



PHYSICOCHEMICAL ANALYSIS OF READY-TO-EAT COMMERCIAL FUFU SOLD IN BENIN CITY NIGERIA

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Abstract: Physicochemical analysis of ready-to-eat commercial fufu sold in Benin City, Nigeria was carried out. Samples of ready-to-eat *fufu* were purchased from the five different markets (Uselu, Oba, Aduwawa, New Benin and Santana). The samples were immediately taken to the laboratory for physicochemical analyses. Results shows pH range from 4.00 ± 0.00 (Oba market) to 4.04 ± 0.01 (New Benin market), titratable acidity from 0.39 ± 0.01 (Uselu market) to 0.41 ± 0.02 (Aduwawa market), percentage ash from 1.53 ± 0.02 (Santana market) to 1.61 ± 0.01 (New Benin market), percentage moisture from 6.25 ± 0.01 (Aduwawa market) to 6.28 ± 0.01 (Oba market), percentage crude fibre from 0.95 ± 0.01 (Santana market) to 1.03 ± 0.02 (Uselu market), percentage protein from 1.59 ± 0.01 (Santana market) to 1.63 ± 0.01 (Oba market), percentage carbohydrate from 84.10 ± 0.01 (New Benin market) to 85.19 ± 0.02 (Santana market) and percentage cyanide from 1.08 ± 0.01 (Uselu market) to 1.11 ± 0.01 (New Benin market). There was a significant difference ($P < 0.05$) in all the physicochemical parameters analyzed among the different markets. Good personal hygiene and sanitation from the handlers of *fufu*, raising the temperature of *fufu* prior to consumption and close monitoring of the production processes as well as the fortification of *fufu* with essential nutrients should be encouraged.

Keywords: Analysis, fermentation, *fufu*, physicochemical parameters

Introduction

Cassava (*Manihot esculenta* Crantz) is the staple root crop of over 800 million people in the humid tropics and ranks sixth in terms of overall global crop production (Nassaret *et al.*, 2007; Han *et al.*, 2001). It is a perennial woody shrub with an edible root, which grows in tropical and sub-tropical areas of the world (Burrell, 2003). Cassava is one of the most important food crops in the tropics that serve as a food security and income generation crop for many millions of people in the developing world (Scott *et al.*, 2002). It is one of the most important food staples in the tropics, where it is the fourth most important source of energy (Hillocks *et al.*, 2002). Worldwide, it is the sixth most important source of calories in the human diet (El-Sharkawy, 2004) and the third most important in the tropics after rice and maize (Prakash, 2006). The main cassava food products of considerable domestic importance in Nigeria are garri in the south, lafun in the west and *fufu* in the east (Olopadeet *et al.*, 2014). *Fufu* is an acid-fermented cassava product produced through submerged fermentation of peeled cassava roots in water and consumed in Nigeria, West African countries and other parts of the world. The principal parts of the mature cassava plant expressed as a percentage of the whole plant are 6% leaves; 44 % stems and 50% storage roots. The roots and leaves of the plant are the two most nutritionally valuable parts that serves as food source. The cassava storage root is essentially a carbohydrate source. Its composition shows 60-65% moisture, 20-31% carbohydrate, 0.2-0.6% ether extracts, 1-2% crude protein and a comparatively low content of vitamins and minerals. The root carbohydrate is made up of 64-72% starch. However, the roots are rich in calcium and vitamin C and contain other significant nutritionally quantities such as thiamine, riboflavin and nicotinic acid that are lost during processing (Nwekeet *et al.*, 2002). During the fermentation of *fufu*, lactic acid bacteria, yeast and other bacteria contribute significantly to starch breakdown, acidification, detoxification and flavour development and enhancement (Oyewole 1991). Among the fermented products of cassava, *fufu* is one of the favourite consumed in many parts of West Africa countries (Uyohet *et al.*, 2009). This is produced by steeping in water peeled cassava cubes for 24 – 72 h. The fermented cassava is sieved to remove the fibers and allow to sediment. After sedimentation, the water is decanted and the sediment is dried,

milled and the *fufu* flour is obtained (Sanniet *et al.*, 2007; Tomlinset *et al.*, 2007).

A major limitation is the toxicity of the cassava roots, cyanogenic glycosides linamarin and lotaustralin which are produced in the process and needs to be detoxified (Nweke and Bokanga, 1994). In Africa, improperly processed cassava is a major problem and it is associated with a number of cyanide-related health diseases, particularly among people who are already malnourished and this is also made worse by the high level of poverty in the continent (Maziya-Dixon *et al.*, 2007). The cyanogenic glycosides begin to break down upon harvest into hydrocyanic acid, acetone and glucose by the action of the enzyme linamarase and the presence of hydrocyanic acid is easily recognized by a bitter taste (Nweke and Bokanga, 1994). Hydrolysis of the glycoside by enzyme can be accelerated by soaking the roots in water, by crushing, cutting or heating. The magnitude of cyanogen varies greatly among different plant species. Cassava contains cyanogenic glucosides in the form of linamarin (95%) and, to a lesser extent, lotaustralin (5%) (Nwekeet *et al.*, 2002; Blagbrought *et al.*, 2010; Montagnac *et al.*, 2009). The amount of cyanogenic glucosides varies with the part of the plant, its age, variety, and environmental conditions as soil moisture and temperature (Oluwoleet *et al.*, 2007). Giraud *et al.* (2002) demonstrated the ability of certain strains of lactic acid bacteria (LAB) to break down cassava linamarin that would lead to the production of a standardized and non-toxic foodstuff. Other studies also confirmed that detoxification of cassava gave the best results when a starter culture consisting of *Lactobacillus plantarum* was used (Holzapfel, 2002). The possibility of chronic toxicity is associated with the habitual consumption of large quantities of cassava products or with consumption of insufficiently processed cassava when the diet is deficient in protein (Nwekeet *et al.*, 2002; Blagbrought *et al.*, 2010). *Fufu* is produced, sold and eaten in Nigeria and West African countries without any formal regulations or certification and this necessitate need for physicochemical studies in order to ascertain the physicochemical and nutritional attributes of the *fufu*.

The study was aimed at evaluating the physicochemical qualities of the commercially available ready-to-eat fermented *fufu* sold in Benin City, Nigeria.

Material and Methods

Study area

This research work was carried out in Benin City, Edo State, Nigeria. Benin City is located on latitude 6.34°N, longitude 5.63°E and 80 m elevation above the sea level.

Collection of sample

Fifty (50) samples (Ten from each market) of ready-to-eat *fufu* were purchased from different five markets (Uselu, Oba, Aduwawa, New Benin and Santana) at different locations (area) in Benin City. They were placed into sterile polythene bags and were taken to the Laboratory within an hour for analysis.

Physiochemical analysis

The *fufu* samples were analyzed for pH, titratable acidity, percentage moisture content, percentage ash contents, percentage protein content, percentage carbohydrate content and percentage cyanide content in triplicate in each of the sample collected at the different market.

Determination of pH

The pH of the samples was determined following the method described by Ogiehor and Ikenebomeh (2005). Ten grams of each sample were homogenized in 10 ml of distilled water and the pH of the suspension determined using a reference glass electrode using a HANNA pH meter (HANNA Instruments, model HI96107, Italy).

Determination of titratable acidity

Exactly 10 g of the sample was homogenized in 200 mL of distilled water and was filtered using Whatman filter paper. 80 mL of filtrate was titrated with 0.1MNaOH using 1% phenolphthalein as indicator (Obilie et al., 2004).

Determination of cyanide content

Hydrogen cyanide content was determined according to the procedure Oghenechavwuko et al. (2013) on the *fufu* samples. Ten grams of the ground sample was put into a Kjeldahl flask, approximately 200 ml of distilled water was added and allowed to stand for 2 – 4 h. It was then steam distilled and about 150 – 160 ml of distillate was collected over 2.5% NaOH solution. Thereafter 8 ml of NH₄OH and 2 ml of 5% KI were added to 100 ml of the distillate. Finally, the distillate was titrated against 0.02NAgNO₃. Endpoint was faint but permanent turbidity was easily recognized against a black background. HCN content was calculated using the equations below:

$$\text{HCN (mg)} = \frac{\text{ml titrates (sample-blank)}}{\text{ml titrate of blank}} \times 20 \times \frac{\text{normality of AgNO}_3}{0.02}$$

$$\% \text{ HCN} = \frac{\text{HCN (mg)} \times 100\%}{\text{mg sample}}$$

Determination of moisture content

2 g of *fufu* was weighed into a pre-weighted flat dish as (W1) and dried at an oven temperature of 105°C for 3 h as W2. The crucible with the sample was then placed in a well-ventilated oven (Fisher Scientific Co. USA, model 65SF) maintained at 105°C for 16 – 18 h. The process was repeated until constant weight was obtained W3 (AOAC, 1990). The percentage moisture was calculated from the equation below.

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where: W1 = weight of sample before drying.

W2 = weight of sample + crucible before drying.

W3 = weight of sample + crucible after drying.

Determination of ash content

The crucible dish was cleaned, dried ignited, cooled and weighed as W1. Two grams of *fufu* was weighed accurately and directly in the dish as W2. The crucible dish was then

placed on a hot plate inside the fume cupboard to char the organic matter, while the remaining residue (inorganic matter) was later transferred into the muffle furnace, (Fisher Scientific Isotemp Muffle by Fisher Scientist Co. USA, model 186A) maintained at 600°C for 6 h to completely ash the sample as W3 (AOAC, 1990). The crucible dishes were then transferred into a desiccator to cool and they were weighed thereafter. The percentage ash content was calculated as follows:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Where: W1 = weight of sample

W2 = weight of crucible + sample before ash formation.

W3 = weight of crucible + sample after ash formation

Determination of crude fibre

Two grams of the sample and a gram of asbestos were put into 200 ml of 1.25% of H₂SO₄ and boiled for 30 min. The solution and content were then poured into Buchner funnel equipped with muslin cloth and secured with elastic band. This was allowed to filter and residue was then put into 200 ml boiled NaOH and boiling was continued for 30 min, and it was then transferred to the Buchner funnel and filtered. It was then washed twice with alcohol, and the material obtained was washed thrice with petroleum ether. The residue obtained was then put in a clean dry crucible and dried in an oven to a constant weight. The dried crucible was removed, cooled and weighed. Then, difference of weight (i.e. loss in ignition) was recorded and expressed as percentage of crude fibre according to Nwokekeet al. (2013)

$$\% \text{ Crude fibre} = \frac{W_1 - W_2}{W_3} \times \frac{100}{1}$$

Where: W1 = weight of sample before incineration

W2 = weight of sample after incineration

W3 = weight of original sample

Determination of protein content

The protein content of each sample was determined using the Kjeldahl Nitrogen method described by AOAC (1990). A 0.5 g of each sample was carefully weighed into the kjeldahl digestion tubes to ensure that all materials get to the bottom of the tubes. One (1) tablet of kjeldahl catalyst and 10 ml of concentrated H₂SO₄ were added before setting in the appropriate hole of the digestion block heaters in a fume cupboard for 4 h. The digest was then cooled and carefully transferred into 100 ml volumetric flask thoroughly rinsing the digestion tube with distilled water. 5 ml portion of the digest was then pipette into the distillation apparatus and 5 ml of 40% (w/v) NaOH was added. The mixture was steam distilled for 2 min into 500 ml conical flask containing 10 ml of 2% Boric acid with mixed indicator solution and placed at the receiving top of the condenser. The solution was then titrated against 0.01NHCl in a 50 ml burette.

% Nitrogen =

$$\frac{\text{Titre value} \times \text{Molarity of HCl used} \times \text{Atomic mass of Nitrogen} \times \text{Volume of flask containing the digest}}{\text{Weight of sample digested in Mg} \times \text{Volume of digest for steam distillation}}$$

$$\times 100$$

$$\% \text{ Crude protein} = \% \text{ Nitrogen} \times 6.25$$

Determination of carbohydrate content

The Percentage carbohydrate content was determined according to the method described by AOAC(1990). The percentage (%) carbohydrate = 100 - (% moisture + % ash + % crude fibre + % protein + % cyanide).

Statistical analysis

The whole experiment was replicated three times and data obtained were analyzed using ANOVA. These analyses were carried out using Statistical Package for Social Sciences (SPSS) Package Version 20. One Way Analysis of Variance (ANOVA) was used to analyze the physiochemical parameters and differences in mean was established using

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Duncan multiple range test at 5% level of significance (Ogbeibu, 2005)

Results and Discussion

The result of the physicochemical parameters analyzed is showed in Figs. 1 – 8. There was a significant difference ($P < 0.05$) in all the physicochemical parameters (pH, titrable acidity, percentage moisture, percentage ash, percentage crude fibre, percentage protein, percentage carbohydrate and cyanide) of the *fufu* samples analysed among the different markets in Benin City. This could be due to the fact that the samples were obtained from the same region or area where similar fermentation methods are used in the preparation or processing of *fufu*. In Fig. 1, the pH of *fufu* ranged from 4.00 ± 0.01 (Oba and Santana markets) to 4.04 ± 0.01 (New Benin market). This is in agreement with Adebayo-Oyetoro et al. (2013) on the microbiological safety assessment of fermented cassava flour “*Lafun*” available in Ogun and Oyo States of Nigeria. All the *fufu* samples had acidic pH and this is in line with the report of Adewole (2005), Achi and Akoma (2006) which stated that the pH value of fermented cassava (*fufu*) falls within the pH range of (3.65-5.12).

Despite the unhygienic wet-milling and wet-sieving processes involved in the traditional preparation of both *fufu*, the low pH of the fermented products would make them safe for consumption against microorganisms that cannot survive at this pH range. Also the acidic fermentation and lactic acid metabolites are responsible for inactivation of *Enterobacteriaceae* including toxin-producing and food borne infectious pathogens (Ana et al., 2006; Byaruhanga et al., 1999; Kunene et al., 1999). This results in an improvement in the organoleptic (aroma, flavor, texture, safety and shelf life) of the food.

The titratable acidity of *fufu* in Fig. 2, ranged from 0.39 ± 0.01 (Uselu and New Benin markets) to 0.41 ± 0.01 (Aduwawa market). The close range in titratable acidity could be due to the similar microorganism isolated from the *fufu*. The percentage ash content (Fig. 3) ranged from 1.53 ± 0.01 (Santana market) to 1.61 ± 0.01 (New Benin market). The low ash contents could be as a result of the length of fermentation and this is supported by the report by Uzomahet al. (2001) on the assessment on fermented garri in Southern Nigeria.

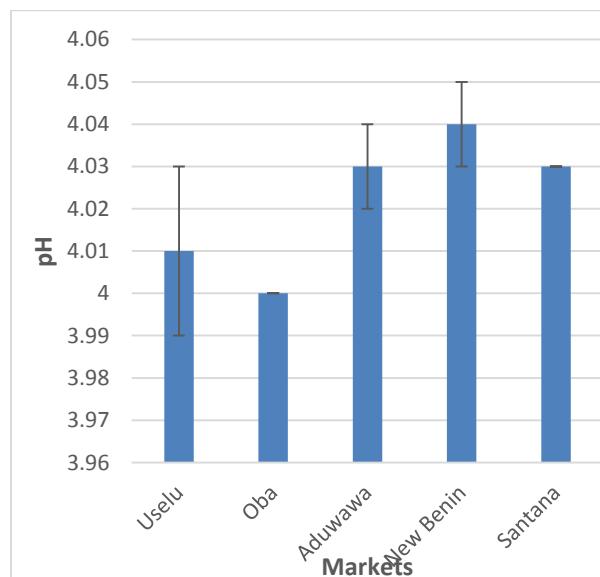


Fig. 1: Comparison of the pH of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual pH of the samples at the different market at $P = 0.05$.

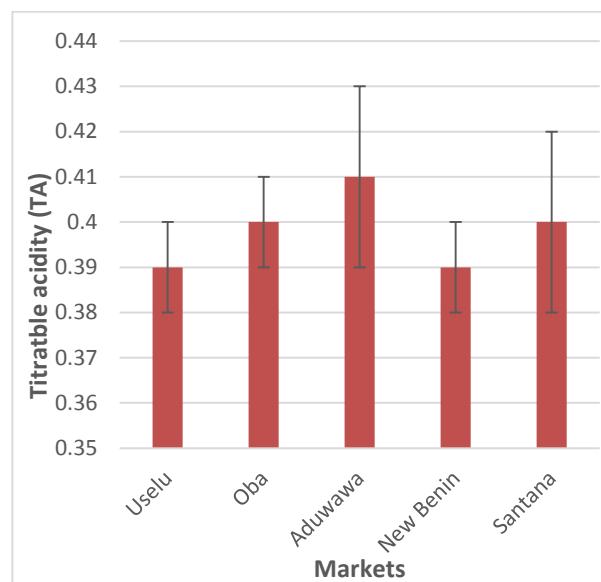


Fig. 2: Comparison of the titratable acidity (TA) of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual TA of the samples at the different market at $P = 0.05$.

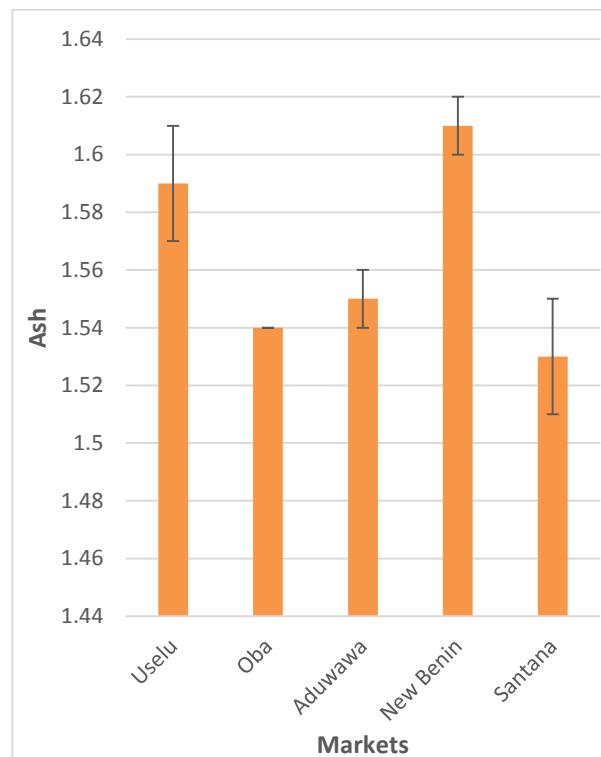


Fig. 3: Comparison of the percentage of ash content of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual ash contents of the samples at the different market at $P = 0.05$.

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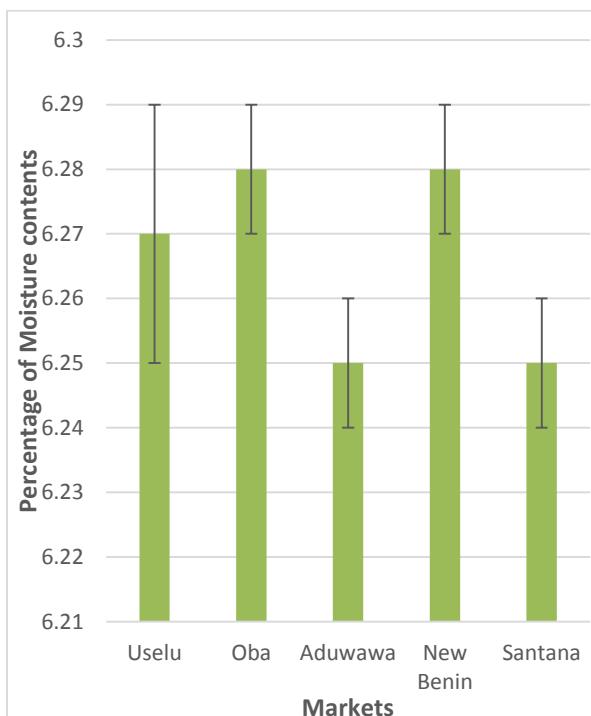


Fig. 4: Comparison of the percentage of moisture contents of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual moisture contents of the samples at the different market at $P = 0.05$.

In Fig. 4, the percentage moisture ranged from 6.25 ± 0.01 (Aduwawa market) to 6.28 ± 0.01 (New Benin and Oba market). The high percentage moisture content could be as a result of the method of fermentation (submerged) which involves high level of water. The percentage crude fibre (Fig. 5) of *fufu* ranged from 0.95 ± 0.01 (Santana market) to 1.03 ± 0.01 (Uselu). The percentage crude fibre content of *fufu* samples were low and this is however within the nutritional maximum level of 3.0% recommended (Makanjuola et al., 2012). The percentage protein contents (Fig. 6) of the *fufu* ranged from 1.59 ± 0.01 (Santana market) to 1.63 ± 0.01 (Oba market). The low protein level in the *fufu* could be attributed to the general low protein in cassava fermented foods. There is therefore need to fortify *fufu* and other cassava derivatives so as to enhance the nutritional quality. The percentage carbohydrate contents (Fig. 7) of *fufu* ranged from 84.10 ± 0.01 (New Benin market) to 85.19 ± 0.01 (Santana market). The high energy (carbohydrate content) obtained from the *fufus* is in agreement with the reported of Agu and Aluyah (2004).

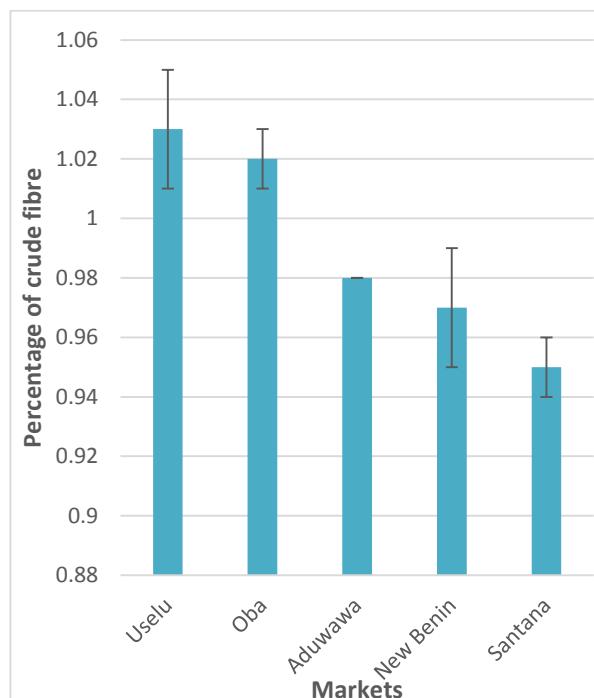


Fig. 5: Comparison of the percentage of crude fibre of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual crude fibre of the samples at the different market at $P = 0.05$.

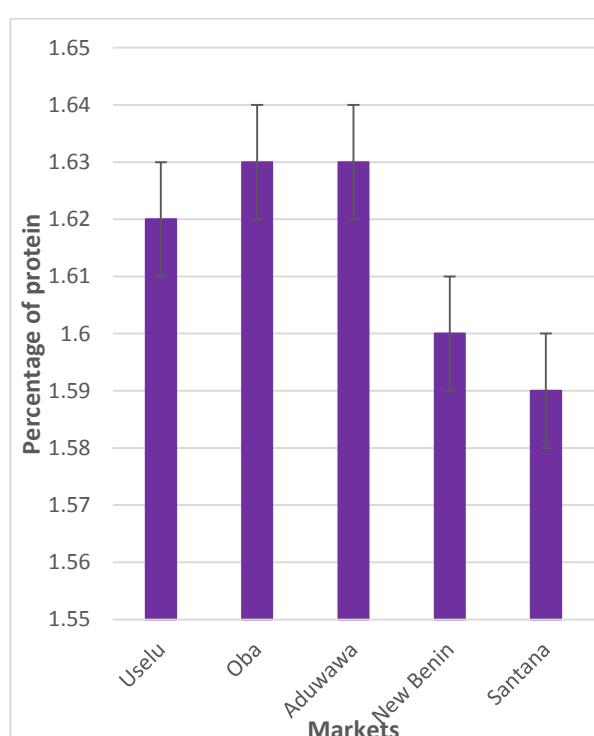


Fig. 6: Comparison of the percentage of protein of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual protein of the samples at the different market at $P = 0.05$.

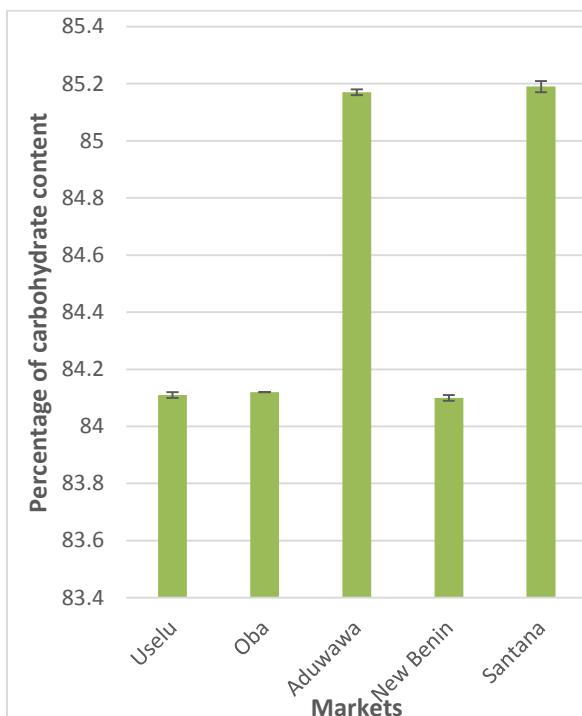


Fig. 7: Comparison of the pH of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual pH of the samples at the different market at $P = 0.05$.

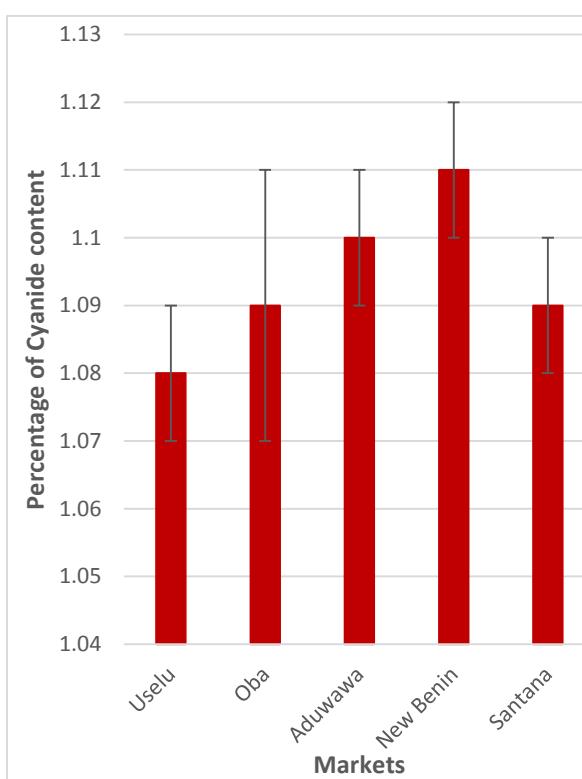


Fig. 8: Comparison of the percentage of cyanide content of the ready-to-eat *fufu* sold at the different markets in Benin City. Values are means of the individual cyanide content of the samples at the different market at $P = 0.05$.

In Fig. 8, the percentage cyanide of the *fufu* ranged from 1.08 ± 0.01 (Uselu market) to 1.11 ± 0.01 (New Benin market). Cassava is one of the very few tropical crops where cyanide content has not restricted its use as an important staple food for human consumption. This is because a variety of

processing technique have been developed in different parts of the world to make *fufu* more palatable (Awekeet *et al.*, 2012). The degree of reduction of cyanide in the final product varies greatly with the type of processing techniques used (Nhassicoet *et al.*, 2008; Cardoso *et al.*, 2005). The plant has long history of cultivation and consumption in other parts of the world and different processing methods had been developed to neutralize the toxin (cyanide). Processing methods such as washing, boiling, drying, length of fermentation and fermentation with cereals help to reduce cyanide in cassava (Awekeet *et al.*, 2012). Solar drying and long fermentation with constant changing of fermentation water were found to be the best methods in removing cyanide content and detoxifying cassava based foods (Awekeet *et al.*, 2012).

Conclusion

The results from this research showed that *fufu* which is a fermented product, has several physicochemical parameters which enhances its quality. The nutritional quality of *fufu* can be improve upon by fortifying the food with essential nutrients and amino acids and. This study has therefore given an insight into some of the physicochemical parameters of the commercially available ready-to-eat *fufu* sold Benin City, Nigeria.

Conflict of Interest

The authors declare that there is no conflict of interest.

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