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Proximate, chemical, and starch analysis of *Fufu* dough sold in different markets of Akwa Ibom and Rivers States, Nigeria.

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ABSTRACT

Fufu, a fermented product of cassava is sold, and consumed in the states of Akwa Ibom and Rivers of Nigeria without official certification or standards; hence, laboratory research and tests are required to determine the product's safety and purity. Six *fufu* dough samples were bought from six distinct marketplaces that were picked at random from the two states. They underwent proximate and surfactant analysis, total hydrocarbon test analysis, total, resistant, and non-resistant starch analysis, as well as chemical analysis (amylose, amylopectin, and free sugar). According to the results of the *fufu* dough samples from Akwa Ibom state, the cationic, anionic, and total hydrogen compositions ranged from 0.04 to 0.06 mg/l, 0.03 to 0.05 mg/l and 0.12 to 0.20 mg/l respectively. The amylose, amylopectin, and free sugar contents ranged from 17.19 to 20.20, 79.80 to 80.44 %, and 2.20 to 2.82 % , whereas the resistant, non-resistant and total starch contents ranged from 2.20 to 2.42 g/100g, 73.40 to 77.24 g/100g and 76.46 to 78.56 g/100g respectively. The results of the *fufu* dough samples from Rivers state shows that the cationic, anionic, and total hydrogen compositions ranged from 0.22 to 0.24 mg/l, 0.20 to 0.21 mg/l, and 0.24 to 0.26 mg/l respectively. The amylose, amylopectin, and free sugar contents ranged from 15.00 to 17.10, 69.24 to 72.10 %, and 1.80 to 1.88 % , whereas the resistant, non-resistant and total starch contents ranged from 1.80 to 2.00 g/100g, 68.10 to 72.68 g/100g and 56.22 to 68.42 g/100g respectively. This study's findings indicate that the *fufu* dough samples from the two states had high total hydrocarbon content, potentially containing polycyclic aromatic hydrocarbons (PAH), and surfactant levels, which were below the acceptable limit for the body of trace metals, including zinc, cadmium, lead, and chlorine salts.

Keywords: *fufu*, surfactant analysis, resistant starch, non-resistant starch, hydrocarbon test, proximate composition

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INTRODUCTION

Nigeria is the world's largest producer of cassava, hosting a diverse array of cassava farmers and processors, with the large majority being small-scale operators (Forsythe *et al.*, 2016). Major cassava-based food products consumed in Nigeria include the following: *gari*, *fufu*, and *lafun*. Most of these products are made and consumed locally by farming households themselves (IITA, 2012). Even though cassava is desirable for use as food and animal feed, it includes several harmful substances such as the very toxic cyanogenic glycosides, *linamarin*, and *lotaustralin*.

Fermentation is one of the cheapest means of performing the dual function of nutrient enrichment with protein, essential amino acids, fatty acids, and vitamins in the cassava, as well as detoxifying the anti-nutrients, thus enhancing the food quality (Binin, 2014). *Fufu* is produced by first, peeling and washing the cassava roots, and cutting them into smaller chunks. Soaking, steeping, or fermentation of the cut roots may be carried out either by continuous soaking of chunked roots for 3–5 days of fermentation (Mokemiabeka *et al*., 2011), or by washing and grating of the soaked root after 48h of fermentation, followed by re-steeping of grated roots (Omodamiro *et al*., 2012). The fermented roots or mash are finally sieved and dewatered to obtain the wet paste. There is a lack of regulation and quality control measures in place for the production and sale of *fufu* dough in Akwa Ibom and Rivers States, which could pose a health risk to consumers. To better advise processors against the practice of using hazardous chemicals in the fermentation of cassava for *fufu* processing, this research work aims to ascertain whether the *fufu* dough from the two states (Akwa Ibom and Rivers) is produced using these harmful fermentation aids (detergents, kerosene, and palm ash) through laboratory analysis.

MATERIALS AND METHODS

Source of raw materials

The *fufu* dough samples were obtained from six different markets in Akwa Ibom and Rivers States which include *Akpan Andem* Market (Uyo), *Eket* Main Market (Eket), and *Etaha Itam* Market (Itu), Oil Mill Market (PH), *Borokiri* Market (Borokiri) and Mile 1/3 market. Reagents and other laboratory services for analyses were supplied and done at the Trait Profiling Laboratory, Biotechnology Program of the National Root Crops Research Institute, Umudike,

Study area

Akwa Ibom State lies between latitude 40 32 and 5 0 53 North; and Longitudes 70 25 and 80 25 East of the Niger. Its 6,900 sq Km land area is located between Cross River, Abia, and Rivers states on the sandy coastal plain of the Gulf of Guinea. Rivers state has a population of 5,198,716 as of the 2006 census and 7,492,366 in 2023, being the 7th most populous state in Nigeria.

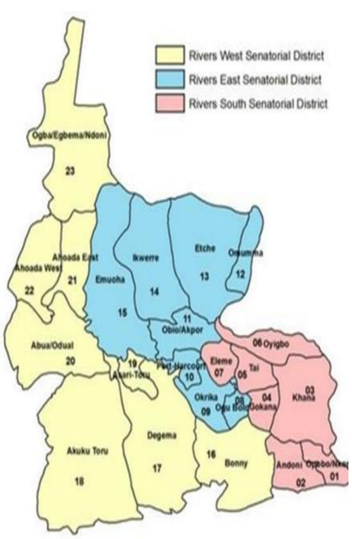

Fig. 1 Map showing Rivers state

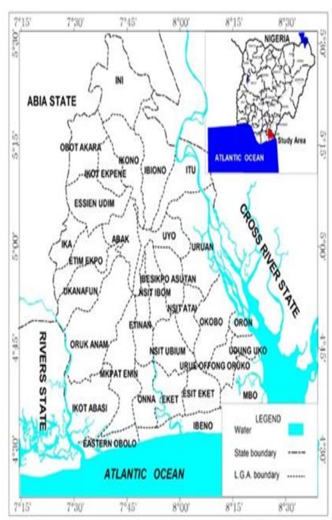

Fig. 2 Map showing Akwa Ibom state

Proximate analysis of *Fufu* dough samples

Proximate analysis of the *fufu* dough samples which were carried out includes the moisture content, total ash, crude protein, crude fat, carbohydrate, and crude fiber and was determined as described by Onwuka (2010). The energy value (calorific value) of the dehydrated experimental materials, using the Atwater factors, was calculated in kcal per 100g as [(% carbohydrate x 4) + (% fat x 9)].

Surfactants (cationic and anionic surface agents) analysis

The cationic (cationic surface agent) and anionic (anionic surface agent) surfactants were determined using the titrimetric method of Ibiam *et al* (2016).

Total hydrocarbon Test

The total hydrocarbon was determined using the method described by Ogbete *et al* (2022) with slight modifications.

Chemical properties of the *Fufu* dough samples

The sugar content of the *fufu* dough samples was done using the calorimetric method of determination of sugars by AOAC (2010), the amylose content of the *fufu* samples was determined using the method of Mohammadkhani *et al,* (1999) involving the preparation of stock iodine solution and iodine reagent, while the Amylopectin content was calculated using the equation explained by Torruco-Uco, *et al* (2006).

Total Starch, Resistant and Non-resistant Analysis

These were determined using the enzymatic method described by AOAC (2020).

Statistical Analysis of Data

The data from this study were statistically analyzed using a one-way analysis of variance (ANOVA), and the means were separated by Duncan's new multiple range test (DNMRT) using the Statistical Package for Social Sciences (SPSS) version 21 at 5% (P<0.05) acceptable level (Hinkelmann and Kempthorne, 2008).

RESULTS AND DISCUSSION

The Proximate Composition of the *Fufu* dough samples.

Moisture content

Moisture content of food or processed product gives an indication of its shelf life and nutritive values. Low moisture content is a requirement for a longer shelf life. The moisture content of the *fufu* dough samples ranged from 52.6 - 59.4 %, with highest value observed in the *fufu* from *Eket* market (Sample B) having 59.4% and the lowest result observed in *fufu* from *Akpan Andem* market having 52.6%. The moisture content obtained in this research is in close range with moisture content of 55.02 -73.16 % reported for wet *fufu* mash for microbial assay (Adegbehingbe *et al,* 2019). There was no significant difference (p> 0.05) among the *fufu* samples except with *fufu* with *Fufu* from *Eket* market (59.4%). The difference could be due to the processing technique employed in the *fufu* processing. The moisture content of the *fufu* samples were low, this implies high dry matter content and a longer shelf life.

Dry matter refers to material remaining after water has been removed from a food sample, and it is an indicator of the amount of nutrients that are available in such a food sample. The dry matter content of the *fufu* samples ranged from 45.4 - 48.3 % with the highest value seen in *fufu* from *Borokiri* market while the lowest value was observed in *fufu* from *Akpan Andem* market. The high dry matter is an indication of desirable quality attributes in a food sample. Dry matter is a practical approach to improving the shelf life and marketability of *fufu* flour (Akingbala *et al*., 1991). There was no significant difference (p> 0.05) seen among all the *fufu* samples.

Ash content

The ash content is indicative of inorganic constituents (such as minerals). It helps to determine the amount of minerals in food. The ash content of the *fufu* samples ranged from 0.63 to 0.85 %. This result is similar to 0.76 - 0.92 % reported by Fayemi et al., 2012. Also, Micheal, (2021) reported ash content ranges of 0.53 - 0.99 % on organoleptic properties of *fufu* flour produced from three varieties of yellow root cassava. There was no significant difference (p> 0.05) between the ash content of all the *fufu* dough samples except between fufu from *Akpan Andem* (0.75 %) and *fufu* from *Eket* market (0.85 %) which were seen to be significantly different (p<0.05) from the rest of the *fufu* dough samples. Food materials with a high percentage of ash content are likely to have high concentrations of mineral elements, which are expected to speed up metabolic processes and in turn improve growth and development in humans (Bello *et al*., 2008).

Crude fiber

The crude fiber content ranged from 0.94 % (*fufu* from *Eket* market) to 1.25 % (*fufu* from Mile 1/3 market). The crude fiber content from this research is within the range 1.52 - 1.81% reported by Michael (2021) for the work on organoleptic properties of *fufu* flour produced from three varieties of yellow cassava root. There was no significant difference (p> 0.05) observed between the crude fiber content of *fufu* from *Akpan Andem* market (sample A), Oil Mill market (sample D), *Borokiri* market (sample E), and *Fufu* from Mile 1/3 market (sample F), as well as between *fufu* from *Akpan Andem* market (sample A) and *Fufu* from *Etaha Itam* market (sample C), and also between *Fufu* from *Eket* market (sample B) and *Fufu* from *Etaha Itam* market (sample C). Crude fiber helps to prevent heart diseases, diabetes, colon cancer, etc. (Oppong *et al*., 2015).

Fat content

The fat content ranged from 0.27 to 0.42 %. The result for the fat content obtained from this research is comparable to 0.51 -1.33 % recorded for the Suitability of Different Cassava Varieties for *Gari* and *Fufu* Flour Production in Liberia as reported by Wasiu *et al*. (2020). The low-fat content of the *fufu* samples could be attributed to cassava being a low-fat food. It is known that cassava and its products are very low in protein and fat content (Etudaiye *et al*., 2018). There was no significant (p> 0.05) difference between *Fufu* from *Akpan Andem* market (0.42%) and *Fufu* from *Eket* market (0.27 %), as well as between *Fufu* from Oil Mill market, *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market, while a significant difference (p<0.05) was seen between *Fufu* from *Etaha Itam* market and the rest of the *fufu* dough samples.

Crude protein

The crude protein content ranged from 0.96 (*Fufu* from *Eket* market) to 1.49 % (*Fufu* from *Akpan Andem* market). There was no significant (p> 0.05) difference between all the *fufu* samples. The crude protein contents of the *fufu* samples are within the range of 1.83 - to 2.37 % reported by Michael, (2021), and 0.35 to 2.88 % by Etudaiye *et al*., (2018). The low protein content of *fufu* pastes and flours is not of serious concern as *fufu* is usually consumed accompanied by different protein sources both of animal and vegetable origin.

Carbohydrate

The carbohydrate content of the *fufu* samples ranged from 67.50 (*Fufu* from *Eket* market) to 83.73 % (*Fufu* from *Akpan Andem* market). The carbohydrate content observed in this work compares well with 82.57 - 84.03 % reported by Fayemi *et al*., (2012) in their study “The Effect of Different Fermentation Techniques on the Nutritional Quality of the Cassava Product (*fufu*)” and 76.89 to 91.38 % reported by Etudaiye *et al*. (2018). The carbohydrate content of *fufu* from Eket market (67.50%) was significantly ($p < 0.05$) lower than the rest of the *fufu* samples. This could be attributed to the variety of cassava that was used in the processing of the f*ufu*. From the data, it could be observed that the carbohydrate contents are high. This confirms the carbohydrates as the main nutritional component of cassava roots with about 80 % as starch (Purseglove, 1991).

Energy content

Food energy is defined as the energy released from carbohydrates, fats, proteins, and other organic compounds. When the three major calorigenic nutrients (carbohydrates, fats, and proteins) in a food are burnt entirely with sufficient amounts of oxygen, it releases energy or food calories that are expressed in kilojoules (kJ) or kilocalories (kcal) (Allison, 2020). The energy content of the *fufu* samples ranged from 157.21 (*Fufu* from *Eket* market) to 187.61 kcal/100g (*Fufu* from *Borokiri* market). There was no significant ($p > 0.05$) difference observed among the *fufu* samples.

Table 1. Proximate composition of the *fufu* dough samples

Sample	Moisture (%)	Dry matter (%)	Total ash (%)	Crude fiber (%)	Total fat (%)	Crude protein (%)	CHO (%)	Energy (Kcal/J)
A	52.6^{b}±1.67	45.4^{a}±2.40	0.75^{b}±0.04	1.01^{ab}±0.01	0.42^{a}±0.03	1.49^{a}±0.13	83.73^{a}±0.35	184.66^{a}±1.67
B	59.4^{a}±3.35	45.6^{a}±0.85	0.85^{a}±0.01	0.94^{c}±0.03	0.37^{a}±0.02	0.96^{a}±0.12	67.50^{b}±0.69	157.21^{a}±3.35
C	53.8^{b}±1.09	46.2^{a}±0.28	0.67^{c}±0.01	0.97^{bc}±0.01	0.31^{b}±0.01	1.14^{a}±0.13	83.11^{a}±0.11	179.79^{a}±1.09
D	53.5^{b}±1.09	46.5^{a}±0.28	0.63^{c}±0.01	1.03^{a}±0.01	0.25^{c}±0.01	1.31^{a}±0.12	83.27^{a}±0.12	180.61^{a}±1.09
E	54.6^{b}±1.08	48.3^{a}±0.26	0.68^{c}±0.01	1.01^{a}±0.01	0.27^{c}±0.01	1.39^{a}±0.12	86.36^{a}±0.12	187.61^{a}±1.00
F	55.7^{b}±1.21	47.4^{a}±0.24	0.71^{c}±0.01	1.25^{a}±0.01	0.33^{c}±0.02	1.22^{a}±0.12	85.67^{a}±0.12	181.77^{a}±1.09
LSD	1.429	3.583	0.068	0.052	0.052	0.344	1.095	562.019

Note: values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$).
Key: *Fufu* **A** = *Fufu* from *Akpan Andem* market, *Fufu* **B** = *Fufu* from Eket market, *Fufu* **C** = *Fufu* from *Etaha Itam* market, *Fufu* **D** = *Fufu* from Oil Mill market, *Fufu* **E** = *Fufu* from *Borokiri* market, *Fufu* **F** = *Fufu* from Mile 1/3 marke

Surfactant composition and Hydrocarbon analysis of the *Fufu* dough samples

The surfactant composition of the *fufu* samples are presented in Table 2. From the table, the cationic surfactant values ranged from 0.03 (*Fufu* from *Akpan Andem* market) to 0.17mg/l (*Fufu* from Mile 1/3 market) while the anionic surfactant values ranged from 0.03 (*Fufu* from *Akpan Andem* market) to 0.15 mg/l (*Fufu* from Mile 1/3 market). In the cationic composition, there was no significant ($p>0.05$) difference between *Fufu* from *Akpan Andem* market, *Fufu* from *Eket* market, and *Fufu* from *Etaha Itam* market. Also, no significant difference ($p>0.05$) was observed between *Fufu* from Oil Mill market, *Fufu* from *Borokiri* market and *Fufu* from Mile 1/3 market. Whereas, in anionic composition, a significant difference ($p<0.05$) was observed between *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market, with no significant difference ($p>0.05$) seen between sample *Fufu* from *Eket* market, and *Fufu* from Oil Mill market, as well as between sample *Fufu* from *Akpan Andem* market and *Fufu* from *Etaha Itam* market respectively.

The result agrees with the range of 0.01 – 0.16 mg/l for cationic surfactants and 0.01 – 0.13 mg/l for anionic surfactants reported by Ogbete *et al.* (2022) in "Quality Assessment of *fufu* produced with different fermentation Aids". According to WHO/FAO, (2012), the body's tolerable limit of cationic and anionic surfactants (which contain some levels of trace metals like lead, cadmium, zinc, and chlorine salts) that should be present in food samples is to be 0.2mg/l. From the table, all the *fufu* samples were seen to be below this limit, which suggests that the cationic and anionic surfactants were within the tolerable limit. The total hydrocarbon values of the *fufu* samples ranged from 0.21 (*Fufu* from *Eket* market) to 0.64 mg/l (*Fufu* from Mile 1/3 market). There was no significant ($p>0.05$) difference observed between *Fufu* from *Akpan Andem* market, and *Fufu* from *Eket* market, as well as between *Fufu* from *Etaha Itam* market, and *Fufu* from Oil Mill market. However, there was a significant difference ($p<0.05$) observed between *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market. Ogbete *et al.* (2022) in "Quality Assessment of *fufu* produced with different fermentation Aids" had values ranging from 0.12 – 1.86mg/l. The Occupational Safety and Health Administration (OSHA) (1995), has set a limit of 0.2 milligrams for body tolerance to PAHs (Polycyclic Aromatic Hydrocarbons), and it can be seen from the table that all the *fufu* samples have hydrocarbon levels above this limit. This level of hydrocarbon concentration could serve as a risk factor in the consumption of *fufu* purchased without knowing the hygiene of the environment where it was produced.

Table 2. Surfactant composition of the *Fufu* dough samples

Samples	Cationic nt (mg/l)	Anionic Surfactant (mg/l)	Total Hydrocarbon (mg/l)
A	0.03^{a} + 0.00	0.03^{d}+ 0.00	0.23^{d} + 0.00
B	0.11^{a} + 0.00	0.11^{c} + 0.00	0.21^{d} + 0.00
C	0.07^{a} + 0.00	0.07^{d} + 0.00	0.47^{c} + 0.01

D	0.13^{b} + 0.00	0.13^{c} + 0.00	0.46^{c} + 0.01
E	0.17^{b} + 0.00	0.17^{a} + 0.00	0.64^{a} + 0.02
F	0.15^{b} + 0.00	0.15^{b} + 0.00	0.62^{b} + 0.02
LSD	**0.00310**	**0.002597**	**0.04047**

Note: values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$).

Key: *Fufu* **A** = *Fufu* from *Akpan Andem* market, *Fufu* **B** = *Fufu* from Eket market, *Fufu* **C** om *Etaha Itam* market, *Fufu* **D** = *Fufu* from Oil Mill market, *Fufu* **E** = *Fufu* from *Borokiri* *ufu* **F** = *Fufu* from Mile 1/3 m

Free Sugar, Amylose, and Amylopectin composition of the *Fufu* dough samples

Free sugar content

The free sugar content (Table 4.3) ranged from 1.90 (*Fufu* from *Eket* market) to 2.72 % (*Fufu* from Mile 1/3 market). There was no significant difference (p>0.05) between the free sugar content of *Fufu* from *Akpan Andem* market, *Fufu* from *Eket* market and *Fufu* from Oil Mill market, while a significant difference (p<0.05) was observed between sample *fufu* from *Etaha Itam* market, *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market. These values are within the range of 1.69 - 2.07 % reported by Awoyale *et al*. (2022) in *fufu* flours from different cassava varieties. Free sugar in *fufu* results from the conversion of starch to sugar during fermentation (Awoyale *et al*., 2022).

Amylose content

The amylose contents ranged from 29.41 (*Fufu* from *Eket* market) to 30.12 % (*Fufu* from *Borokiri*). *Fufu* from *Borokiri* had the highest amylose content (30.12 %) while *Fufu* from *Eket* market had the least amylose content (29.41 %). There was no significant difference (p>0.05) observed in the amylose content of *Fufu* from *Akpan Andem* market, *Fufu* from *Etaha Itam* market, and *Fufu* from Oil Mill market. Also, no significant difference (p>0.05) was observed in the amylose content of *Fufu* from *Eket* market, *Fufu* from *Etaha Itam* market and *Fufu* from Mile 1/3 market. In the same vein, no significant difference (p>0.05) was seen between the amylose content of *Fufu* from *Borokir*i market, and *Fufu* from Mile 1/3 market respectively. These values fell within the range reported by Chijioke *et al*. (2016) of values 15.02 to 22.83 %. The functional characteristics of starches and flour are significantly influenced by their amylose concentration. Also, According to Awoyale *et al.* (2022), the amylose content of starchy foods determines the stability of the viscous solution formed when starch is heated.

Amylopectin content

The amylopectin content ranged from 69.86 (*Fufu* from *Eket* market) to 70.21 % (*Fufu* from *Borokiri* market). There was no significant difference (p>0.05) between the amylopectin contents of sample *fufu* from *Akpan Andem* market, *Fufu* from *Eket* market, *Fufu* from *Etaha Itam* market, and *Fufu* from Oil Mill market, but a significant difference (p<0.05) was seen between *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market respectively. This result is in agreement with the ranges 77.1 to 86.02 % and 78.76 to 87.09 % reported by Chijioke *et al.* (2016) and Ogbete *et al*. (2022) respectively who reported that high amylopectin levels of cassava flours is associated with high expansion.

Table 3. Chemical composition of the *fufu* dough samples

Samples	Free Sugar (%)	Amylose (%)	Amylopectin (%)
A	$1.92^{a} + 0.02$	$29.85^{c} + 0.02$	$69.86^{c} + 0.01$
B	$1.90^{a} + 0.03$	$29.41^{b} + 0.03$	$69.82^{c} + 0.01$
C	$1.97^{b} + 0.03$	$29.93^{bc} + 0.03$	$69.96^{c} + 0.01$
D	$1.92^{a} + 0.02$	$29.89^{c} + 0.02$	$69.91^{c} + 0.01$
E	$2.04^{c} + 0.04$	$30.12^{a} + 0.02$	$70.15^{a} + 0.01$
F	$2.72^{d} + 0.06$	$30.02^{ab} + 0.03$	$70.21^{b} + 0.01$
LSD	0.0196	0.0196	0.0196

Note: values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$).
Key: *Fufu* A = *Fufu* from *Akpan Andem* market, *Fufu* B = *Fufu* from *Eket* market, *Fufu* C = *Fufu* from *Etaha Itam* market, *Fufu* D = *Fufu* from Oil Mill market, *Fufu* E = *Fufu* from *Borokiri* market, *Fufu* F = *Fufu* from Mile 1/3 market

Starch composition of the *Fufu* dough samples

Total Starch content

The total starch content of the *fufu* dough samples ranged from 78.46 (*Fufu* from *Eket* market) to 79.85 % (*Fufu* from Mile 1/3 market). There was no significant difference (p>0.05) between the total starch contents of *Fufu* from *Akpan Andem* market, *Fufu* from *Eket* market, and *Fufu* from Oil Mill market, as well as between *Fufu* from *Borokiri* market, and *Fufu* from Mile 1/3 market respectively, which rather showed a significant difference (p<0.05) from the other *fufu* samples. This result is in agreement with the ranges 68.57 to 84.76 % and 84.00 to 86.0 % reported by Deepika *et al.* (2024) and Nwosu *et al.* (2023). According to Awoyale *et al*. (2022), starch content is one of the vital quality indices of starchy food, which determine the texture of the cooked dough.

Resistant Starch

Resistant starch is defined as that fraction of starch, which escapes digestion in the small intestine and passes into the large intestine where it is more or less fermented by gut microflora. It is considered a functional component of food due to the health benefits it confers following its consumption (Frank, *et al,* 2015). The resistant starch content of the *fufu* dough samples ranged from 2.11 (*Fufu* from *Akpan Andem* market) to 2.45 % (*Fufu* from *Borokiri* market). There was no significant difference (p>0.05) observed between the resistant starch contents of all the *fufu* dough samples analyzed. This result is in agreement with the ranges 0.16 to 5.71 % and 1.32 to 3.49 % of processed food samples (plantain, oat meal, yam, potato and rice flour) sold in Enugu metropolis of Nigeria reported by Deepika *et al.* (2022) and Nwosu *et a*l. (2023) as well as that of Frank *et al*, (2015) who reported values with the range of 1.59 – 2.39 % in "The resistant starch content of some cassava based Nigerian foods".

Non-Resistant Starch

Digestible or non-resistant starch is digested throughout the entire length of the small intestine to provide sustained glucose release with a low initial rise in blood glucose levels and subsequently a release of glucose and insulin (Jaspreet *et al*, 2010). The non-resistant starch content of the *fufu* dough samples ranged from 76.28 (*Fufu* from *Eket* market) to 77.65 % (*Fufu* from *Borokiri* market). There was no significant difference (p>0.05) observed among the non-resistant starch contents of all the f*ufu* samples analyzed. This result is in agreement with the ranges 53.60 to 61.70 reported by Frank *et al*, (2015) in "The resistant starch content of some cassava based Nigerian foods". According to Goni *et al*, (1999), digestibility characteristics of starch-based foods mostly depends on the processing conditions adopted and the resulting retrogradation steps because during processing, the starch molecule undergoes several physical modifications depending on the type of starch and severity of the conditions employed.

Table 4. Starch composition of the *Fufu* dough samples

Samples	Total Starch (g/100g)	Resistant Starch (g/100g)	Non Resistant Starch (g/100g)
A	$78.87^{a} + 0.02$	$2.11^{a} + 0.02$	$71.55^{a} + 0.01$
B	$78.46^{a} + 0.02$	$2.14^{a} + 0.04$	$70.28^{a} + 0.01$
C	$78.97^{b} + 0.04$	$2.33^{a} + 0.02$	$74.11^{a} + 0.01$
D	$78.89^{a} + 0.02$	$2.29^{a} + 0.02$	$72.87^{a} + 0.01$

E	$79.21^{c} + 0.04$	$2.45^{a} + 0.02$	$74.65^{a} + 0.01$
F	$79.85^{d} + 0.04$	$2.41^{a} + 0.04$	$73.11^{a} + 0.01$
LSD	**0.0096**	**0.0096**	**0.0096**

Note: values are means of duplicate determinations. Means with different superscripts along a column are significantly different at ($p < 0.05$).
Key: *Fufu* **A** = *Fufu* from *Akpan Andem* market, *Fufu* **B** = *Fufu* from Eket market, *Fufu* **C** = *Fufu* from *Etaha Itam* market, *Fufu* **D** = *Fufu* from Oil Mill market, *Fufu* **E** = *Fufu* from *Borokiri* market, *Fufu* **F** = *Fufu* from Mile 1/3 market

CONCLUSION

This research work on Proximate, chemical, and starch analysis of *fufu* dough sold in different markets of Akwa Ibom and Rivers States, Nigeria has shown to be of safety concern owing to the findings obtained from the study. *Fufu*, which is one of the staple food product from cassava, could be unsafe for consumption due to the methods or materials used during its processing. It is believed that hydrocarbons, particularly PAHs (Polycyclic Aromatic Hydrocarbons), have harmful effects on people. This level of PAH shows potential toxicity to health on continuous consumption. This could be because of using non-treated water during the processing of the food. Furthermore, the starch composition analysis showed that the *fufu* dough samples had very high total starch and resistant starch contents. It has been suggested that starchy foods that are digestible (resistant) result in low blood glucose and are more beneficial to health and in the management of diabetes and hyperlipidemia.

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