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Physicochemical and Sensory Properties of Unfermented Fufu Composite Flour Made from Cassava Sievate, Guinea Corn and Unripe Plantain Flours Blend

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Abstract The physicochemical and sensory properties of unfermented fufu composite flour prepared from cassava sievate, guinea corn and unripe plantain flour blends were evaluated. The raw material samples were procured and processed into unfermented fufu composite flour using standard methods. Total number of eight unfermented fufu composite flour samples were randomly generated and subjected to analysis using standard methods. The result findings ranged as follows: 2.85 to 12.5, 0.96 to 3.0, 0.5 to 2.53, 0.33 to 2.54, 6.6 to 10.99 and 27.63 to 87.96% for crude protein, fat, ash, crude fiber, moisture and carbohydrate, respectively; 0.05 to 0.15 mg/kg for hydrogen cyanide; 18.10 to 38.10%, 0.54 to 0.72 g/ml, 162.42 to 230.06, 94.20 to 150.72, 51.33 to 79.34, 198.69 to 287.55 and 56.31 to 87.10 RVU, 6.17 to 6.97 min and 93.13 to 93.66°C for water absorption capacity, bulk density; peak, trough, breakdown, final and setback viscosity, pasting time and temperature, respectively for the unfermented composite flour blends samples, respectively. Sensory evaluation of the hot water reconstituted fufu paste (swallow) values ranged from 4.6 to 7.4, 6.4 to 7.8, 6.5 to 7.8, 6.6 to 7.3 and 5.8 to 7.9 for colour, mouldability, texture/hand feel, taste and overall acceptability, respectively. Based on the findings of this work, it was ascertained that this novel product (unfermented fufu composite flour) could be a better substitute to conventional cassava fufu especially for people living in a high starch dense area to combat protein malnutrition considering the appreciable level of protein in this product (11.16%).

Keywords: *cassava sievate flour, guinea corn flour, unripe plantain flour, unfermented fufu composite flour, physicochemical properties and sensory evaluation*

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1. Introduction

Fufu is fermented food product produced and consumed widely in West African countries in particular Nigeria, Ghana and Cameroun [1]. The product is highly perishable with short shelf life [2] due to high moisture content [3]. It is prepared from starchy food such as cassava, yam, plantain and cocoyam by pounding the boiled material to form a dough. It is a domestic food and yet to be industrialized [3]. The aspect of high perishability was addressed through production of reconstituted fufu flour that form paste upon addition of hot water, and this product is increasingly becoming useful to the inhabitants of West Africa [2]. Originally fufu is made from fermented cassava. However, it can also be made from unfermented maize, millet or guinea corn (sorghum) and unripe plantain flour. In addition fufu was made using blended starches of different botanical origins for improved textural and sensory characteristics [4]. Cassava roots are rich in calories but low in protein, fat, minerals and vitamins [5]. Thus, blending is desired for improvement of nutritional composition on fufu [6] such as blending Cassava sievate, Guinea corn and Plantain fruit.

Cassava sievate, a by-product of garri production makes up to 15 to 17% of the root in weight [7], is a popular West African food [8]. It is discarded away as a waste into the immediate environment to rot and cause environmental pollution with strong offensive smell [9]. It is commonly used for livestock feeds and not for human food which is an underutilization [9] considering its probable role in food security sustainability.

Guinea corn (*Sorghum bicolor (L) Moench*), also known as sorghum, is an underutilized gluten-free cereal in Nigeria [10], forms the staple diet of a majority of the populations in the semi-arid tropics [11] and the second most important grain in Africa with improved production to a great extent over the past four decades [12]. Its flour can be used for making varieties of foods such as bread and pap (*ogi* or *akamu*) in Nigeria [13]. It is a good source of protein, carbohydrate, fibre, fat, calcium, iron, phosphorus and potassium [14], helps to slow the growth of colon cancer cells [15] and a safe food for gluten intolerant people [16].

Plantain fruit (*Musa paradisiaca*) is an important starchy staple in Sub-Saharan Africa providing more than 25 % of the carbohydrate and 10 % of the daily intake for more than 70 million people in the continent [17]. It is also a good source of other nutrients such as proteins, minerals, vitamin A, B and C and fibre which is in higher amounts in the unripe fruits than in the ripe fruits [18]. More than 2.5 million metric tons of plantain are produced annually but about 40 to 60 % post-harvest losses had been reported which is attributed to storage facilities and inadequate technologies in food processing [19]. However, these losses can be reduced through processing to flour. When processed into flour, it is used traditionally to produce gruel (fufu) which is made by mixing the appropriate quantities of boiling water to form a thick paste [20].

According to [21], protein-energy malnutrition is a serious concern of public health in the Sub-Saharan Africa. The Nigerian fortification initiative is a public health policy responding to increasing malnutrition. Thus, the production of unfermented fufu with improved protein content and other nutrient, knowing that fufu is generally poor in protein and other nutrients.

2. Materials and methods

2.1. Source of Materials

The unripe plantain and guinea corn were purchased from Eke-Awka Market, and the cassava sievate was procured from Garri Processing Plant, all from Awka South Local Government Area, Anambra State, Nigeria. The equipment and chemicals used were of analytical grade.

2.2. Experimental Design

Completely Randomized Design (CRD) was used for the formulation ratio and generated eight different ratios of unfermented fufu composite flours which included: 80:10:10, 90:5:5, 85:10:5, 70:20:10, 10:80:10, 5:90:5, 10:85:5, and 20:70:10 for cassava sievate: guinea corn: unripe plantain, respectively. One hundred per cent of cassava sievate, guinea corn and unripe plantain flours served as control samples.

2.3. Production of Cassava Sievate Flour

The cassava sievate flour was produced using the method [7] with some modifications (oven drying instead of sun drying). The cassava sievate was first sorted to remove foreign materials. It was thereafter oven-dried at 90°C till dryness and cooled. The dried cassava sievate was then milled to flour and packaged in airtight plastic container at room temperature for further processing and analysis.

2.4. Production of Guinea Corn Flour

The guinea corn flour was produced using the method [22] with some modifications (not malted). The guinea corn grains were winnowed and sorted to remove dirt and other foreign materials and thereafter milled to produce fine flour. The flour was packaged in airtight plastic container at room temperature for further processing and analysis.

2.5. Production of Unripe Plantain Flour

The plantain flour was produced using the method described by [23] and [20] with some modifications (Oven dried without sun drying first). The plantain head was cut into separate bunches which were subsequently de-fingered. The plantain fingers were washed to remove adhering dirt and soil particles. They were peeled and cut into slices of about 0.45 cm. The plantain slices were oven-dried at 90°C for 5 hours, cooled and milled into fine flour. The flour was packed and sealed in polythene bags enclosed inside airtight plastic container at room temperature for further processing and analysis.

2.6. Formulation of Unfermented Fufu Composite Flour

The unfermented fufu composite flour samples were mixed using the formulation ratio generated by completely randomized design and generated eight (8) samples as follows:80:10:10, 90:5:5, 85:10:5, 70:20:10, 10:80:10, 5:90:5, 10:85:5 and 20:70:10 with sample code as C: G: U were C is cassava sievate flour, G is guinea corn flour and U is unripe plantain flour.

2.7. Proximate Composition Determination

The moisture, fat, crude protein, ash and crude fiber content of the samples were determined according to the conventional standard method [24] in percentage. Moisture content was determined by air oven (DHG-9101-1SA GALLENKOMP) drying. Fat content was by the Soxhlet (BIONIC SCIENTIFIC BST/SXM-3A) fat extraction method. Crude protein was determined using the Micro Kjeldahl (DK-420 TECHMEL & TECHMEL, USA) method. The crude fiber was determined by hydrolysis while ash content was by muffle furnace (NAVYUG UDOG, AMBALA CANT-133001). Carbohydrate determination was by difference according to the method of Pearson (1976) as %carbohydrate = 100 – (%moisture content + %fat + %ash + %crude protein + %crude fiber).

2.8. Hydrogen Cyanide Determination

The hydrogen cyanide (HCN) content of the samples was determined using the standard alkaline picrate colorimetric method [25] and expressed in mg/kg. One gram of each sample was weighed into a conical flask and

200ml of distilled water added to it. Each sample was thoroughly mixed and a strip of alkaline picrate paper was suspended over the mixture with the aid of a rubber stopper, in such a way that that the paper did not touch the surface of the mixture. The set-up was incubated (SURGIFIED SM9022A, ENGLAND) for 18 hours at room temperature. At the end of the incubation period, the picrate paper was carefully removed and placed in 60 ml distilled water. Meanwhile, a standard cyanide solution was prepared and treated as above. The absorbance of the elutes from the standard and the sample was measured using a spectrophotometer (NU-T5, NB nanBei, ZHENGZHOU) at 540 nm. The hydrogen cyanide content in mg/Kg was calculated using the formula

$$HCN\left(mg / Kg\right) = \left(100 / W\right)\ X\ A_u\left(A_s\right)$$

Where W = Weight of sample analyzed (g)
A_u= Absorbance of sample (nm)
A_s = Absorbance of the standard HCN solution (nm)

2.9. Functional Properties Determination

The bulk density, water absorption capacity (Centrifuge model 800D, G-BOSCH GERMANY and Scanfrost warring mixer was used) and pasting properties (peak, trough, breakdown, final and setback viscosity, pasting time and temperature, RVA model WK 300 LAUDA was used) of the unfermented fufu composite flour samples were determined by the conventional standard methods as described by [26].

2.10. Sensory Evaluation

The samples of the unfermented fufu composite flour were reconstituted into fufu by cooking in boiling water while stirring vigorously. The fufu samples were coded and served warm to the 30-member panels that are identified as regular fufu consumers. The panellists evaluated for colour/appearance, mouldability, texture/hand feel, taste and overall acceptability using a 9-point Hedonic scale with 1 representing the least score (dislike extremely) and 9 representing the highest score (like extremely).

2.11. Statistical Analysis of Data

All analyses except sensory were carried out in triplicates. Data generated was subjected to two-way Analysis of Variance (ANOVA) and means separated using Duncan test at p<0.05 significant level using IBM SPSS version 18.

3. Results and Discussion

3.1. Proximate Composition of Fresh Cassava Sievate (C), Guinea Corn (G), Unripe Plantain (U) and Cassava Sievate, Guinea Corn and Unripe Plantain Flour

The proximate composition of fresh cassava sievate, guinea corn, unripe plantain; and cassava sievate, guinea corn and unripe plantain flours are shown in Table 1. The protein, fat, ash, crude fiber, moisture and carbohydrate content of the fresh samples of cassava sievate, guinea corn and unripe plantain significantly (p<0.05) differed from their respective flour samples except for the protein and fat content of fresh and flour samples from guinea corn after processing. It was observed that the protein and moisture content of the fresh samples of cassava sievate and unripe plantain decreased with drying while fat, ash, crude fiber and carbohydrate content increased with drying. A decreased trend in fat, ash, crude fiber and moisture content; and an increase in crude protein and carbohydrate content was seen in the fresh sample of guinea corn. This result showed that protein was negatively affected by heat (Heating can lead to losses in nutrients by inducing biochemical and nutritional variation in food composition [27]) in cassava sievate and unripe plantain fresh sample but had a positive concentration effect on guinea corn fresh sample. This could imply that protein in guinea corn is more heat stable than in the other samples. The increased effect observed in fat, ash, crude fiber and carbohydrate could be as a result of nutrient concentration due to loss of moisture due to heat.

Table 1. Proximate Composition of Fresh Cassava Sievate, Guinea Corn, Unripe Plantain and Cassava Sievate, Guinea Corn and Unripe Plantain Flour (%)

Samples	Crude Protein	Fat	Ash	Crude Fibre	Moisture Content	Carbohydrate
Fresh Cassava Sievate	3.82±0.01^a	2.47±0.06^a	0.61±0.01^a	1.23±0.01^a	62.02±0.01^a	29.85±0.06^a
Cassava Sievate Flour	3.72±0.01^b	3.00±0.02^b	1.01±0.01^b	2.00±0.02^b	10.00±0.01^b	80.26±0.02^b
Fresh Guinea Corn	12.49±0.02^a	1.07±0.06^a	2.67±0.06^a	2.57±0.02^a	9.05±0.01^a	72.15±0.07^a
Guinea Corn Flour	12.50±0.02^a	1.00±0.10^a	2.53±0.06^b	2.54±0.04^a	9.01±0.02^a	72.41±0.19^a
Fresh Unripe Plantain	9.89 ±0.02^a	1.48 ±0.01^a	1.20±0.01^a	1.02±0.01^a	58.77±0.03^a	27.63 ±0.04^a
Unripe Plantain Flour	8.12 ±0.03^b	1.50 ±0.00^b	2.46±0.06^b	1.63±0.01^b	8.52 ±0.02^b	77.76 ±0.01^b

Data represent means of three determinations ± Standard Deviation. Values. In the same column with colour differences, means with different lower superscripts indicate a significant difference (p<0.05).

The range of protein contents obtained for fresh and flour of cassava sievate was higher than the ranged value of 0.61 % to 1.38 % reported by [7] but lower than the value of 7.13 % by [28] for cassava flours reported. [29], also reported that a decrease in protein on the application of heat could be as a result of the effect of tannins that form complexes with protein and reduce their availability. The fat values for fresh and flour samples of cassava sievate were higher than the value range of 0.26 to 0.61 % reported by [7] for garri sievate. The cassava sievate ash contents obtained from this study is lower than the value of 0.97 to 1.59% and its flour value in a close range to the values range of 0.97 to 1.59% reported by [7]. The fresh and flour cassava sievate sample crude fiber values were lower than the value of 1.23% and within the ranged values of 1.66 to 3.64%, respectively as reported by [30]. The increase in ash, fiber, fat and carbohydrate content after drying and milling fresh cassava sievate and unripe plantain into flour could be because of the moisture removal which increases the concentration of nutrients [31]. The decrease in moisture content of the fresh samples could be due to the dehydration effect of drying which removed moisture by dehydration to prevent the growth of microorganisms that cause deterioration [32]. Moisture content is a vital factor as regards flour quality, shelf life and application in the food industry [33].

The values for crude protein for the fresh and flour of guinea corn samples were higher than the values of 6.28 and 9.47 % reported by [34] and 10.80 % and 10.00% by [20], respectively. However, [35] stated that the protein content of guinea corn is quite variable ranging from 7 % to 15 %. The fat content of the raw and flour of guinea corn were higher than the values of 0.15 and 0.32% for guinea corn flour by [34] but lower than 5.03 and 3.02%, respectively by [33]. Fiber content of raw and flour of guinea corn was higher than 1.97% (raw guniea corn) but in the same range of 2.33% (guinea corn flour). Their ash contents were higher than the values of 1.87 and 1.97% for raw and flour of guinea corn samples as reported by [32]. Moisture content for raw and flour of guinea corn samples was slightly lower than 9.51% and; 10.09 and 11.04% as reported by [34] while their carbohydrate values were in close range value of 72.12 and 73.98% [33] but lower than 81.33 and 83.64% [34] for raw and flour sample of guinea corn.

The raw unripe plantain protein value is higher than the value of 5.4% and 8.83% reported by [18] and [36], respectively while its flour value is higher than 2.82, 3.07, 3.21 and 3.04% for unripe plantain flour [32] and 3.14% [37]. Raw unripe plantain fat content is lower than 6.69% [18] and higher than 0.53% [36] while its flour is higher than 1.15, 0.68 and 1.39% for oven-dried, tray-dried and sun-dried [37] but similar to 1.53% for fluidized bed dried unripe plantain flour and lower than 5.36% [37]. Ash content of unripe plantain is in agreement with the reported value of 1.20% by [18] and lower than 4.71% [36] while its flour is higher than the values of 3.11, 3.14, 3.91 and 3.56% [32] and 0.36% [37]. The crude fiber of raw unripe plantain is lower than 2.88% [18] and 2.21% [36] while its flour value is higher than 1.04 and 1.05% [32] but lower than 1.95% [37]. Raw unripe plantain moisture content is higher than the value reported by [18] and lower than the value reported by [14] while its flour moisture is higher than 3.24, 3.48, 5.43 and 4.93% [32]; and 7% [37]. The carbohydrate value for raw unripe plantain is not in agreement with the value of 30.98% [36] while its flour is lower than 87.64, 87.74, 85.72 and 86.04% [32] and; 82.12% [37].

3.2. Proximate Composition of Unfermented Fufu Composite Flours from Cassava Sievate (C), Guinea Corn (G) and Unripe Plantain (U) Flour Blends

The proximate composition of unfermented fufu composite flours from cassava sievate, guinea corn and unripe plantain flour blends are shown in Table 2. Generally, all the proximate parameters analyzed showed significant ($p<0.05$) different among all the unfermented fufu composite flour and when compared with the control samples except for fat content of sample 80:10:10 and 100:0:0, ash (80:10:10, 0:0:100 and 0:100:0) and (90:5:5, 85:10:5, 5:90:5 and 20:70:10), crude fiber (85:10:5 and 70:20:10), moisture content (70:20:10 and 100:0:0) and (5:90:5 and 10:85:5); and carbohydrate (90:5:5 and 85:10:5) for cassava sievate:guinea corn:unripe plantain flour, respectively. Sample 5:90:5 ranked the highest protein value of 11.16% while 90:5"5 showed the lowest value of 2.4%. It was observed that the protein content of unfermented fufu composite flour increased with an increase in guinea corn which could be attributed to the highest value (12.5%) of protein compared to cassava sievate and unripe plantain flour. The protein contents of the unfermented fufu composite flour were higher than that reported in cassava fufu by [28,38,39] (cassava-breadfruit fufu) and [40] (cocoyam-cassava fufu). Their fat contents were within and above the range values of 1.32, 1.21, 1.19 and 1.2%; 1.52, 1.32, 1.2 and 1.08%; and 1.44% by [39,40] and [28], respectively. The ash values obtained from this study were higher than that reported by [38] (cassava fufu) and [39] (cassava-breadfruit fufu) while crude fiber values were within the range values of 0.14 and 1.42 for cassava fufu reported by [40] and [28], respectively.

Table 2. Proximate Composition of Unfermented Fufu Composite Flours from Blends of Cassava (C) Sievate, Guinea Corn (G) and Unripe Plantain (U) Flours (%)

Sample (C:G:U)	Crude Protein	Crude Fat	Ash	Crude Fibre	Moisture Content	Carbohydrate
80:10:10	$3.02±0.02^{i}$	$0.96±0.06^{a}$	$2.47±0.06^{a}$	$0.33±0.03^{j}$	$7.35±0.01^{f}$	$85.87±0.01^{b}$
90:5:5	$2.40±0.02^{k}$	$2.03±0.06^{f}$	$0.52±0.03^{e}$	$0.42±0.03^{i}$	$6.84±0.03^{g}$	$87.78±0.06^{a}$
85:10:5	$2.85±0.02^{j}$	$1.57±0.06^{h}$	$0.50±0.00^{e}$	$0.52±0.03^{h}$	$6.60±0.02^{h}$	$87.96±0.10^{a}$
70:20:10	$3.94±0.01^{g}$	$2.13±0.23^{e}$	$1.10±0.10^{c}$	$0.52±0.02^{h}$	$10.00±0.02^{b}$	$82.31±0.26^{c}$
10:80:10	$8.29±0.01^{e}$	$2.47±0.06^{d}$	$0.43±0.06^{f}$	$1.00±0.01^{g}$	$10.99±0.03^{a}$	$76.81±0.12^{g}$
5:90:5	$11.16±0.02^{b}$	$2.90±0.10^{b}$	$0.53±0.06^{e}$	$1.35±0.02^{e}$	$8.01±0.02^{e}$	$76.05±0.06^{h}$
10:85:5	$10.73±0.02^{c}$	$2.52±0.03^{c}$	$1.43±0.06^{b}$	$1.53±0.03^{d}$	$8.01±0.01^{e}$	$75.78±0.03^{i}$
20:70:10	$8.54±0.02^{d}$	$2.00±0.00^{g}$	$0.52±0.03^{e}$	$1.05±0.06^{f}$	$9.03±0.02^{c}$	$78.87±0.05^{e}$
0:0:100	$8.12±0.035^{f}$	$1.50±0.00^{i}$	$2.47±0.06^{a}$	$1.63±0.01^{c}$	$8.52±0.02^{d}$	$77.76±0.01^{f}$
0:100:0	$12.50±0.02^{a}$	$1.00±0.10^{j}$	$2.53±0.06^{a}$	$2.54±0.04^{a}$	$9.02±0.02^{c}$	$72.41±0.19^{j}$
100:0:0	$3.72±0.01^{h}$	$3.00±0.02^{a}$	$1.01±0.01^{d}$	$2.00±0.02^{b}$	$10.00±0.01^{b}$	$80.26±0.02^{d}$

Data represent means of three determinations ± Standard Deviation. In the same column, means with different superscripts indicate a significant difference ($p<0.05$).

Table 3. Hydrogen Cyanide of Fresh and Flours Samples of Cassava Sievate (C), Guinea Corn (G), Unripe Plantain (U); and Unfermented Fufu Composite Flour from Cassava Sievate, Guinea Corn, Unripe Plantain Flour Blends

Samples (C:G:U)	Hydrogen Cyanide (mg/kg)
Fresh Cassava Sievate	0.42±0.01^{a}
Cassava Sievate Flour	0.22±0.03^{b}
Fresh Guinea Corn	0.07±0.03^{c}
Guinea Corn Flour	0.10±0.00^{c}
Fresh Unripe Plantain	0.07±0.01^{c}
Unripe Plantain Flour	0.05±0.01^{c}
80:10:10	0.12±0.00^{a}
90:5:5	0.12±0.00^{a}
85:10:5	0.15±0.00^{b}
70:20:10	0.07±0.02^{c}
10:80:10	0.12±0.02^{a}
5:90:5	0.10±0.00^{d}
10:85:5	0.12±0.00^{a}
20:70:10	0.07±0.00^{e}
0:0:100	0.05±0.01^{f}
0:100:0	0.10±0.00^{d}
100:0:0	0.22±0.03^{g}

Data represent means of three determinations ± Standard Deviation. In the same column with different colours, means with different superscripts indicate a significant difference (p<0.05).

3.3. Hydrogen Cyanide of Fresh and Flour Samples of Cassava Sievate (C), Guinea Corn (G), Unripe Plantain (U); and Unfermented Fufu Composite Flour from Cassava Sievate, Guinea Corn and Unripe Plantain

The hydrogen cyanide of fresh and unfermented fufu composite flour samples of cassava sievate, guinea corn, unripe plantain; and unfermented fufu composite flour from cassava sievate, guinea corn and unripe plantain is shown in Table 3. There was a significant (P<0.05) difference in the hydrogen cyanide contents of the fresh samples except for fresh and flour samples of cassava sievate when compared with each other and control samples (cassava sievate, guinea corn and unripe plantain hundred per cent); the hydrogen cyanide value ranges from this study were below 10mg/kg permissible limit approve by world health organization [41].

There were significant (p<0.05) differences in the hydrogen cyanide of all the unfermented fufu composite flour samples except for samples 80:10:10, 90:5:5, 10:80:10 and 10:85:5 when compared with each other and control samples. However, the hydrogen cyanide values from this study were lower than that reported by [42] 395 mg/kg for cassava whole tuber (bitter variety), 462 mg/kg for cassava whole tuber (sweet variety) and 2500 mg/kg for immature whole sorghum plant and; [43]'s (2009) study revealed 0.3 mg/Kg HCN in the sorghum grain.

3.4. Functional and Pasting Properties of Unfermented Fufu Composite Flour from Cassava Sievate (C), Guinea Corn (G) and Unripe Plantain (U) Flour Blends

The functional and pasting properties of unfermented fufu composite flours from cassava sievate, guinea corn and unripe plantain flour blends are shown in Table 4. The percentage water absorption capacity and bulk density values of the unfermented fufu composite flour samples significantly (p<0.05) differed with each other and controls except for samples 85:10:5 and 0:0:100 (water absorption capacity). Sample 10:80:10 for cassava sievate: guinea corn: unripe plantain had the highest value of 38.10% water absorption capacity. This connotes that this sample has a greater ability to associate with water under limited water conditions [20]. Sample 80:10:10 had the lowest bulk density value of 0.54 g/ml. this implies that this sample would be easier to package and transport because bulk density is a crucial factor in the determination of packaging requirement, material handling and the application in wet processing in the food industry [44]. The values of the bulk density of the unfermented fufu composite flour sample were lower than that reported by [37] for plantain flour.

Table 4. Functional and Pasting Properties of Unfermented Fufu Composite Flour from Cassava Sievate (C), Guinea Corn (G) and Unripe Plantain (U) Flours

Samples (C:G:U)	Water Absorption Capacity (%)	Bulk Density (g/ml)	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Time (Min)	Temperature (°C)
80:10:10	29.33±0.29^{a}	0.54±0.02^{a}	164.91±0.02^{a}	100.34±0.01^{a}	64.57±0.03^{a}	227.35±0.03^{a}	62.42±0.01^{a}	6.38±0,01^{a}	93.48±0.00^{a}
90:5:5	25.33±0.29^{b}	0.63±0.02^{b}	162.77±0.01^{b}	94.20±0.01^{b}	68.57±0.00^{b}	225.07±0.06^{b}	58.18±0.01^{b}	6.18±0.01^{b}	93.21±0.01^{b}
85:10:5	22.10±0.17^{c}	0.63±0.01^{c}	163.93±0.03^{c}	98.12±0.01^{c}	65.81±0.02^{c}	226.80±0.02^{c}	59.33±0.01^{c}	6.22±0.01^{cb}	93.47±0.01^{af}
70:20:10	24.07±0.12^{d}	0.62±0.02^{d}	210.68±0.01^{d}	144.34±0.01^{d}	66.34±0.00^{d}	231.43±0.01^{d}	87.10±0.01^{d}	6.17±0.02^{db}	93.17±0.01^{c}
10:80:10	38.10±0.17^{e}	0.71±0.01^{e}	200.42±0.01^{e}	132.12±0.01^{e}	68.30±0.02^{e}	228.86±0.01^{e}	66.47±0.01^{e}	6.57±0.04^{e}	93.28±0.02^{d}
5:90:5	18.10±0.10^{f}	0.71±0.01^{e}	165.30±0.01^{f}	108.09±0.01^{f}	57.22±0.01^{f}	236.42±0.01^{f}	71.11±0.01^{f}	6.87±0.01^{f}	93.66±0.01^{e}
10:85:5	28.43±0.12^{g}	0.70±0.01^{f}	190.07±0.01^{g}	131.35±0.02^{g}	58.73±0.04^{g}	198.69±0.01^{g}	67.34±0.00^{g}	6.44±0.01^{g}	93.49±0.01^{a}
20:70:10	31.13±0.23^{h}	0.71±0.01^{g}	201.11±0.01^{h}	133.57±0.01^{h}	67.54±0.03^{h}	201.33±0.01^{h}	65.03±0.01^{h}	6.38±0.06^{a}	93.45±0.00^{f}
0:0:100	22.03±0.06^{c}	0.71±0.10^{h}	168.23±0.01^{i}	116.90±0.01^{i}	51.33±0. 00^{i}	287.55±0.01^{i}	78.34±0.01^{i}	6.95±0.01^{h}	93.13±0.01^{g}
0:100:0	24.10±0.10^{d}	0.72±0.01^{i}	162.42±0.01^{j}	106.07±0.01^{j}	56.35±0.01^{j}	242.17±0.01^{j}	73.92±0.01^{j}	6.97±0.01^{h}	93.72±0.01^{h}
100:0:0	34.07±0.12^{i}	0.55±0.01^{j}	230.06±0.01^{k}	150.72±0.01^{k}	79.34±0.01^{k}	218.43±0.01^{k}	56.31±0.01^{k}	6.45±0.00^{g}	93.19±0.01^{bc}

Data represent means of two determinations ± Standard Deviation. In the same column, means with different superscripts indicate a significant difference (p<0.05).

The pasting properties of the unfermented fufu composite flour samples showed significant ($p<0.05$) difference among each other and controls except for the 80:10:10 and 20:70:10; 90:5:5, 85:10:5 and 70:20:10 (pasting time in min.); and 80:10:10, 85:10:5 and 10:85:5; 90:5:5 and 100:0:0; and 70:20:10 and 100:0:0 (pasting temperature in degree centigrade). Sample 70:20:10 for cassava sievate: guinea corn: unripe plantain had the highest value (210.68 RVU) of peak and trough (144.34RVU) viscosity. This implies that this sample would have maximum ability to swell freely before its physical breakdown (indicate good water-holding capacity and often correlated with final product quality) when compared to other samples of unfermented fufu composite flour [45]. Sample 5:90:5 had the lowest value of 57.22 RVU for breakdown viscosity and the highest value of 236.42 RVU for final viscosity when compared to other unfermented fufu composite flour samples. This connotes more resistance to shear stress or breakdown (decrease in the rate of rupturing of starch granule) and it's a vital factor in determining paste stability and ease of cooking starch; and ability to form viscous paste after cooking and cooling, respectively [32]. Sample 90:5:5 had the lowest value of 58.18 RVU for setback viscosity when compared to the other unfermented fufu composite flour. This means that this sample would have a higher resistance to retrogradation tendency than other samples which makes it more preferable (lower retrogradation tendency than others) [45]. Sample 70:20:10 showed the lowest pasting time of 6.17 minutes when compared with other unfermented fufu samples. This implies that it would be easier to cook than other samples. [46] described the peak time as a measure of the cooking time, the shorter the peak time the higher the ease of cooking. The lowest pasting temperature value of 93.17°C was observed in sample 70:20:10 when compared to other samples. The low pasting temperature value is an indicator that food starch can cook with minimal temperature which also influences the energy cost of cooking [32].

Table 5. Sensory Properties of Unfermented Fufu Composite Flour from Cassava Sievate (C), Guinea Corn (G) and Unripe Plantain (U) Flour

Samples (C:G:U)	Colour/Appearance	Mouldability	Texture/Hand feel	Taste	Overall Acceptability
80:10:10	7.4 ± 0.97^b	6.9 ± 1.29^b	7.8 ± 0.79^a	7.0 ± 1.41^a	7.6 ± 1.07^a
90:5:5	7.3 ± 1.42^b	7.8 ± 1.23^a	7.6 ± 0.84^a	7.1 ± 0.57^a	7.9 ± 0.74^a
85:10:5	7.2 ± 1.32^b	7.1 ± 1.79^b	7.4 ± 0.84^b	6.9 ± 1.20^a	7.8 ± 0.92^a
70:20:10	7.1 ± 0.99^b	7.4 ± 1.43^b	7.6 ± 0.84^a	7.0 ± 0.67^a	7.3 ± 1.25^b
10:80:10	6.9 ± 1.10^b	6.8 ± 1.32^b	6.6 ± 1.51^b	6.7 ± 1.89^a	6.8 ± 1.40^c
5:90:5	6.8 ± 1.48^b	6.9 ± 0.99^b	6.7 ± 1.57^b	7.1 ± 1.10^a	7.2 ± 0.92^b
10:85:5	6.6 ± 1.17^b	6.9 ± 1.10^b	6.5 ± 0.97^b	6.8 ± 0.79^a	6.8 ± 1.14^c
20:70:10	7.5 ± 1.18^a	7.6 ± 1.17^a	7.2 ± 0.92^b	7.3 ± 1.25^a	7.6 ± 1.26^a
0:0:100	4.6 ± 3.34^d	6.6 ± 1.71^b	7.0 ± 2.16^b	6.7 ± 1.64^a	5.8 ± 2.62^d
0:100:0	7.3 ± 1.49^b	6.4 ± 2.27^c	6.8 ± 1.62^b	6.6 ± 1.43^a	6.7 ± 1.57^a
100:0:0	5.5 ± 0.99^c	7.0 ± 0.60^b	7.3 ± 0.50^b	6.8 ± 1.01^a	7.1 ± 1.00^b

Data represent means of ten evaluations ± Standard Deviation. . In the same column, means with different lower sub superscripts indicate a significant difference ($p<0.05$).

3.5. Sensory Properties of Unfermented Fufu Composite Flour from Cassava Sievate (C), Guinea Corn (G) and Unripe Plantain (U) Flours

Table 5 shows the result of the sensory evaluation carried out on the unfermented fufu composite flours for colour/appearance, mouldability, texture/hand feel, taste and overall acceptance using a 9-point Hedonic scale. The mean score range for colour/appearance was 4.6 to 7.5 with no significant difference ($p<0.05$) among all the samples except for samples 20:70:10; 0:100:0 and 100:0:0 for cassava sievate: guinea corn: unripe plantain, respectively. Sample C:G:U 20:70:10 had the highest score of 7.5, meaning liked moderately while sample C:G:U 0:0:100 (unripe plantain flour only) had the lowest mean score apparently because of its dark brown colour. Mouldability mean scores of the unfermented fufu samples ranged from 6.4 to 7.8. Sample 0:100:0 significantly ($p<0.05$) differed from every other sample with the lowest score means of 6.4 while sample 90:5:5 had the highest score of 7.8 which approximately mean liked very much. Samples 80:10:10, 90:5:5 and 70:20:10 have no significant difference ($p<0.05$) among each other but significantly ($p<0.05$) different with other samples in their texture/hand feel. Sample C:G:U (80:10:10) had the highest texture mean score of 7.8 (indicates liked very much approximately) while sample C:G:U (10:85:5) had the least texture mean score of 6.5 (meaning it was liked moderately in approximation). It can be seen that the unfermented fufu samples with a high amount of guinea corn had less texture scores than the samples with a high amount of cassava sievate. The taste mean scores ranged from 6.6 (for sample C:G:U 0:100:0) to 7.3 (for sample C:G:U 20:70:10). There was no significant difference between the taste mean scores of the unfermented fufu samples. The different proportions of cassava sievate, guinea corn and unripe plantain flours did not significantly affect the taste of the fufu flours. In terms of general acceptability, sample C:G:U 0:0:100 had the least mean score while C:G:U 90:5:5 had the highest general acceptability mean score of 7.9 which implied like very much approximately.

4. Conclusion

In this research work, the proximate composition (except carbohydrate) of the unfermented fufu flours improved with the increase in the proportions of guinea corn and plantain flours. The carbohydrate content increased with an increase in cassava sievate flour. From the fufu flour blends, samples C:G:U 5:90:5, C:G:U 10:85:5, C:G:U 10:80:10 and C:G:U 20:70:10 had the best proximate composition. The hydrogen cyanide content of the fufu flours are below the permissible limit therefore they are not deleterious to human health. The pasting and functional properties analyzed showed an indication that the unfermented fufu composite flour from cassava sievate, guinea corn and unripe plantain would substitute cassava fufu flour for consumption by swallowing. Also, sensory properties evaluation is an indicator that this product (90:5:5 (7.9 score value) for cassava sievate: guinea corn: unripe plantain) was liked very much on approximation. This work is proof that unfermented fufu flour processed from blends of cassava sievate, guinea corn and unripe plantain flours would be a cheap, safe, healthier and better substitute to conventional fufu and fufu flour. Hence, it should be adopted and commercialized.

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