will help us to pay more attention to our choice of water when producing fufu for human consumption as magnesium is needed for more than 300 biochemical reactions in the body also required for energy production. Tuber in distilled water had the lowest iron content, this may be due to the de-mineralized state of the water. While fufu produced with tap and well water had the highest iron content and Iron is a mineral that is very important to a healthy body, According to Medline plus Medical Encyclopedia, iron is needed to form part of the blood, iron is also needed by the human body to make the oxygen-carrying proteins, it is also an essential constituent of haemoglobin, myoglobin and a number of enzymes. Zinc is also an important mineral essential to a good health and healthy immune system so since the fufu produced with well and tap water had the highest zinc content, this indicates that our choice of water in preparing cassava fufu is of paramount importance.

Anti-nutrients are chemical substances that are inherent in staple food crops. These substances antagonize and reduce the nutritional value of food interfering with mineral bioavailability and digestibility of essential nutrients thereby making them unavailable for the cells when consumed (Ames et al., 1990). One of such anti-nutrients is cyanide which fermentation process helps to decrease its content (Cereda, and Mattos, 2003), in this study, despite a general reduction in the cyanide content of all the tubers fermented with the different water sources, There was a further reduction of the cyanide in the fufu made from all the water sources used for fermentation with fufu made with tap water having the lowest cyanide content. This are evidence that in addition to the fermentation process, cooking further helps in the removal of the toxic compound (Cooke and Madugwu, 1978).Most of the anti-nutrients found in food crops can be reduced by post- harvest processing (Uyoh,et al 2009). There are many proteinase inhibitors that are denatured easily by heating. Cyanogenic glycosides, which are found in cassava, produce hydrogen cyanide on hydrolysis. This, when consumed, is converted to thiocyanate which can interfere with iodine metabolism giving rise to goiter and cretinism (Ames et al., 1990). That is why the water source that better reduces the cyanide content of fermented cassava tubers and the fufu is most preferred.Tubers in tap water had the lowest phytate content due to dephosphorylation of phytate which occurs during processing of cassava, especially during fermentation where > 85% of phytate is removed (Marfoet al., 1990).

Nutritional inhibitors such as Oxalic acid when consumed in large quantities causes gastroenteritic shock, convulsive symptoms and renal damage. These effects can be reduced through post-harvest processing. However, oxalates play a very important role in limiting the availability of some elements like calcium, manganese and phosphorus in the food crops. Also the consumption of oxalate causes stone formation in the urinary tract. Having this in mind, foods containing little or no oxalate will be safe for consumption and in this study fufu produced with tap water had the lowest oxalate content (0.092) followed by fufu made with distilled water (0.135).

Tannins are considered anti-nutrients because they can interfere with the absorption of iron and other minerals as well as precipitate dietary proteins potentially rendering them indigestible. This is evident in this research work because fufu made with well water had the lowest tannin content and the highest iron content.

The sensory evaluation conducted on the fufu processed with different water sources, after determining the average score of all the 15 panelist for all the four attributes it was observed that fufu made with tap, well and distilled water were most preferred in terms of taste, aroma, texture and appearance while fufu made with boiled water was least preferred for all the attribute, fufumade with boiled water had the highest number of dislikes indicating thatboiled water is not suitable for fermentation of cassava tubers for fufu production.

5. CONCLUSION

Water is an inorganic, transparent, tasteless, odourless chemical substance which is the main constituent of earth's hydrosphere, it is a universal solvent and plays an important role in submerged fermentation. Submerged fermentation of cassava tubers leads to leaching off of toxic chemicals such as cyanide, tannin, phytate and oxalic acid that are inherent in cassava tubers and also some essential minerals are reduced so it is important that the choice of water used should be one that can retain those essential minerals, In this study cassava tubers steeped in and processed into fufu with well and tap water had the highest zinc, iron and magnesium content and these are minerals essential for a healthy body system while fufu processed with tap water had the lowest cyanide content. I therefore encourage fufu processors to pay attention to the sources of water used in processing cassava tubers into fufu.

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